58713

TA-16 MATERIAL DISPOSAL AREA-P

CLOSURE PLAN

Revision 0

February 1995

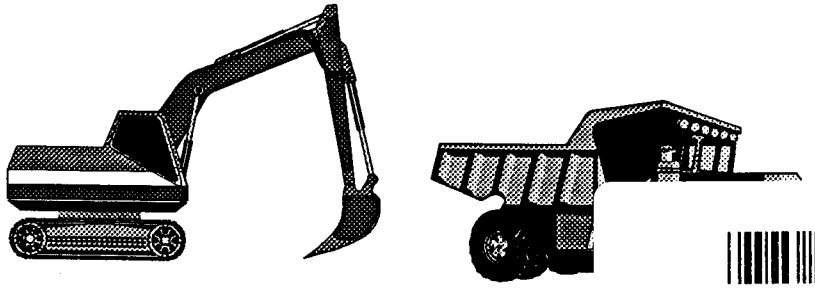

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TABLE OF CONTENTS

1.0 INTRODUCTION 1-1

1.1 Closure Strategy 1-2
1.1.1 Waste Pile Boundaries and Nearby Potentially Contaminated Sites 1-2
1.1.2 Contingent Approach 1-5
1.1.3 Technical Approach 1-8

2.0 FACILITY DESCRIPTION 2-1

2.1 General Description 2-1
2.1.1 MDA-P Waste Pile 2-1
2.1.2 Topographic Maps 2-5
2.1.3 Land Use 2-5

2.2 Environmental Setting 2-5

3.0 EXISTING WASTE CHARACTERIZATION INFORMATION 3-1

3.1 Previous Chemical/Physical Analytical Results 3-1

3.2 Process Knowledge 3-8
3.2.1 General Waste-Pile Operations Information 3-8
3.2.2 General S-Site Information 3-10
3.2.3 General Information on Explosives Composition 3-11

3.3 Potential Constituents in the Waste 3-12

4.0 SAMPLING AND ANALYSIS PLAN FOR PHASE 1 AND PHASE 2 CLOSURE SAMPLING 4-1

4.1 Strategy, Sample Point Location, and Number of Samples for Phase 1 Sampling and Analysis 4-1
4.1.1 Sampling to Establish Background Concentrations 4-2
4.1.2 Sampling to Establish Baseline 4-3
4.1.3 Sampling of the Waste Pile 4-3

4.2 Strategy, Sample Point Location, and Number of Samples, for Phase 2 Sampling and Analysis 4-5
4.2.1 Sampling of the Soil Beneath and Downgradient of the Former Waste Pile 4-5
4.2.2 Sampling of the Soil Below the Closure Waste Handling/Management Areas at the Top of the Mesa 4-6

4.3 Strategy, Sample Point Location, and Number of Samples for Sampling and Decontamination Wastes 4-7
4.3.1 Decontamination Liquids 4-7
4.3.2 Disposable Personal Protective Equipment and Sampling Equipment 4-7

6.2.5 Detailed Description of Closure of Waste Residues [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114] 6-21
6.2.6 Detailed Description of Other Necessary Activities [20 NMAC 4.1, Section 265.112(b)(5) and 265.114] 6-23
6.2.7 Schedule for Closure of Each Unit [20 NMAC 4.1, Section 265.112(b)(6)] 6-26

6.3 Decontamination Procedures [20 NMAC 4.1, Section 265.112(b)(4) and 265.114] 6-26
6.3.1 Procedures for Cleaning Equipment and Removing Contaminated Soils [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114] 6-26
6.3.2 Management of Generated Wastes [20 NMAC 4.1, Sections 265.112(b)(3) and 265.114] 6-28
6.3.3 Criteria for Determining the Extent of Decontamination Necessary [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114] 6-30
6.3.4 Methods for Sampling and Testing to Demonstrate Success of Decontamination [20 NMAC 4.1, Section 265.112(b)(4) and 265.114] 6-30

6.4 General Postclosure Care Requirements [20 NMAC 4.1, Sections 264.258(b), 265.116 - 265.120, 265.144, and 265.145 and 265.147] 6-31

7.0 CLOSURE REPORTS 7-1

8.0 REFERENCES 8-1

LIST OF FIGURES

Page
1-1 MDA-P Project Boundary . . . . . pocket
1-2 Decision Tree 1-7

2-1 Regional Map of Los Alamos National Laboratory 2-2
2-2 Los Alamos National Laboratory Technical Areas 2-3
2-3 Existing Surface Run-on Trench and Typical Cross Section 2-6
2-4 MDA-P Topographic Map and Site Layout . . . . . pocket

3-1 Previous Sample Locations . . . . . pocket

4-1 MDA-P Sample Grid . . . . . pocket
4-2 Example of Sample Label 4-13
4-3 Example Chain of Custody/Request for Analysis Form 4-14
4-4 Data Format Checklist 4-22

6-1 Process for Determining if Closure Performance Standard is Met 6-4
6-2 Estimated Project Schedule with No Risk Assessment 6-10
6-3 Estimated Project Schedule with Risk Assessment 6-11

LIST OF TABLES

1-1 Applicable Closure Regulations and Associated Closure Plan Sections 1-3

3-1 Material Disposal Area P Borehole Sampling 1988 Barium Concentrations 3-3
3-2 Material Disposal Area P Borehole Sampling 1988 Residual High Explosive 3-4
3-3 Material Disposal Area P Sampling Results April 1994 3-5
3-4 Potential Constituents in the Waste at MDA-P Waste Pile 3-13

4-1 Sample Containers, Preservation and Holding Times 4-10
4-2 Summary of Samples and Analyses 4-17
4-3 Summary of Field Quality Control Samples 4-24

LIST OF EXHIBITS

6-1 Example Owner or Operator Closure Certification 6-13
6-2 Example Independent Registered Professional Engineer Closure Certification . . . 6-14

LIST OF APPENDIXES

A. Derivation of Screening Action Levels

B. Data Evaluation and Risk Assessment Methodologies for Demonstrating Clean Closure

C. Photographs of the MDA-P Waste Pile and Surface Run-on Control Trench

D. Vadose Zone Monitoring Observations at the TA-16 Area P Landfill

E. Historical Records Associated with TA-16 and Material Disposal Area P

F. Composition of Explosives used at the Laboratory

G. Sampling Procedures for MDA-P Closure

H. Appendix VIII Constituents Evaluation

I. Site-Specific Standard Operating Procedures

J. Site Geology and Hydrology of Technical Area 16, Area P

LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Atomic absorption spectroscopy
AES	Atomic emission spectroscopy
Appendix VIII	Constituents listed in 20 NMAC 4.1, Section 261, Appendix VIII
CFR	Code of Federal Regulations
CPF	Cancer potency factor
DOE	US Department of Energy
DQO	Data Quality Objective
DU	Depleted Uranium
EP	Extraction Procedure
EPA	Environmental Protection Agency
EQL	Estimated quantitation limit
ER	Environmental Restoration
FIMAD	Facility for Information Management and Display
GC	Gas chromatography
HEAST	Health Effects Assessment Summary Table
20 NMAC 4.1	New Mexico Hazardous Waste Regulations-7
HASP	Health and Safety Plan
HE	High Explosive
HMX	Cyclotetramethylenetetranitramine
ICP	Inductively coupled plasma
IRIS	Integrated Risk Information System
IWP	Installation Work Plan for Environmental Restoration
Laboratory	Los Alamos National Laboratory
LOD	Limit of Detection
MCL	Maximum contaminant level
MS	Mass spectroscopy
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic aromatic hydrocarbons

PETN	Pentaerythritol tetranitrate
PCB	Polychlorinated biphenyls
PRG	Preliminary remedial goal
QA	Quality assurance
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RDX	Cyclonitrate, cyclotrimethylenetrinitramine
RfD	Reference dose
RPD	Relative percent difference
RPF	Records Processing Facility
SAL	Screening action levels
SOP	Stardard operating procedures
SVOC	Semivolatile organic compound
TA	Technical Area
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
Tetryl	Trinitrophenyl methylnitramine
TNT	Trinitrotoluene
UTL	Upper Tolerance Level
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This closure plan is submitted to the New Mexico Environment Department (NMED) to meet the requirements of the New Mexico Hazardous Waste Regulations (20 NMAC 4.1) and the Resource Conservation and Recovery Act (RCRA). This closure plan addresses only the clean closure of the Material Disposal Area (MDA)-P at Technical Area (TA)-16 at the Los Alamos National Laboratory (Laboratory). The Laboratory is owned by the U.S. Department of Energy (DOE) and is operated by the University of California. The MDA-P has been referred to as a landfill in previous reports, but will be referred to as a waste pile for this closure as described in Section 1.1.1.

This closure plan provides a description of the MDA-P waste pile and the actions that will be implemented during closure. The waste pile will undergo clean closure by removal of the waste and excavation of any contaminated subsoils. After the waste pile has been removed, the remaining soil and tuff may be left in place if contamination is below acceptable levels as defined in Chapter 6.0 of this plan. If remaining contamination is above acceptable levels, an amendment to this closure plan will be submitted to NMED. This closure plan addresses the removal or decontamination of RCRA-regulated waste. Radioactive waste and mixed waste are not anticipated to be present in this waste pile.

Chapter 1.0 of this plan provides an introduction and outlines the clean closure strategy. Chapter 2.0 provides descriptive information on TA-16 and on the design and operation of the waste pile. Chapter 3.0 summarizes existing information concerning the chemical and physical characteristics of the material in the waste pile. Chapter 4.0 provides a plan for sampling and analysis during the closure as well as for sampling and analysis to confirm clean closure. Chapter 5.0 discusses the status of the groundwater monitoring for the site. Chapter 6.0 provides a detailed description of closure activities and the decision process that will be used to demonstrate that clean closure requirements have been met. Chapter 7.0 describes the reports that will be prepared to document the clean closure. Chapter 8.0 lists the references used for preparation of this document.

Appendix A describes the derivation of the screening action levels (SALs). Appendix B describes the methodology used to develop site-specific Preliminary Remediation Goals (PRGs) in

accordance with EPA guidance (EPA 1991a). Appendix C contains photographs of the waste pile and run-on control trench. Appendix D describes vadose-zone observations from 1988 at MDA-P. Appendix E provides historical records associated with TA-16 and MDA-P. Appendix F describes the composition of explosives produced at the Laboratory. Appendix G describes sampling procedures for MDA-P closure. Appendix H presents an evaluation of the 20 NMAC 4.1 Section 261, Appendix VIII (Appendix VIII) hazardous constituents for selection of analytical methods. Appendix I provides site-specific standard operating procedures. Appendix J describes the site geology and hydrology of TA-16, Area P.

Compliance with specific regulatory requirements for closure are addressed in Chapter 6.0. The 20 NMAC 4.1 have incorporated, with a few minor exceptions, the Code of Federal Regulations (CFR) Title 40, Parts 260 to 266 and 268 to 270 through July 1, 1993. Most regulatory citations in this closure will, therefore, be referenced to 20 NMAC 4.1. Table 1-1 lists the regulations applicable for closure of waste piles and identifies which sections of Chapter 6.0 address compliance with these regulations.

1.1 Closure Strategy

In the past, the disposal site at Area P was referred to as a landfill. However, RCRA regulations do not explicitly provide a clean-closure option for landfills. The U.S. Environmental Protection Agency (EPA) has addressed this problem by issuing guidance that allows a landfill, if clean closed under 40 CFR 265 standards, to make an equivalency demonstration under 40 CFR Section 270.1(c) (5),(6), by redefining the landfill as a waste pile (Lowrance 1989). Therefore, to clean close this unit and make an equivalency demonstration as described above, the Laboratory is referring to the MDA-P landfill as the MDA-P waste pile.

1.1.1 Waste Pile Boundaries and Nearby Potential Contaminated Sites

In order to clean-close the MDA-P waste pile, a boundary must be established to differentiate between the waste pile and three adjacent potentially contaminated areas. The approximate location of the proposed waste pile project boundary is shown in Figure 1-1 (see map in pocket at the end of this chapter). The waste pile project boundary was selected to include the area that could be contaminated

Table 1-1.
Applicable Closure Regulations and Associated Closure Plan Sections

20 NMAC 4.1 Regulation	Closure Plan Section
264.258(a)	6.1.1.2
264.258(b)	6.2.1, 6.4
265.111	6.1.1.1
265.112(b)	6.1.1.3
265.112(b)(1)	6.2.1
265.112(b)(2)	6.2.1, 6.2.2
265.112(b)(3)	6.2.3, 6.2.4, 6.2.5, 6.2.6, 6.3.2.
265.112(b)(4)	6.2.4, 6.2.5, 6.2.6, 6.3.1, 6.3.3, 6.3.4
265.112(b)(5)	6.2.7
265.112(b)(6)	6.2.8
265.112(c)	6.1.1.4
265.112(d)	6.1.1.5
265.112(e)	6.1.1.6
265.113(a)	6.1.2.1
265.113(b)	6.1.2.1
265.113(c)	6.1.2.2
265.114	6.1.3, 6.2.5, 6.2.6, 6.3.1, 6.3.2, 6.3.3,
265.115	6.1.4
265.116	6.1.5
265.117 - 265.120	6.4
265.142	6.1.6
265.143	6.1.7
265.144 - 265.145	6.4
265.147	6.1.8, 6.4
270.1(c)(5)	6.1

primarily by the MDA-P waste pile. Contamination within the waste pile project boundary will be addressed during this closure. Any debris that has moved outside the waste pile project boundary will be removed during closure.

Contamination within other potentially contaminated areas beyond this boundary will be addressed by the RCRA Facility Investigation (RFI) for Operable Unit (OU) 1082 (LANL 1993). Two of the adjacent potentially contaminated areas beyond the waste pile boundary include the burn pads located at the top of the mesa to the south of the waste pile and the area affected by the drainage from the burn pads located to the southwest and west of the waste pile. The burn pads are RCRA-regulated interim status units. These potentially contaminated areas are labeled as 16-016(b) and 161-010(c), and the estimated boundaries are depicted on Figure 1-1. These areas are potentially contaminated with constituents similar to those in the waste pile. These areas will be investigated during Phase 1 of the RFI for OU 1082, which is scheduled to begin during the spring of 1995.

The third potentially contaminated area is the stream at the bottom of the Cañon de Valle, located north of the waste pile. The stream is contaminated with constituents similar to those potentially present in the waste pile (see Section 3.1). However, several other known sources of potential contamination are located upstream of the waste pile. These sources include the drainage from the burn pads, located approximately 60 ft upstream and the effluent from a National Pollutant Discharge Elimination System (NPDES)-permitted outfall from Building 260, located approximately 1,700 ft upstream of the waste pile. The outfall is currently being monitored as required by the NPDES permit but not all of the potential contaminants identified in the RFI Work Plan are included in that monitoring. Another source is the MDA-R, a material disposal area that includes a World War II S-Site burning ground and its waste disposal area; this area is located approximately 1,900 ft upstream of the waste pile. One or more of these sources has produced elevated concentrations of several potential contaminants in the stream and associated sediments. Because the stream continues to receive contaminants (e.g., barium) from these upstream sources, cleaning up the stream to the clean-closure performance goals would not be possible.

The RFI for 1082 will address contamination in the stream located at the bottom of Cañon de Valle within OU 1082. All of the contaminants in this section of the canyon are likely to have been derived from TA-16 programmatic activities. In addition, the principal contaminants (HE and barium) in Cañon de Valle are the principal contaminants for upstream potentially contaminated areas in OU 1082. The Laboratory has not set the date for beginning the OU 1082 Phase 1 investigation for Cañon de Valle.

The Laboratory will ensure that the RFI will investigate the adjacent potentially contaminated areas up to the boundary of the MDA-P waste pile. In addition, the Laboratory will ensure that the contaminants identified for the adjacent potentially contaminated areas will include all the contaminants detected during the closure of the MDA-P waste pile.

The MDA-P boundary to the south of the MDA-P waste pile was selected to parallel (but not include) the surface run-on control trench located upgradient of the waste pile. The western boundary was selected to coincide with a small ridge that divides the drainage from the burn pads and drainage from the waste pile. The northern boundary was selected to coincide with the approximate elevation of the 100-year flood-plain of the Cañon de Valle stream. However, the northwest corner of the waste pile project boundary is below the 100-year flood-plain boundary. The eastern boundary was selected to include the last drainage channel to the east that could possibly include contamination from the waste pile. The eastern boundary was selected to include the eastern and western sides of this natural drainage divide. Markers will be used to permanently identify the surveyed boundary of the MDA-P waste pile.

1.1.2 Contingent Approach

This closure plan describes the removal of the waste pile and waste residues. Phase 1 sampling will be conducted during removal of the waste pile to characterize the waste for disposal. After the waste pile is removed, Phase 2 sampling will be conducted to determine if the remaining contamination, if any, is below acceptable levels. Soil or tuff below the waste pile may be left in place if NMED grants approval and if any of the following conditions are met:

- The 20 NMAC 4.1, Part 261, Appendix VIII hazardous constituents are present at concentrations less than the background upper tolerance levels (UTL) (see Section 4.1.1), or

- All Appendix VIII hazardous constituents in the soil or tuff are less than SALs (see Appendix A), or

- The sum of the SAL comparison ratios for multiple Appendix VIII constituents is less than a target value of 1 (see Section 6.1.1.2).

If all Appendix VIII constituent concentrations are below these levels, then the clean closure will be achieved.

If the remaining Appendix VIII constituent concentrations equal or exceed these levels, risk-based preliminary remedial goals (PRGs) will be developed as described in Appendix B. The soil or tuff may be left in place as described in Section 6.1.1.2 if NMED grants approval, and risk-based PRG levels are not exceeded. If risk-based PRG levels are exceeded, a risk assessment may be conducted in accordance with EPA guidance (EPA 1989, EPA 1991b, and EPA 1992a). See Figure 1-2.

If additional waste must be removed, an amendment to the closure plan will be prepared for removal of additional wastes to reduce risk to target levels based on an industrial exposure setting. The amendment will include a Phase 3 sampling plan (if additional sampling is necessary to better define the areas that require removal for clean closure). It will also include a Phase 4 confirmatory sampling and analysis plan to demonstrate that the clean-closure performance standard has been met. If Phase 3 sampling is necessary, the Phase 4 sampling plan will be submitted after the Phase 3 sampling results have been reviewed. NMED must approve this amendment and these sampling plans before they are implemented.

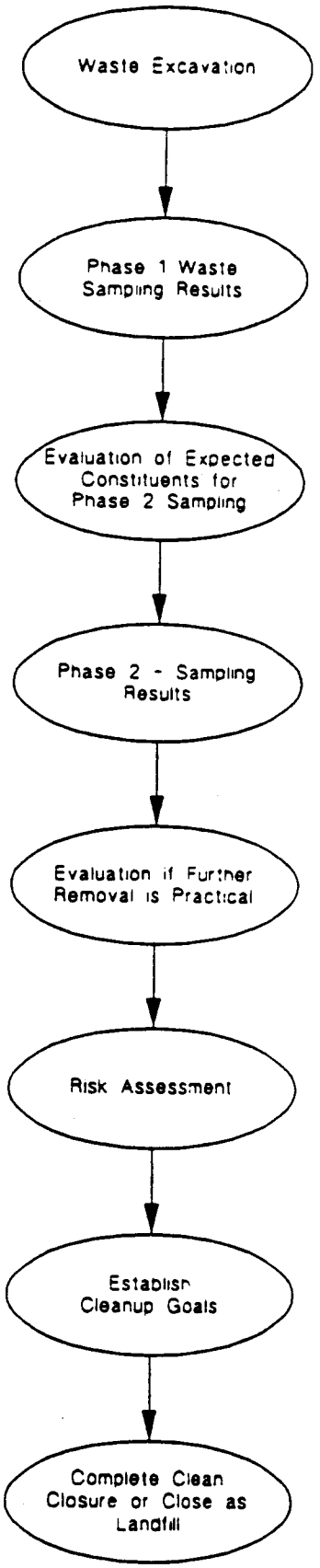


Figure 1-2. Decision Tree

1.1.3 Technical Approach

To achieve closure, the entire waste pile, including hazardous and nonhazardous waste and soil, will be removed. Approximately 30,000 cubic yards (yd^3) of debris will be excavated. The primary decontamination technique will be steam cleaning. The waste contained within the pile is very heterogeneous; most of it appears to be structural steel and miscellaneous debris, which cannot be easily sampled or characterized because of the impracticality of drilling through the material and the physical size of the material. Chapter 3.0 of this plan describes what is known about the waste pile, both from process knowledge and from the limited number of samples that have been taken to characterize the waste pile.

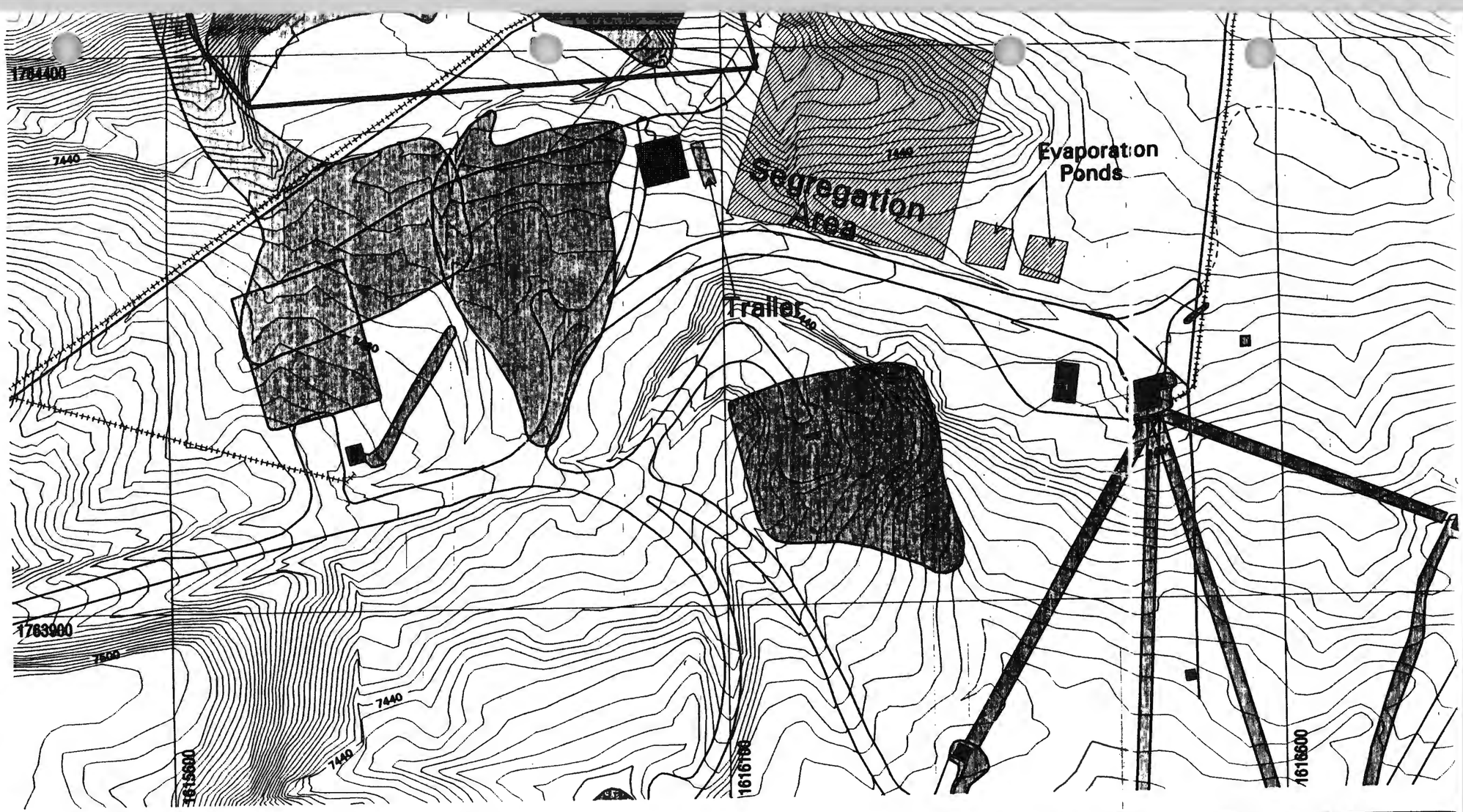
During closure, the waste will be characterized during excavation as sections of the pile are removed. For safety reasons, the debris will be decontaminated using steam and hot water to remove potential high explosives (HE) contamination. If the HE materials cannot be effectively removed from the debris, the debris will be flashed at the TA-16 open burn pad. If a significant amount of debris is generated beyond the estimates of this plan, alternate waste treatment methods will be explored. After decontamination and/or flashing, most of the debris is expected to be designated as nonhazardous.

The final rinsate from the debris will be sampled to demonstrate that any debris waste characteristics have been removed. If Appendix VIII hazardous constituents are not detected in the final rinsate samples, then the debris will be sent to a RCRA Subtitle D facility.

Soil, decontamination wastes (i.e., liquids and sludges), or free liquids (i.e., those liquids found in pockets or containers within the waste pile) that contain HE materials or exceed the regulatory levels for toxicity characteristic (TC) metals (e.g., barium, chromium, lead) may be treated onsite or offsite at a permitted facility. On-site treatment of this waste may include stabilization on a batch basis for metals, such as barium, chromium, or lead. The batches of material will be approximately 100 yd^3. Treatment that may be conducted onsite will occur inside tanks meeting the requirements of 20 NMAC 4.1, Sections 264.192 through 264.199. This treatment will occur

in less than 90 days and is exempted from permit requirements as described in 20 NMAC 4.1. Section 262.34.

The depth of waste contaminant migration into the upper vadose zone is unknown. After the waste materials are removed and decontaminated, the underlying soil will be over-excavated. Field screening instruments will be used to detect barium in conjunction with the over-excavation. Some areas will be excavated to different depths than others. The approximate depth of this over-excavation is expected to be two feet. After completion of the over-excavation the Phase 2 sampling will be conducted. Based upon Phase 2 sampling, closure may be certified. or additional waste may be removed. If additional waste will be removed. an amendment to the closure plan will be submitted to NMED.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7440
Segregation Area
Evaporation Ponds
Trailer
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1616100
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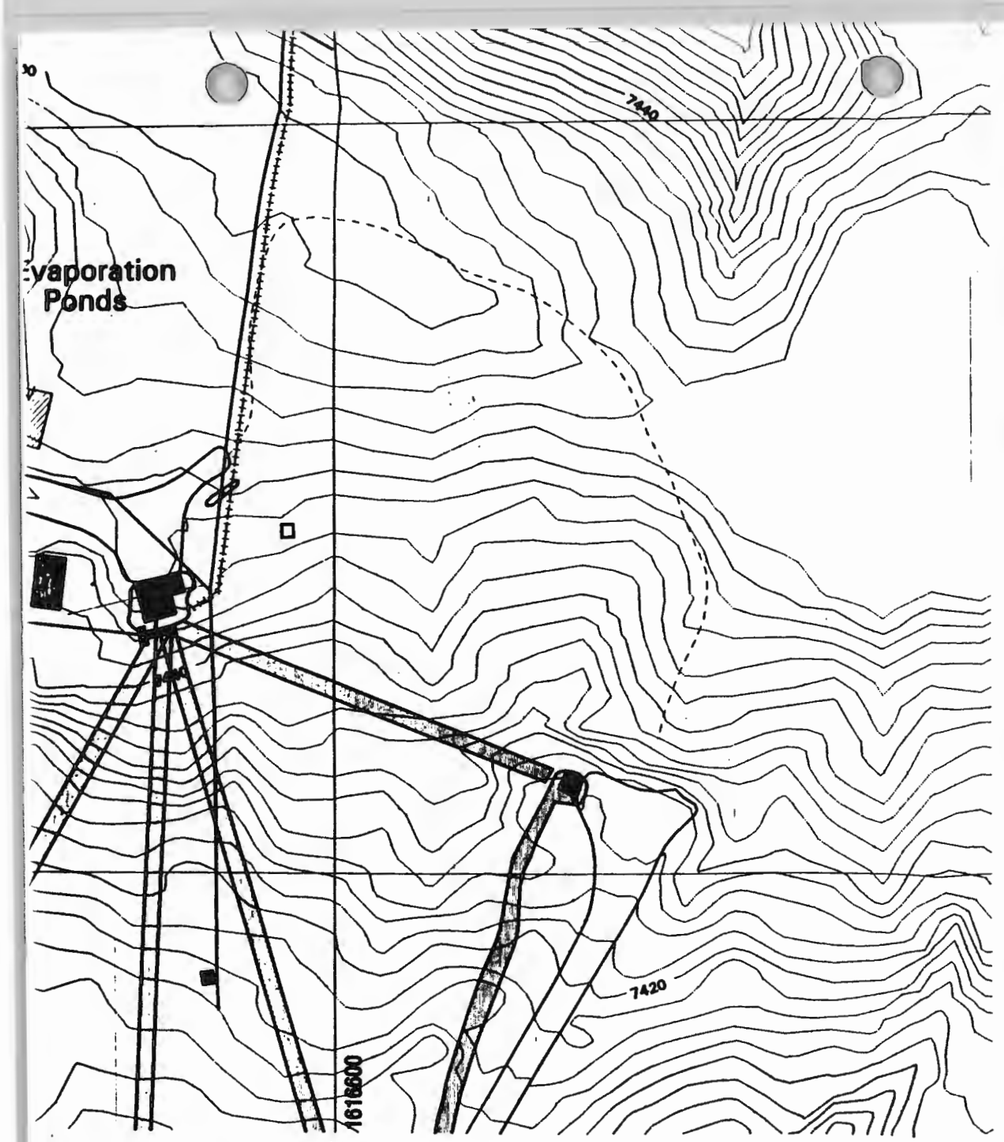


Permanent Structure

PRS, point location

MDA-P Project Boundary
Figure 1-1

N

State Plane Coordinate System, New Mexico Central Zone.
1983 North American Datum

Grid provides NM State Plane coordinates in feet.
Grid Interval, in feet: 500

0 30 60 90 120
METERS

0 100 200 300 400
FEET

NOTICE: The information on this map is provisional and the accuracy has not been confirmed. Feature locations are dependent on scale and symbology and should not be relied upon to establish legal claims. Basemap Sources: Boundary, structure and utility data are from Los Alamos National Laboratory Engineering Division and Los Alamos County Utility and Engineering Departments. Contour data is from Los Alamos National Laboratory Environmental Restoration Program aerial survey, September, 1991.

University of California

Los Alamos National Laboratory

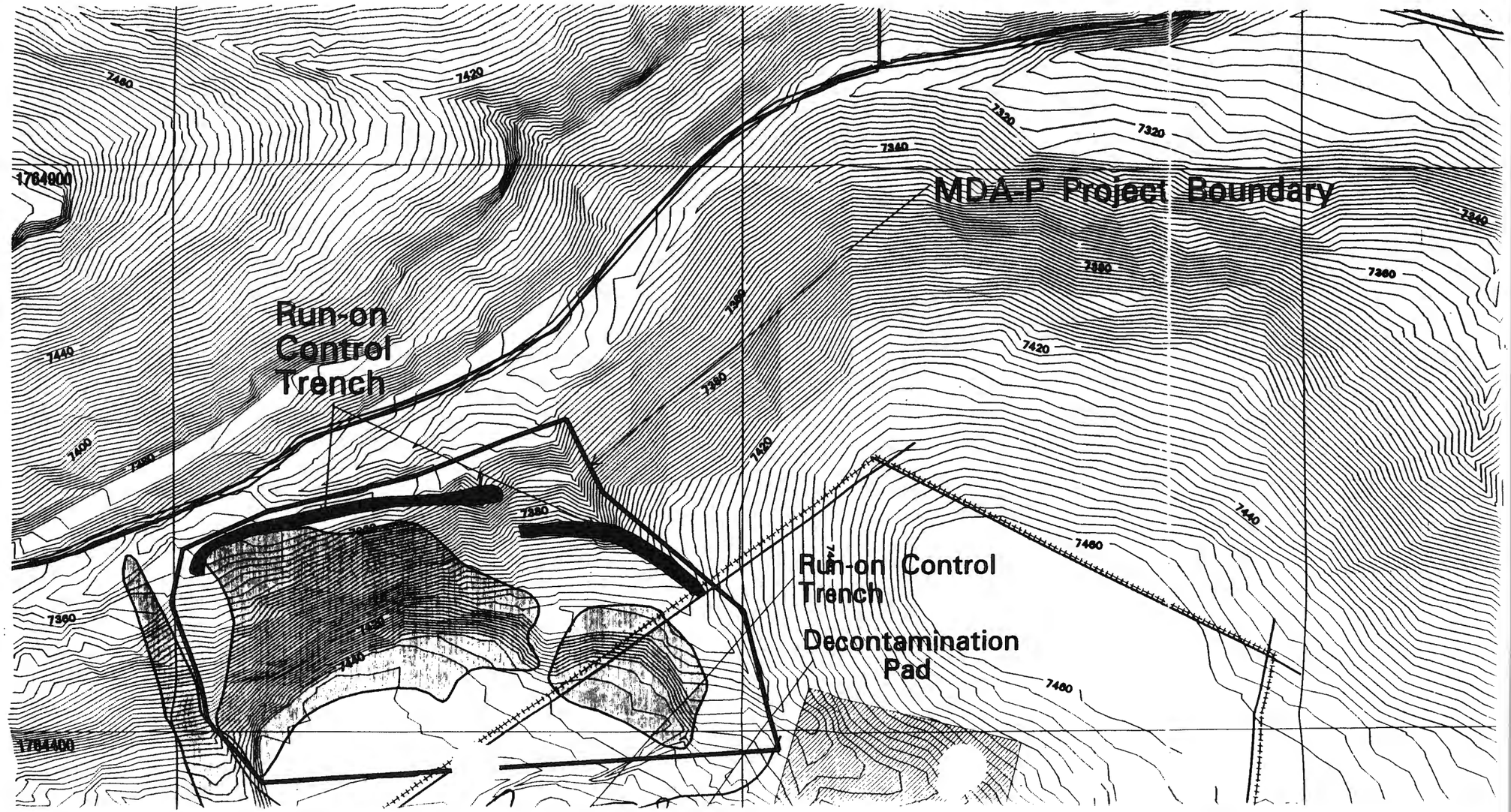
Earth & Environmental Sciences Division

FIMAD Facility for Information Management, Analysis and Display
FIMAD is the electronic data repository for the Environmental Restoration Program at Los Alamos National Laboratory.

Produced by: Marcia Jones

Date: February 01, 1995 FIMAD Plot ID: 102929

MDA-P PROJECT BOUNDARY



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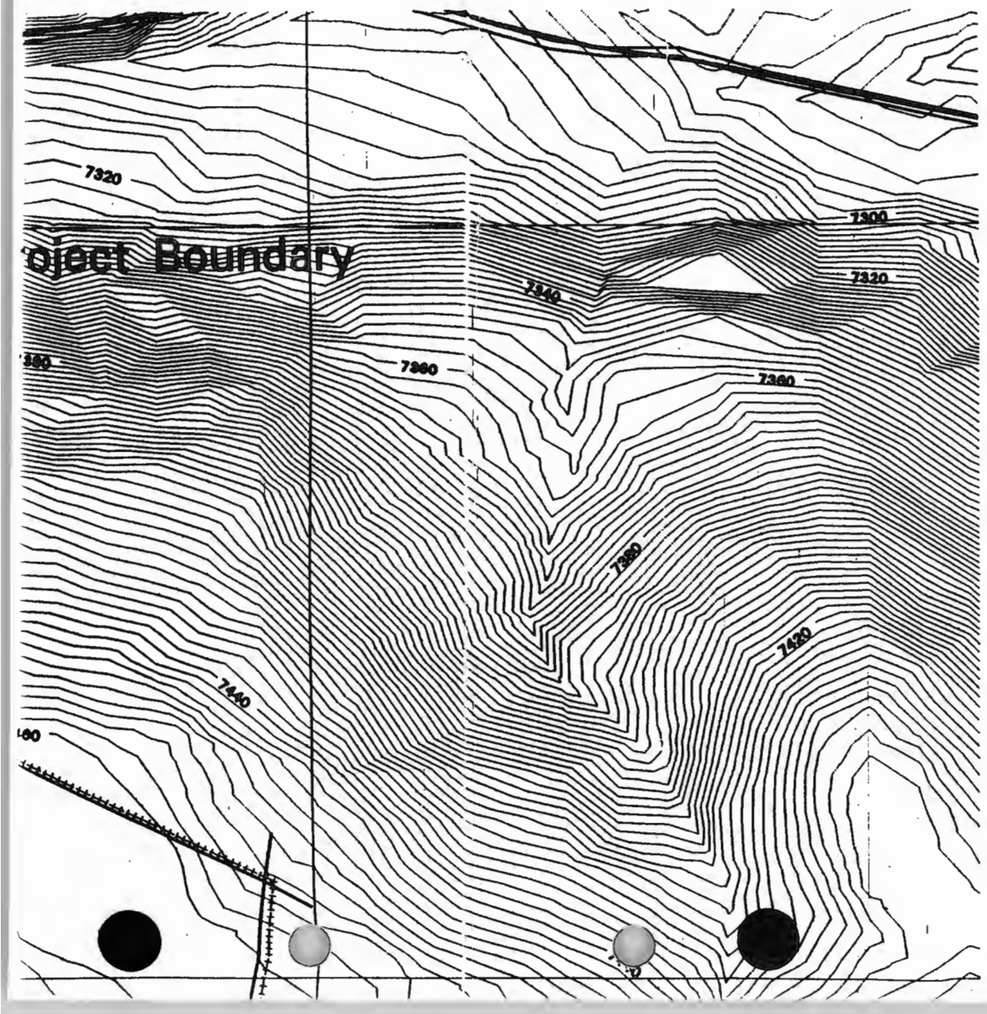


- Contours, 10 ft
- Contours, 2 ft
- Boundary, OU
- Boundary, TA
- Contours, 10 foot
- Contours, 100 foot
- Electrical >13.2 kV
- Electrical <13.2 kV
- Roads, Dirt
- Roads, Paved
- Road/Trail
- Telephone Line
- PRS
- Permanent Structure
- PRS, point location

2.0 FACILITY DESCRIPTION

2.1 General Description

The Laboratory is located in Los Alamos County in north-central New Mexico, approximately 60 miles (mi) north-northeast of Albuquerque and 25 mi northwest of Santa Fe (Figure 2-1). The Laboratory, which occupies an area of 43 mi^2, and the associated residential areas of Los Alamos and White Rock are situated on the Pajarito Plateau. The communities closest to the Laboratory are Los Alamos, just north of the Laboratory, and White Rock, east-southeast of the Laboratory (see Figure 2-1). The total population of Los Alamos County is approximately 19,000 (LANL 1993a).

The plateau consists of a series of fingerlike mesas separated by deep east-west-trending canyons; ephemeral streams lie at the bottoms of most of the canyons. The mesa tops range in elevation from approximately 7,800 ft at the flank of the Jemez Mountains (west of Los Alamos) to about 6,200 ft at their eastern termination above the Rio Grande Valley (LANL 1993a).

The Laboratory is divided into 51 TAs, 34 of which are developed (Figure 2-2). The MDA-P waste pile is located at TA-16. The main activities at TA-16 are HE production and development.

2.1.1 MDA - P Waste Pile

This section provides a description of the MDA-P waste pile. This description addresses design and construction, operation and maintenance, and erosion controls.

2.1.1.1 Design and Construction

MDA-P operated from the early 1950s until 1984 as a landfill for rubble and debris generated by the burning of HE, HE-contaminated equipment and material, barium nitrate sands, building materials, empty drums and bottles, and trash. These burning operations were conducted at burn pads adjacent to the waste pile. After burning material at the pad, the resulting debris would be pushed over the edge of the mesa. Gradually, this practice formed the existing waste pile.

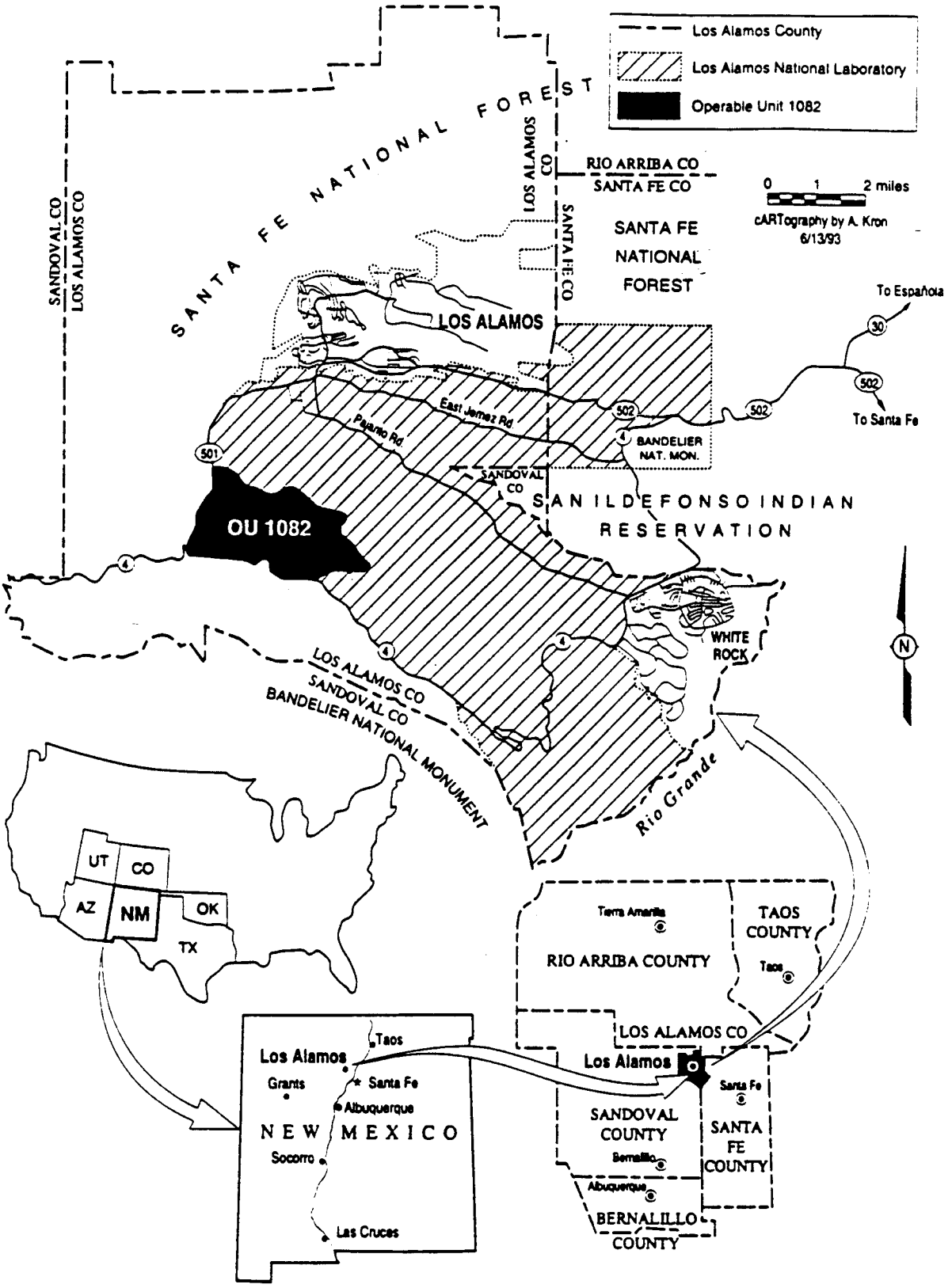


Figure 2-1. Regional map of Los Alamos National Laboratory

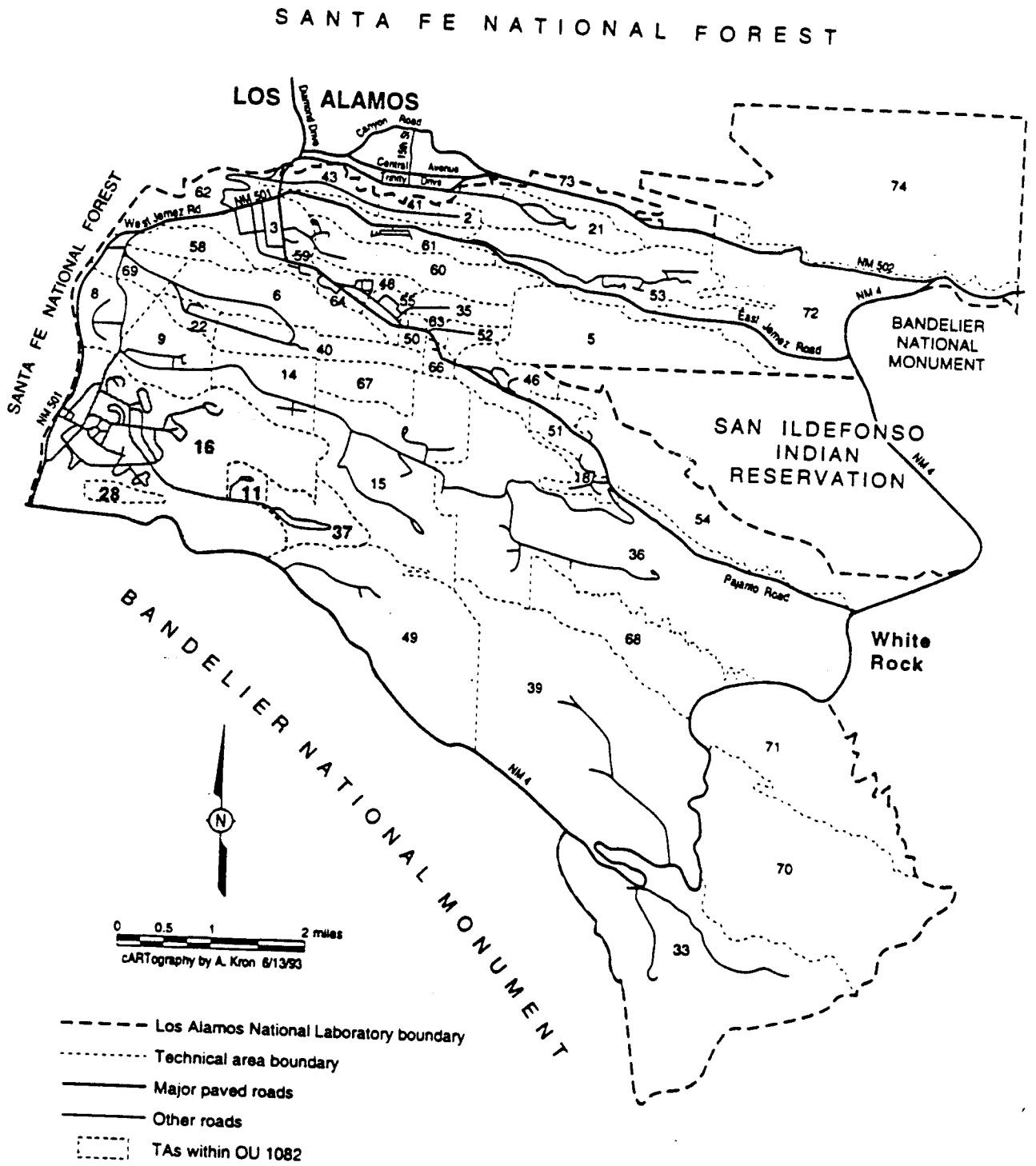


Figure 2-2. Los Alamos National Laboratory technical areas

The total surface area of MDA-P encompasses approximately 2 acres. The depth of the waste is approximately 12 to 14 ft.

The waste pile was not constructed or filled in a manner consistent with current RCRA landfill design. There is no liner or leachate collection under the waste pile. The pile was formed by pushing flashed and burned debris over the mesa edge. Eventually, a 6-ft earth cover was placed over the waste pile, and a surface run-on control trench made of asphalt was constructed upgradient of the waste pile. Appendix C contains photographs of material visible within the waste pile. This material includes concrete sumps, glass, empty containers, and steel (LANL 1993a).

2.1.1.2 Operation and Maintenance

MDA-P was operated as a disposal site for rubble and debris from the 1950s to approximately 1984. The majority of disposed materials consisted of residues and noncombustible debris resulting from burning HE, HE-contaminated equipment, building materials, empty drums and bottles, and trash. Before burning and disposal, HE-contaminated materials were disassembled and cleaned. The wastes and equipment were then taken to the sand-covered burn pads at TA-16 and flashed with combustible materials needed to support destruction by fire. After the burn, the sand and burned wastes were removed and disposed of over the edge of the slope that forms the south wall of Cañon de Valle.

The disposal site operation began at the western portion of the canyon rim, gradually progressing toward the east along the narrow mesa and forming two distinct waste lobes. The western area of the disposal site has been leveled and covered with crushed tuff and sandy clay soils from the surrounding area. However, wastes such as demolition rubble and pipe remain visible on parts of the north-slope face. The eastern area was covered with soil as waste deposition proceeded; however, some wastes remain exposed (LANL 1993a).

2.1.1.3 Erosion Controls and Storm-Water Controls

A surface run-on control trench was installed in 1994 as a mechanism for erosion control (Figure 2-3). This trench redirects rainwater and snowmelt around the waste pile. This trench also

serves to limit infiltration of water into the waste pile, allowing the waste to dry and limiting any potential migration. Over time, the slope has started to support native vegetation and small trees. These also serve as erosion control mechanisms.

The MDA-P Closure Project Manager will revise the TA-16 Storm Water Pollution Prevention Plan for closure activities at MDA-P. Responsibility for ensuring compliance with this revised plan rests with the Project Manager. Existing storm-water sampling will be continued during closure activities. Additional erosion control mechanisms will be installed during closure as discussed in Section 6.2.6.

2.1.2 Topographic Maps

A topographic map depicting the approximate boundaries of the waste pile is shown in Figure 2-4 (see pocket). Contour lines on this figure are at 2-ft intervals.

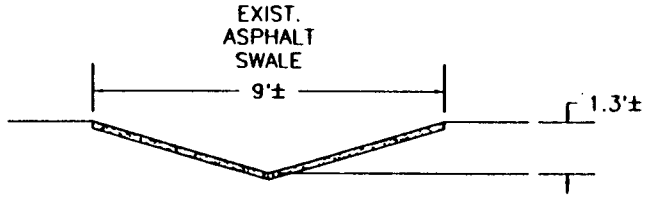
2.1.3 Land Use

Most of Los Alamos County and adjoining portions of neighboring Sandoval, Rio Arriba, and Santa Fe counties are undeveloped. The only significant developments in Los Alamos County are the Laboratory facilities and the associated residential communities.

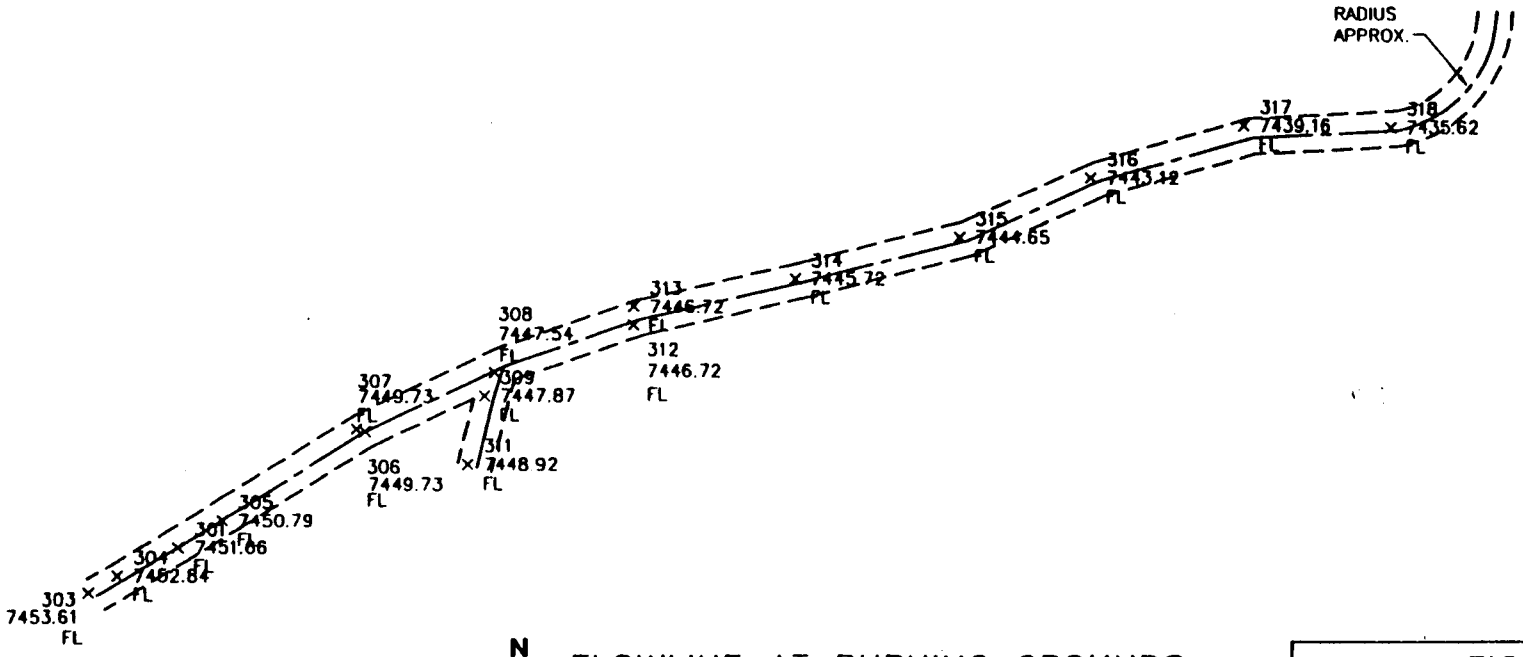
TA-16 continues to be an operating TA under the jurisdiction of Engineering Sciences and Application Division, although the Energetic Materials Division has operations in several buildings. Development and testing of explosive formulations, fabrication of explosive charges, and assembly of weapons test devices continues to the present.

2.2 Environmental Setting

The northwest corner of the MDA-P waste pile may be within the 100-year flood-plain boundary of the Cañon de Valle system. This waste pile is situated in the saddle of a short narrow mesa on the southern rim of Cañon de Valle and extends to the streambed at the bottom of the canyon (LANL 1993a).



TYPICAL CROSS-SECTION



N

FLOWLINE AT BURNING GROUNDS

SCALE: 1" = 50'

FIGURE 2-3

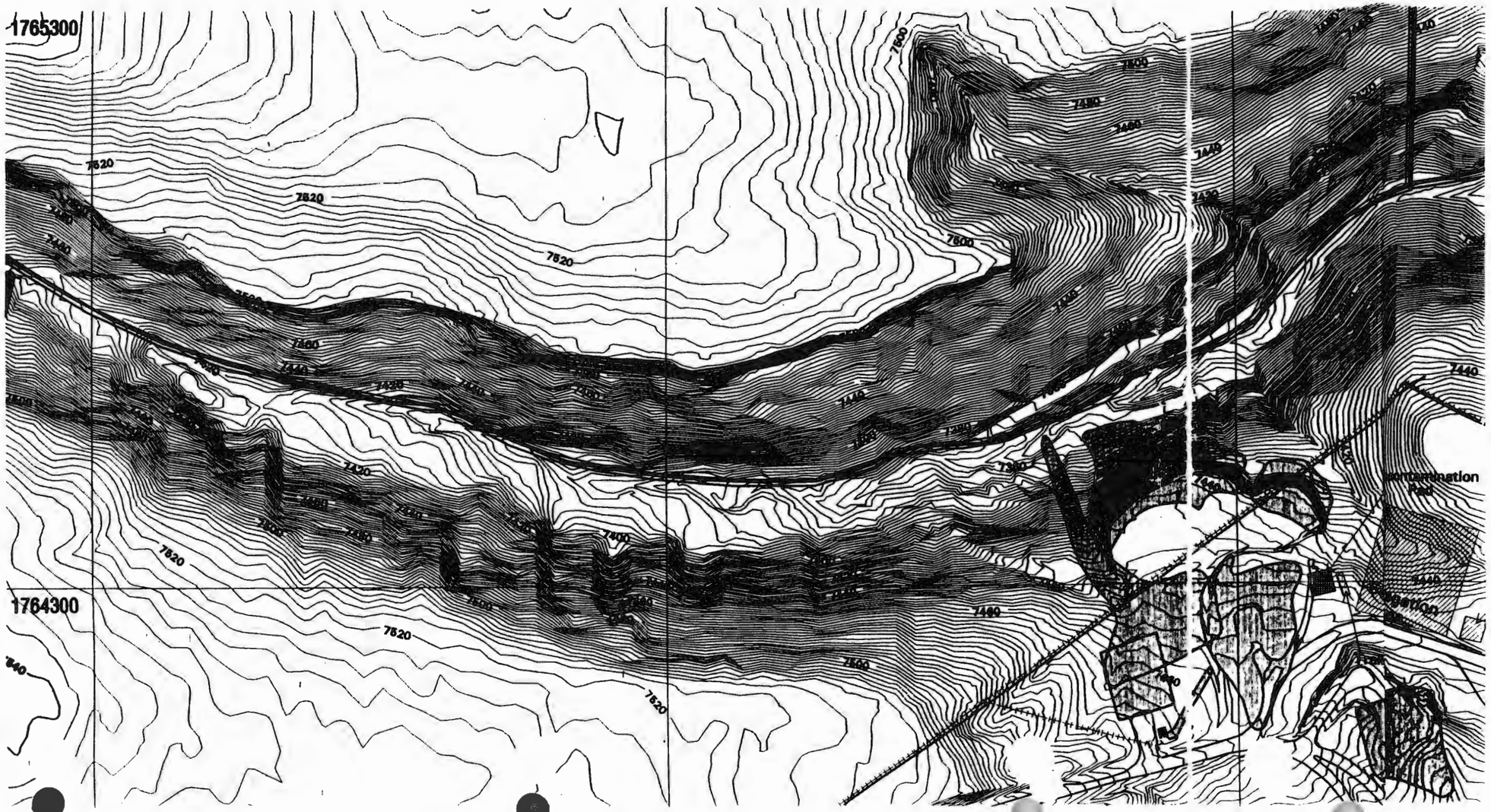
EXISTING SURFACE RUN-ON CONTROL TRENCH TYPICAL CROSS SECTION

Fig 2-3. Existing surface run-on trench and typical cross-section

The Laboratory is on the east-central edge of the Jemez Mountains. The Jemez Mountains are formed by a complex pile of volcanic rocks along the northwest margin of the Rio Grande Rift. The immense volume of Pliocene and Quaternary extrusive rocks that represents the Jemez volcanic field covers an area of more than 30 mi east-to-west and 50 mi north-to-south, and is 4,000 ft thick near the center (LANL 1993a).

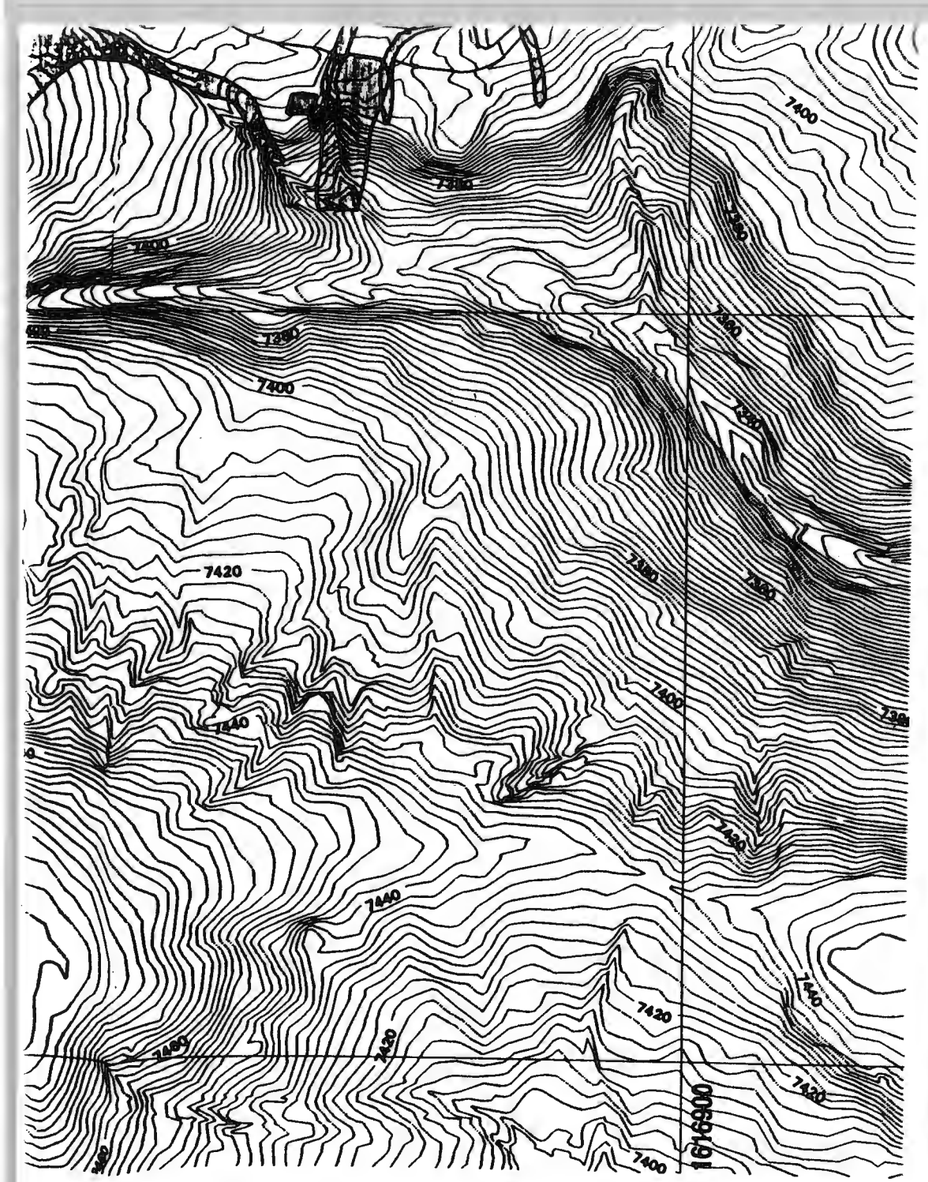
The only aquifer of the Pajarito Plateau capable of providing municipal and industrial water supply lies in rocks of the Santa Fe Group and Puye Formation. The potentiometric surface of the main aquifer at Area P is approximately 850 ft below the surface of the mesa (LANL 1993a).

MDA-P TOPOGRAHIC MAP AND SITE LA

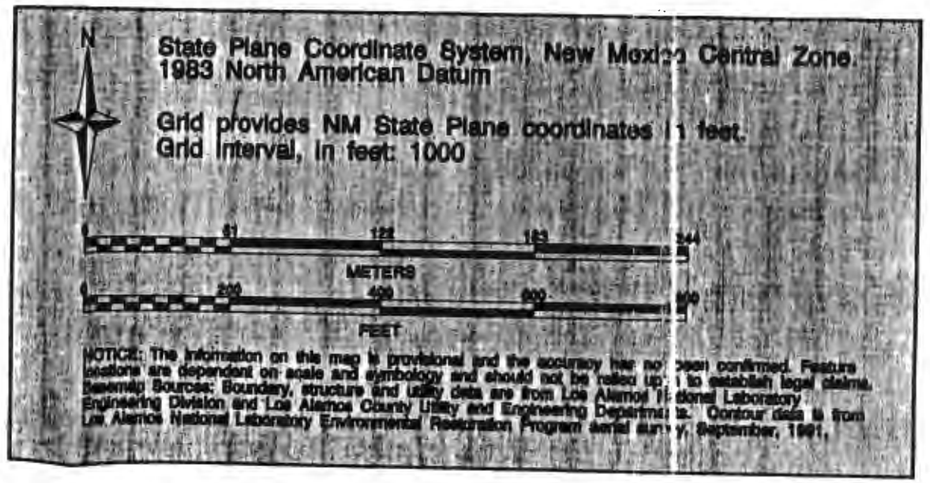


- Contours, 10 ft
- Contours, 2 ft
- Boundary, OU
- Boundary, TA
- Contours, 10 foot
- Contours, 100 foot
- Electrical >13.2 kV
- Electrical <13.2 kV
- Roads, Dirt
- Roads, Paved
- Road/Trail
- Telephone Line
- PRS
- Permanent Structure
- PRS, point location

Staging Area 3
1763300
7640
7620
7600
7580
7560
7540
7520
7500
7480
7460
7440
7420
7400



MDA-P Topographic Map and Site Layout Figure 2-4



University of California
Los Alamos National Laboratory
Earth & Environmental Sciences Division

FIMAD Facility for Information Management, Analysis and Display
FIMAD is the electronic data repository for the Environmental Restoration Program at Los Alamos National Laboratory.

Produced by: Marcia Jones
Date: February 01, 1995 FIMAD ID: 102928

3.0 EXISTING WASTE CHARACTERIZATION INFORMATION

The existing waste characterization information consists of previous chemical/physical analytical results and process knowledge derived from general information on waste-pile operations, S-Site operations, and information on explosives composition.

3.1 Previous Chemical/Physical Analytical Results

The MDA-P waste pile has been characterized during two major previous sampling efforts. The first sampling effort was conducted in 1988 and reported on in 1989 (Appendix D), the second in 1994 (Raw Sampling Data).

During the 1988 sampling effort, 13 boreholes were drilled through the waste pile and into the underlying tuff. The locations of the samples are shown in Figure 3-1. The following six boreholes were sampled for barium using the EPA extraction-procedure (EP) toxicity test: B-4, B-5, L-17, L-18, L-19, and L-20. The analytical results for barium are presented in Table 3-1. All of the elevated concentrations of barium were from samples collected from the eastern portion of the waste pile. Samples from the western portion of the waste pile exhibited barium concentration levels below the detection limit of 5 mg/L.

At borehole B-4, the EP toxicity concentration for barium was 14.8 mg/L at a depth of 19 ft, and at borehole L-17, the barium concentration was 8.8 mg/L at a depth of 16 ft. This represents at least 6 ft of barium penetration into the tuff at both boreholes. Note that at these depths, the barium concentrations did not exceed the regulatory EP toxicity level of 100 mg/L. In borehole B-4, the barium concentrations exceeded the regulatory level to a depth of 16 ft, which indicates that the upper 2 ft of the tuff contained barium above the EP toxicity level. In borehole L-17, the barium concentrations exceeded the regulatory level to a depth of 10 ft in the soil above the tuff. However, at this borehole it is possible that EP toxicity levels of barium were exceeded in the upper 1 ft of tuff because this interval was not sampled.

Five boreholes were sampled for total HE using acetonitrile for extraction. In addition, the samples were analyzed for the following specific HE components: HMX (cyclotetramethylenetetranitramine), RDX (cyclonitrite, cyclotrimethylenetrinitramine), TNT

(trinitrotoluene), and DNT (2-4 dinitrotoluene). Samples from boreholes B-2, B-4, L-17, L-18, and L-20 were collected in clay/sand/soils above the tuff. Elevated levels of total HE and specific HE components were found in samples collected from the eastern and western portions of the waste pile. RDX and TNT concentrations above SALs were found at depths ranging from 1 ft to 10 ft in boreholes B-4, L-17, and L-20.

A second sampling effort to characterize the area near the waste pile was conducted in 1994 (Raw Sampling Data). The locations of the samples are shown in Figure 3-1. The results of the soil samples are presented in Table 3-3. Note that some of the anlytical results are not available.

Surface soil samples were collected within and along the margin of the waste pile (R-1, R-2, R-3, R-4). Samples collected at locations R-1 and R-2 were collected from what appeared to be uncontaminated, undisturbed soil near the boundary of the waste pile. Samples collected at R-3 and R-4 were collected from a shallow gully within and downgradient of the waste pile.

The R-series samples were analyzed for total metals, HE, nitrates, gross alpha, gross beta, and gamma. HE and nitrates were detected in the R-series samples; gross alpha, gross beta, and gamma were not detected. Barium, copper, mercury, and zinc were present in the R-series samples above the Laboratory-wide background UTLs (see Table 3-3). Barium was present in the R-3 and R-4 samples at concentrations above the SAL for soils. The rest of the metal constituents were within the range of the Laboratory-wide background UTLs.

Surface soil samples were collected at three background locations (BKG-1, BKG-2, BKG-3), which were located away from the waste pile in areas that were believed to be representative of background. After further examination, soil from sample location BKG-1 appears to be representative of background, but sample locations BKG-2 and BKG-3 are located downwind from the burning grounds and may not be representative of true background.

The BKG-series samples were analyzed for semivolatile organic compounds (SVOC), total metals, HE, nitrates, gross alpha, gross beta, and gamma. Nitrates were detected in the BKG-series samples. However, SVOCs, gross alpha, gross beta, and gamma were not detected. All metal constituents were within the range of the Laboratory-wide background UTLs.

Table 3-1
MDA-P Borehole Sampling 1988
Barium Concentrations (McLin 1989)

Depth (ft)	Borehole Number					
	B-4	B-5	L-17	L-18	L-19	L-20
1	686.5		2486.4	18114.4	<5.0	<5.0
2		<5.0	13206.9		<5.0	
3	4169.7			12.3		
4			16803.3	11		
5					<5.0	
6		<5.0		7.5		
7	11300					
8				<5.0		<5.0
9			3014.8	<5.0		
10			2048.5		<5.0	<5.0
11	1839.5			<5.0		
12		<5.0	6.5			
13				<5.0		<5.0
14		<5.0	17.8	<5.0		
15			9			<5.0
16	229.3		8.8	<5.0		
17	23.4					
18	20.7			<5.0		
19	14.8					
20						
21						
22						
23						<5.0
24						
25						<5.0
26						<5.0
27						
28						<5.0
29						<5.0
30						

Notes: (a) EP toxic concentrations reported in mg/L
(b) Shaded area indicates tuff
(c) Refer to Appendix D for further detail

Table 3-2
Material Disposal Area P Borehole Sampling 1988
Residual High Explosives Content

Borehole Number	Depth (ft)	High Explosives (Total)* (soluble wt %)	HMX (ppm)	RDX (ppm)	TNT (ppm)	DNT (ppm)
B-2	2	0.11	0	0	0	0
B-2	2	0.12	0	0	0	0
B-4	3	1.68	730	343	7869	0
B-4	3	1.24	1010	292	7115	0
B-4	7	0.21	585	13	26	0
B-4	7	0.18	370	4	12	0
L-17	1	0.27	1201	32	0	0
L-17	1	0.27	1301	139	1	0
L-17	2	0.95	2551	2206	0	0
L-17	2	1.00	2582	2138	0	0
L-17	4	0.77	821	4133	594	0
L-17	4	0.78	1099	4132	557	0
L-17	9	0.70	164	1195	211	0
L-17	9	0.83	146	983	406	0
L-17	10	0.58	220	2639	1497	0
L-17	10	0.53	270	2655	1275	0
L-18	3	0.06	14	3	17	0
L-18	3	0.08	0	0	54	0
L-18	4	0.08	22	2	4	0
L-18	4	0.04	22	1	0	0
L-18	6	0.10	0	2	0	0
L-18	6	0.07	5	0	7	0
L-20	6	0.18	21	50	27	0
L-20	6	0.05	0	0	0	0

*Extracted with acetonitrile

(a) Concentrations reported in ppm
(b) Samples collected in clay/sand/soil
(c) Refer to Appendix B for further detail

Table 3-3
Material Disposal Area P Sampling Results, April 1994[1]

SOIL (mg/kg)									
Constituent	SAL soil (mg/kg)	UTL soil	Sample Location						
			R-1	R-2	R-3	R-4	BKG-1	BKG-2	BKG-3
Ag	400	n/a		2.1		6.8		3.5	
Al	n/a	58900	7800	6200	5400	8900	8000	8500	6900
As	n/a	11.6	3.5	2.4	1.9	3.8	3.1	3.3	2.9
Ba	5600	1140	1100	630	**7800**	**38000**	110	410	940
Be	n/a	331	0.59	0.47	0.34	0.36	0.56	0.56	0.45
Ca	n/a	54400	5700	3200	1400	2200	2200	2300	1500
Cd	80	2.7	0.51		0.52	1.2			
Co	n/a	51.1	4.3	3.3	2.3		6.9	6.7	4.1
Cr	[2]	34.2	9.4	4.6	8.7	26	7.4	7.2	5.5
Cu	3000	15.7	31	5.4	***68***	***200***	4.4	4.6	6.2
Fe	n/a	35600	8400	7800	8700	15000	n/a	7600	9300
Hg	24	.1			***0.13***	0.08			
K	n/a	6180	1300	1100	800	1000	1600	1300	1200
Mg	n/a	16100	1200	1100	1400	1100	1800	1400	1200
Mn	11000	1030	270	390	250	300	290	290	280
Na	n/a	1800	150	180	150	350	140	140	290
Ni	1600	26.7	3.1	2.2	5.2	8.3	4.1	5	3.3
Pb	400	39	37	11	37	36	18	21	19
Sb	32	2.5			0.4				
Se	400	1.7				0.7			
Tl	6.4	.9				.3			
V	560	66	11	8.3	9.5	11	15	12	8.6
Zn	24000	101	49	30	81	***320***	21	25	37
Nitrates (NO_3)	n/a	n/a		3	11	5	29	22	22
∝, ß, γ	n/a	n/a							
HMX	4000	n/a	8.8		13.5	n/a	n/a	n/a	n/a
SVOCs[3]	n/a	n/a	NS	NS	NS	NS			
VOCs[3]	n/a	n/a	NS	NS	NS	NS	NS	NS	NS

(1) Compiled from raw, unvalidated data, data has not been validated
(2) SAL for Cr-III is 80,000 mg/kg and for Cr-VIII is 400 mg/kg
(3) Unpublished data from FIMAD

Shaded cell indicates constituent below level of detection
n/a = not available
Levels above SAL in **boldface**
Levels above UTL in ***bold italics***
NS = No Sampling

Table 3-3 (continued)
Material Disposal Area P Sampling Results, April 1994[1]

WATER-UNFILTERED (µg/l)							
Constituent	**SAL water (µg/l)**	**Sample Location**					
		S-1	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**
Ag	170						
Al	n/a	310	560	740	370	180	
As	50						
Ba	2000	**3000**	**3000**	**3100**	**3400**	**3400**	**3300**
Be	4						
Ca	n/a	19000	19000	19000	18000	18000	17000
Cd	5						
Co	n/a						
Cr	n/a						
Cu	1300						
Fe	n/a		340	350	310		
Hg	2						
K	n/a	3000	3100	2500	2700	2800	2500
Mg	n/a	5600	5500	5500	5300	5200	5100
Mn	180						
Na	n/a	21000	20000	20000	20000	20000	20000
Ni	100						
Pb	50						
Sb	6						3
Se	50			3			
Tl	2						
V	240				5		
Zn	10000						
Nitrates (NO_3)	n/a	100	120				
∝, ß, γ	n/a						
RDX	3.2	**180**	**152**	**196**	**133**	**146**	**162**
SVOCs[3]	n/a						
VOCs[3]	n/a						

(1) Compiled from raw, unvalidated data, data has not been validated
(2) SAL for Cr-III is 80,000 mg/kg and for Cr-VIII is 400 mg/kg
(3) Unpublished data from FIMAD

Shaded cell indicates constituent below level of detection
n/a = not available
Levels above SAL in **boldface**
Levels above UTL in ***bold italics***
NS = No Sampling

Table 3-3 (continued)
Material Disposal Area P Sampling Results, April 1994[1]

SEDIMENT (mg/kg)								
Constituent	SAL soil (mg/kg)	UTL soil	Sample Location					
			S-1	S-2	S-3	S-4	S-5	S-6
Ag	400	n/a						
Al	n/a	58900	6300	12000	4700	6400	9400	4800
As	n/a	11.6	3	n/a	3.1	3	3	2
Ba	5600	1140	***3000***	***4300***	***2300***	850	***1900***	1000
Be	n/a	331	0.6	0.99	0.45	0.62	0.65	0.36
Ca	n/a	54400	1900	4200	1600	1700	2400	1100
Cd	80	2.7			0.51			
Co	n/a	51.1	5.8	6.3	2.6	4.1	8.1	2.7
Cr	[2]	34.2	5.5	12	4.7	5.2	7.6	4.3
Cu	3000	15.7	11	**20**	11	3.9	16	11
Fe	n/a	35600	8200	10000	6900	8800	10000	7000
Hg	24	0.1		***0.14***	***0.22***			
K	n/a	6180	680	1300	540	1100	1100	660
Mg	n/a	16100	950	1900	710	1300	1300	800
Mn	11000	1030	200	230	230	310	***1600***	380
Na	n/a	1800	160	230	120	260	300	230
Ni	1600	26.7	9.6	18	7.9	3.4	11	
Pb	400	39	19	24	20	15	21	18
Sb	32	2.5						
Se	400	1.7	0.6	***3***			0.8	
Tl	6.4	0.9		0.3				
V	560	66	13	21	11	9.5	15	8.5
Zn	24000	101	25	46	27	29	77	39
Nitrates (NO_3)	n/a	n/a	0.6	1.2		0.6	0.66	3
α, β, γ	n/a	n/a						
TNT	40	n/a			1.8			
SVOCs[3]	n/a	n/a						
VOCs[3]	n/a	n/a						

(1) Compiled from raw, unvalidated data, data has not been validated
(2) SAL for Cr-III is 80,000 mg/kg and for Cr-VIII is 400 mg/kg
(3) Unpublisned data from FIMAD

Shaded cell indicates constituent below level of detection
n/a = not available
Levels above SAL in **boldface**
Levels above UTL in ***bold italics***
NS = No Sampling

Sediment and unfiltered water samples were collected at locations within the stream channel in the bottom of Cañon de Valle (S-1, S-2, S-3, S-4, S-5, and S-6). Sample locations S-1, S-2, and S-3 were upstream of the waste pile and represent unaffected locations. Sample locations S-4, S-5, and S-6 were below and downstream of the waste pile and represent potentially affected locations.

The sediment and unfiltered water samples were analyzed for volatile organic compounds (VOC), SVOCs, total metals, HE, nitrates, gross alpha, gross beta, and gamma. HE and nitrates were detected in the water and sediment. However, VOCs, SVOCs, gross alpha, gross beta, and gamma were not detected in the sediment or water samples. Barium and copper were detected in the sediment samples above the Laboratory-wide background UTL both upstream and downstream of the waste pile. Mercury and selenium were detected in the sediment above the Laboratory-wide background UTLs upstream of the waste pile. Manganese was detected in the sediment above the Laboratory-wide background UTL downstream of the waste pile. Barium and RDX were detected in the unfiltered water samples above the SALs for water both upstream and downstream of the waste pile. Silver and copper were detected in the water upstream of the waste pile above the Laboratory-wide background UTLs. Data are not sufficient to determine the portion of contamination that may have come from Area P, but they do demonstrate conclusively the presence of some other source upstream from Area P.

The analytical results show that wastes containing HE and barium were disposed of in the waste pile. These constituents are expected to be present in the waste because they have been previously detected in the waste pile or downgradient from the waste pile.

3.2 Process Knowledge

3.2.1 General Waste-Pile Operations Information

The MDA-P was the main disposal site for nonradioactive waste generated at S-Site. S-Site included TA-11, TA-13, TA-16, TA-24, TA-25, TA-28, TA-29, and TA-37. According to site personnel, Laboratory administrative procedures did not allow waste generated at S-Site to leave the site. The only exception to this was radioactively contaminated waste such as depleted uranium (DU) waste, which was transported off S-Site and disposed of elsewhere. After TA-54

became the official disposal site for the Laboratory, nonradioactive waste was allowed to leave S-Site after it was burned or flashed.

The Laboratory required that records be kept of all waste transported to S-Site from other Laboratory sites to ensure that wastes burned at the burn site and/or disposed of at the waste pile were compatible with the HE residue. The Laboratory also required that records be kept of the types of wastes that were burned at the burn site at MDA-P. The available records are included as Appendix E.

The available MDA-P waste-pile disposal records indicate that the following wastes were disposed of at the waste pile: wastes that were burned at the burn site, building debris, and noncombustible material. The building debris wastes may have contained asbestos. If the waste was HE-contaminated and considered potentially explosive, it was burned before disposal in the waste pile. The vast majority of wastes disposed of at MDA-P were flashed prior to disposal.

According to the available burn site records, the following wastes were burned at the burn site: HE, solvents, DU, and miscellaneous HE-contaminated waste (e.g., barium-nitrate sands, filter baskets, trucks). The records indicate that gasoline and kerosene were commonly used to burn the waste. According to site personnel who operated the site from the 1950s until the early 1980s, all solvents wastes were burned, and the resulting noncombustible debris was placed in the waste pile.

Based on the available burn site records, DU was burned at the burn site and then disposed of at another location. According to site personnel, no DU was known to have been placed in the waste pile. The records do not indicate the types of solvents that were burned.

Based on the available waste-pile disposal records and burn site records, the wastes expected to be in the waste pile include HE residues, barium, residues from the burning of solvents, and asbestos. However, it is possible that wastes containing liquid solvents, or DU were disposed of in the waste pile.

3.2.2 General S-Site Information

The S-Site operations records indicate that site processes included HE pressing, assembly, casting, coating, and machining. In addition, other processes included metal plating, photoprocessing, and cleaning parts and machinery with solvents.

HE constituents and residues are expected to be in the waste pile, but RCRA K-listed explosive wastes are not likely to be present. Because the explosive nature of all HE-contaminated wastes was eliminated prior to disposal, K044 and K045 wastes are not expected to be present in the waste pile.

It is possible that RCRA-listed plating wastes (F006-F012) were generated at the S-Site, but it is not likely that these wastes were disposed of at the waste pile. Records indicate that the plating shops discharged plating wastes via outfalls. Plating wastes typically include cadmium, chromium, hexavalent chromium, cyanide, lead, and nickel. These wastes could be classified as the following RCRA characteristic wastes if the concentrations exceed the TC regulatory levels: cadmium (D006), chromium (D007), and lead (D008).

Even though photoprocessing wastes were generated at the S-Site, it is not likely that they were disposed of at the waste pile. Records indicate that photoprocessing wastes were discharged from buildings via outfalls. Photoprocessing wastes typically include silver, which could be classified as the RCRA characteristic waste D011 if the concentration exceeds the TC regulatory level. In addition, these wastes commonly included cyanide.

S-Site operations records indicate that the following solvents were supplied to the S-Site buildings: Met-L-it™, freon-PCA solvent, dimethyl sulfoxide, acetone, chlorothene (also known as 1,1,1-trichloroethane), methylene chloride, n-butyl acetate, chloroform, 1,2-dichloroethane, dimethylformamide, isopropyl alcohol, n-octane, 1,1,2,2-tetrachloroethane, ethyl acetate, methanol, methyl ethyl ketone, toluene, trichloroethylene, kerosene, ethylene glycol, carbon tetrachloride, chlorobenzene, n-hexane, methylcyclohexane, ethanol, petroleum distillate. Based on this information, it is likely that RCRA F-listed solvents (F001, F002, F003, and F005) may have been used at the S-Site, but it is not likely that they were disposed of unburned at the waste pile. Records indicate that solvents were discharged via outfalls or burned at the burn site.

3.2.3 General Information on Explosives Composition

Detailed information regarding the composition of explosives produced at the Laboratory is presented in Appendix F. This appendix includes a detailed description of the types of explosives used at the Laboratory, a description of the potential constituents typically associated with explosive formulations and open burn/open detonation areas, and detailed lists of products of environmental degradation and constituents that may potentially be detected in the environment at these areas. The following information was taken from Appendix F.

Explosives used at the Laboratory may be divided into three classes: 1) primary or initiating, 2) boostering, and 3) secondary (bursting charge), or HE.

Primary explosives are extremely sensitive to friction, heat, and impact, and some are sensitive to an electrical discharge. When exposed to flame, these explosives can be expected to detonate without burning. Examples of primary explosives are lead azide and lead styphnate.

Boostering explosives are associated with exploding bridge-wire detonators. Boostering explosives are less sensitive to explosion initiators than primary explosives but may be set off by heat, friction, or impact. These explosives may detonate when burned in large quantities. Examples of boostering explosives include HMX, PETN (pentaerythritol tetranitrate), RDX, and tetryl (trinitrophenyl methylnitramine).

Secondary, or HE, requires more energy for initiation than either primary or boostering explosives. All HE will detonate if it receives a strong shock from an impact or from a boostering explosive. Unless, confined, secondary explosives will burn without detonating. Examples of HE include baratol, the cyclotols, TNT, several plastic-bonded explosives, and extrudable explosives. The type of bonding materials used in these explosives include plasticizers (e.g., dioctyl phthalate, di[2-ethylhexyl]sebacate), polystyrenes, and waxes. HE components include HMX, RDX, TNT, PETN, and tetryl. A common TNT byproduct is 2-4 dinitrotoluene, which is a RCRA TC constituent. See Appendix F for a full listing of HE components and details regarding the chemical composition of HE.

Certain metals typically used in processing operations and in assembly and storage areas may be co-constituents of the parent explosive or may have been used to make up the device that housed the explosive. These metals include barium, beryllium, copper, DU, iron, lead, and zinc. Lead was also typically used to line troughs for HE manufacturing and as shielding. Asbestos is associated with certain explosives, and cyanide is a degradation product of cyanuric acid, which is used in mock explosives. According to site personnel, mercury was not used in explosives, but it was associated with explosives manufacturing, as it was used for density determinations and in vacuum pumps.

Polycyclic aromatic hydrocarbon (PAH) constituents can result from the product of incomplete detonation or combustion of explosives that contain motor or fuel oil, or they may be the product of incomplete detonation or combustion of fuels used to ignite the explosives. Typical PAHs constituents include acenaphthylene, anthracene, fluorene, phenanthrene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene.

Based on the explosive composition information, the following constituents are expected to be present in the waste pile: HE residues, barium, beryllium, copper, cyanide, iron, lead, zinc, asbestos, and PAH constituents and plasticizers. DU is not anticipated because radioactively contaminated HE should not have been disposed of at the waste pile.

3.3 Potential Constituents in the Waste

Based on process knowledge and previous sampling and analysis results, the waste may potentially include the constituents identified in Table 3-4.

Table 3-4
Potential Constituents in the Waste at MDA-P Waste Pile

Potential Constituents	Potential RCRA Waste Codes
Asbestos	Not Applicable
Cyanide[a]	Not Applicable
Depleted Uranium	Not Applicable
2-4 Dinitrotoluene[a][b]	D030
Explosive Residues[b]	D003, K044
Explosive Waste[b] (exhibits the characteristic of reactivity)	D003, K044
Metals (TCLP):	
Barium	D005
Cadmium	D006
Chromium	D007
Lead	D008
Mercury	D009
Silver	D011
Metals (Other):	
Beryllium[a]	Not Applicable
Copper	Not Applicable
Iron	Not Applicable
Nickel	Not Applicable
Zinc	Not Applicable
PAH Constituents[a][c]	Not Applicable
Solvent Constituents[d]	F001, F002, F003, F005
Plasticizers[a][e]	Not Applicable

(a) - U- and P-listed wastes are not expected to be present in the waste, unless a can containing a U- or P-listed waste is found in the waste pile. Based on process knowledge, waste containing PAHs, beryllium, 2-4 dinitrotoluene, mercury, plasticizers, or cyanide will not be considered P- or U-listed waste. The PAHs will be assumed to be the product of incomplete detonation or combustion of explosives that contain motor or fuel oil or the product of incomplete detonation or combustion of fuels used to ignite the explosives. Beryllium will be assumed to be a co-constituent of the parent explosive or a part of the device that housed the explosive, as described in Section 3.1. The constituent 2-4 dinitrotoluene will be assumed to be an explosive residue. Mercury will be assumed to be waste associated with vacuum pump cleaning and density determinations. Plasticizers will be assumed to be a co-constituent of explosives. Cyanide will be assumed to be a degradation product of explosives.

(b) - Explosive residue constituents include the following: 2-4 Dinitrotoluene, HMX, RDX, TNT. Because the HE was burned before disposal, D003 and K044 waste is not expected to be present. If the waste exhibits the characteristic of reactivity due to explosivity, it will be classified as D003 and K044 waste.

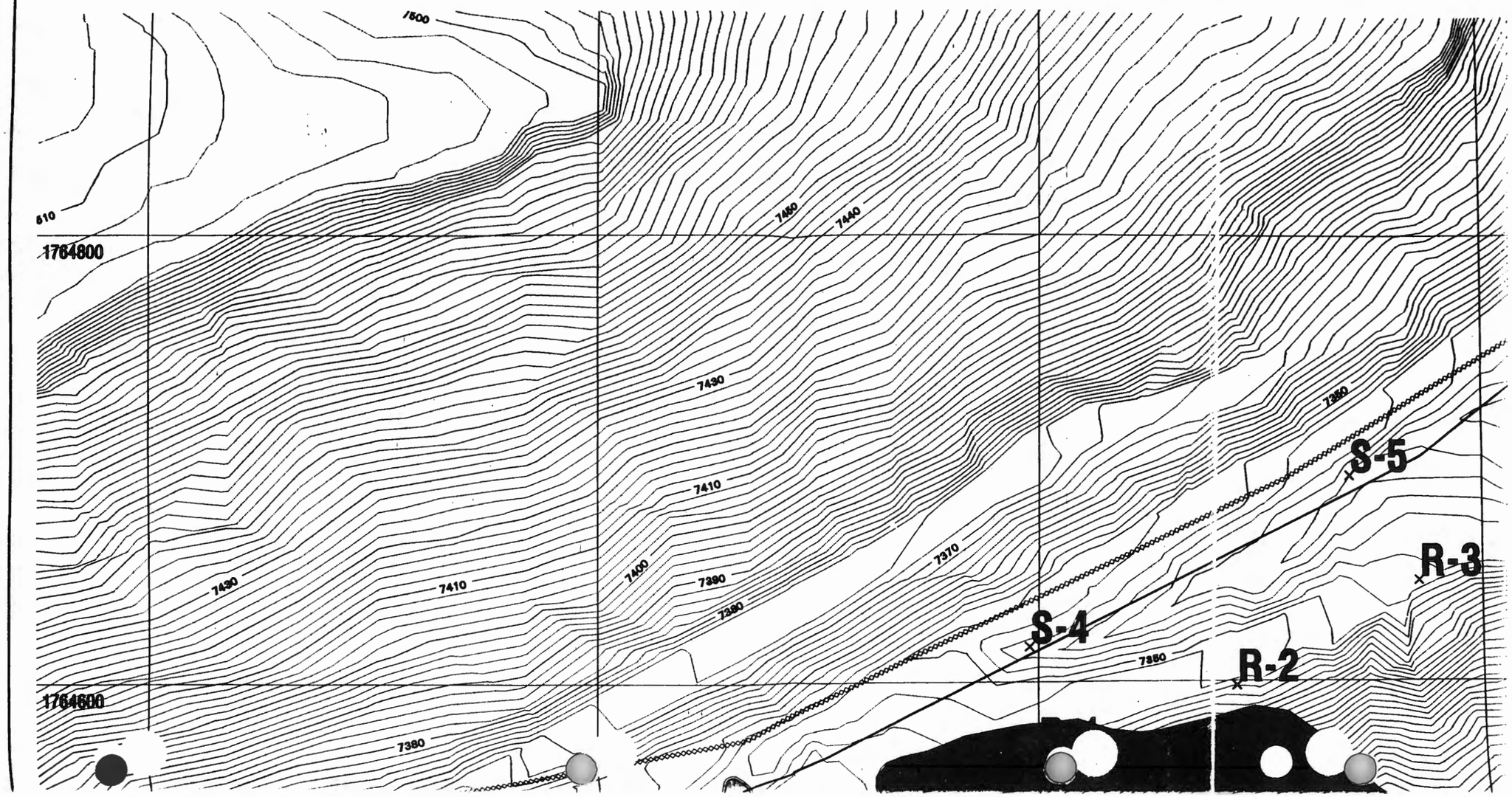
(c) - PAH constituents include the following: acenaphthylene, anthracene, fluorene, phenanthrene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene).

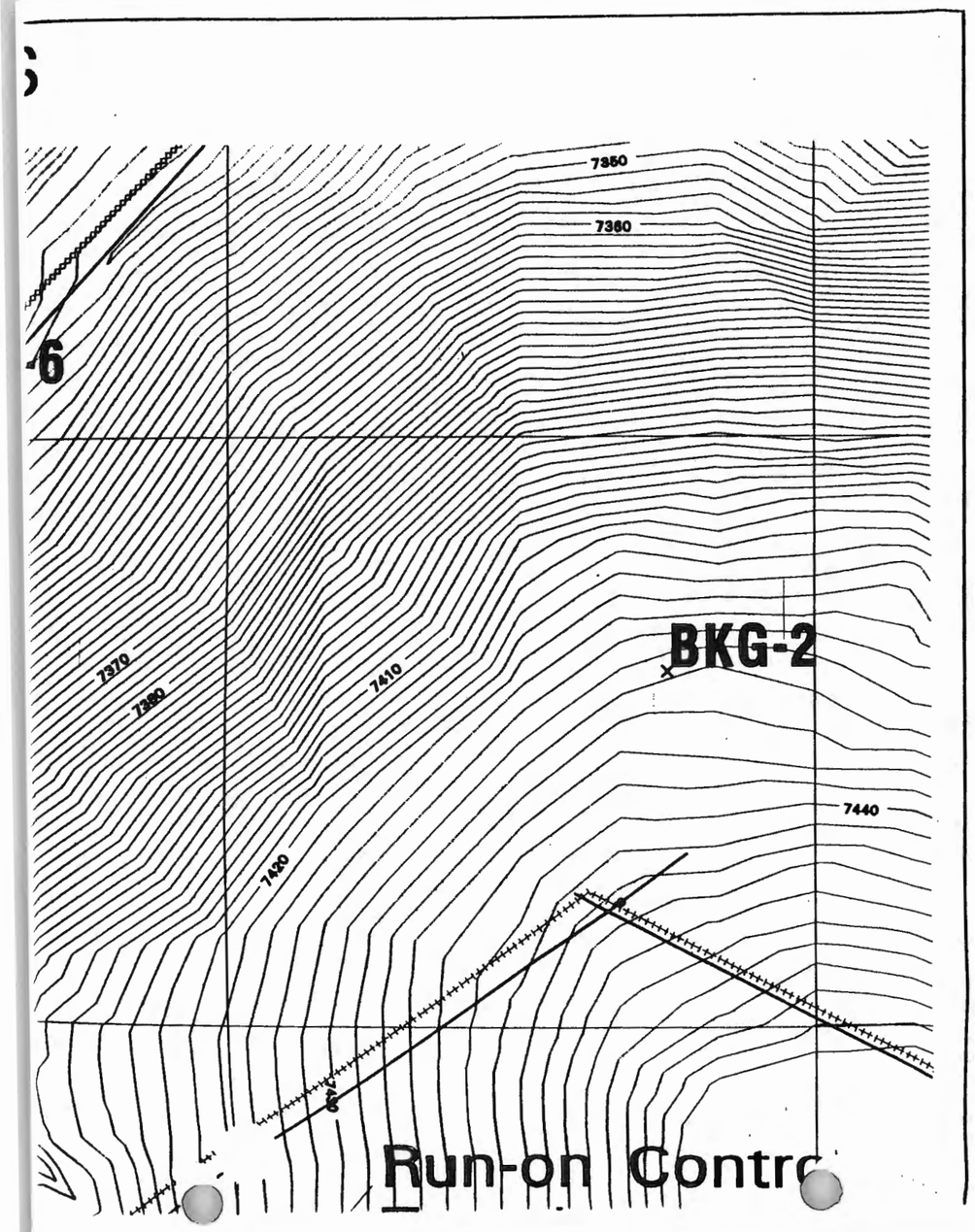
(d) - Solvent constituents include the following: Met-l-it™, freon-PCA solvent, dimethyl sulfoxide, acetone, chlorothene (also known as 1,1,1-trichloroethane), methylene chloride, n-butyl acetate, chloroform, 1,2-dichloroethane, dimethylformamide, isopropyl alcohol, n-octane, 1,1,2,2-tetrachloroethane, ethyl acetate, methanol, methyl ethyl ketone, toluene, trichloroethylene, kerosene, ethylene glycol, carbon tetrachloride, chlorobenzene, n-hexane, methylcyclohexane, ethanol, petroleum distillate.

(e) - Plasticizers include dioctyl phthalate and di[2-ethylhexyl]sebacate.

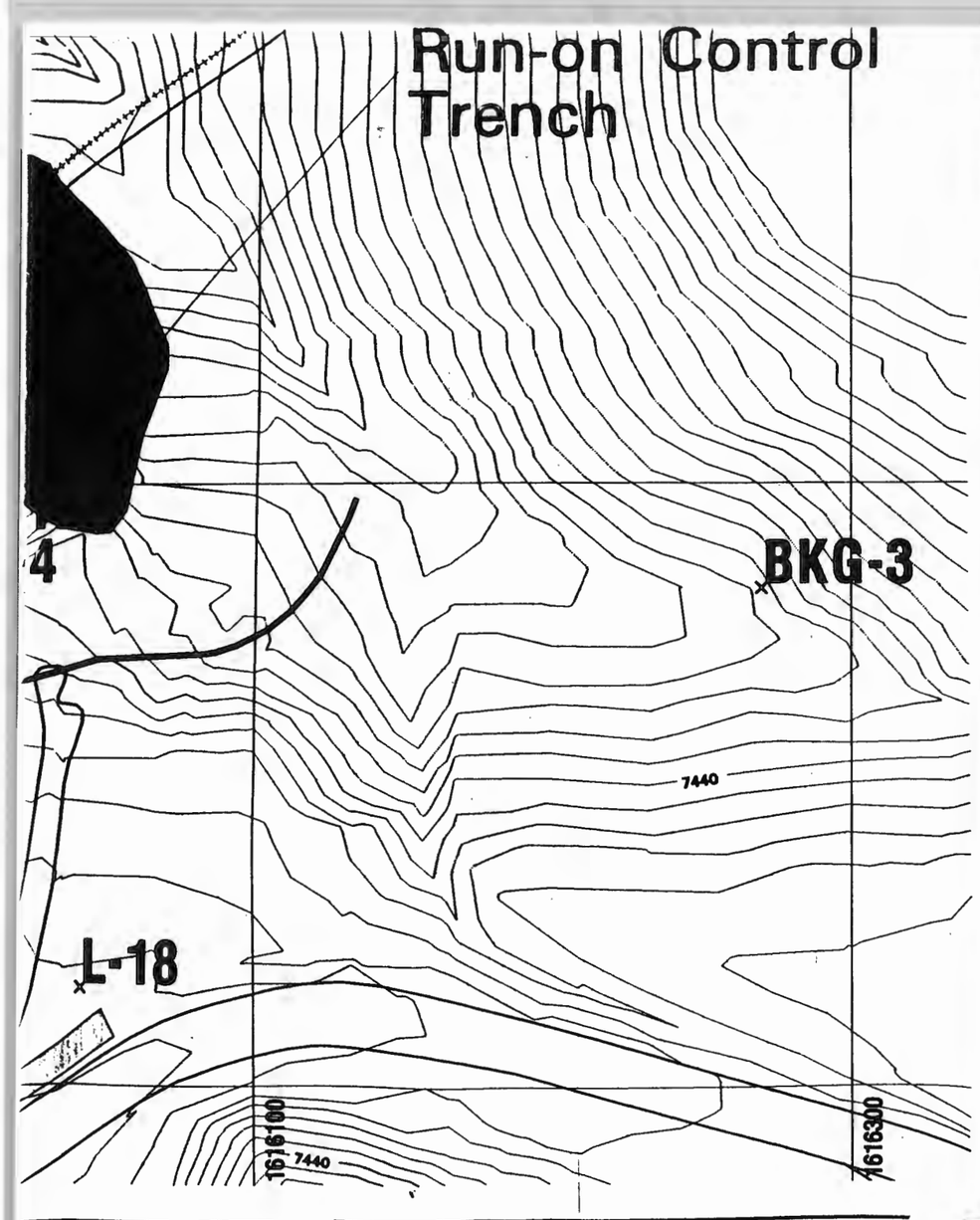
The analytical methods that will be performed during closure are identified in Table 4-3. These analytical methods were selected to detect the constituents listed above.

MDA-P PREVIOUS SAMPLE LO

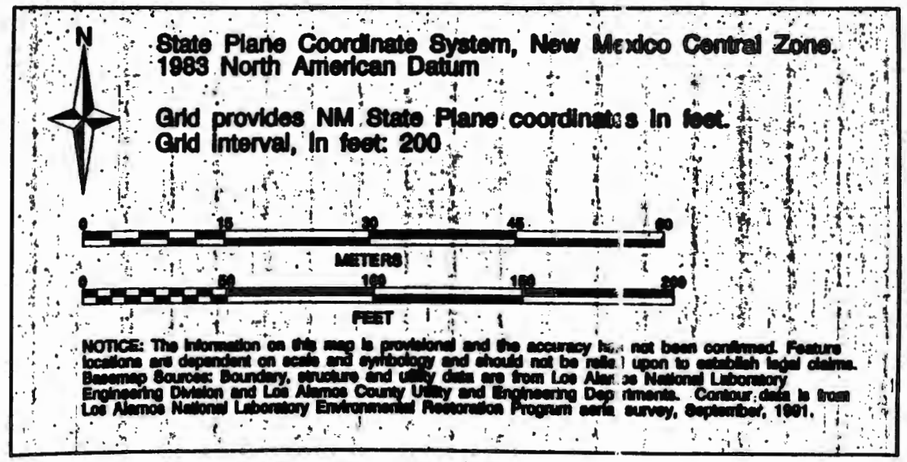




- Contours, 10 ft
- Contours, 2 ft
- Drainage
- Fence, Industrial
- Fence, Security
- Power Line >13.2 kV
- Road, Paved
- Telephone Line
- MDA
- PRS
- Temporary Structure
- Power Pole
- Previous Sample Location



MDA-P Previous Sample Locations Figure 3-1



University of California

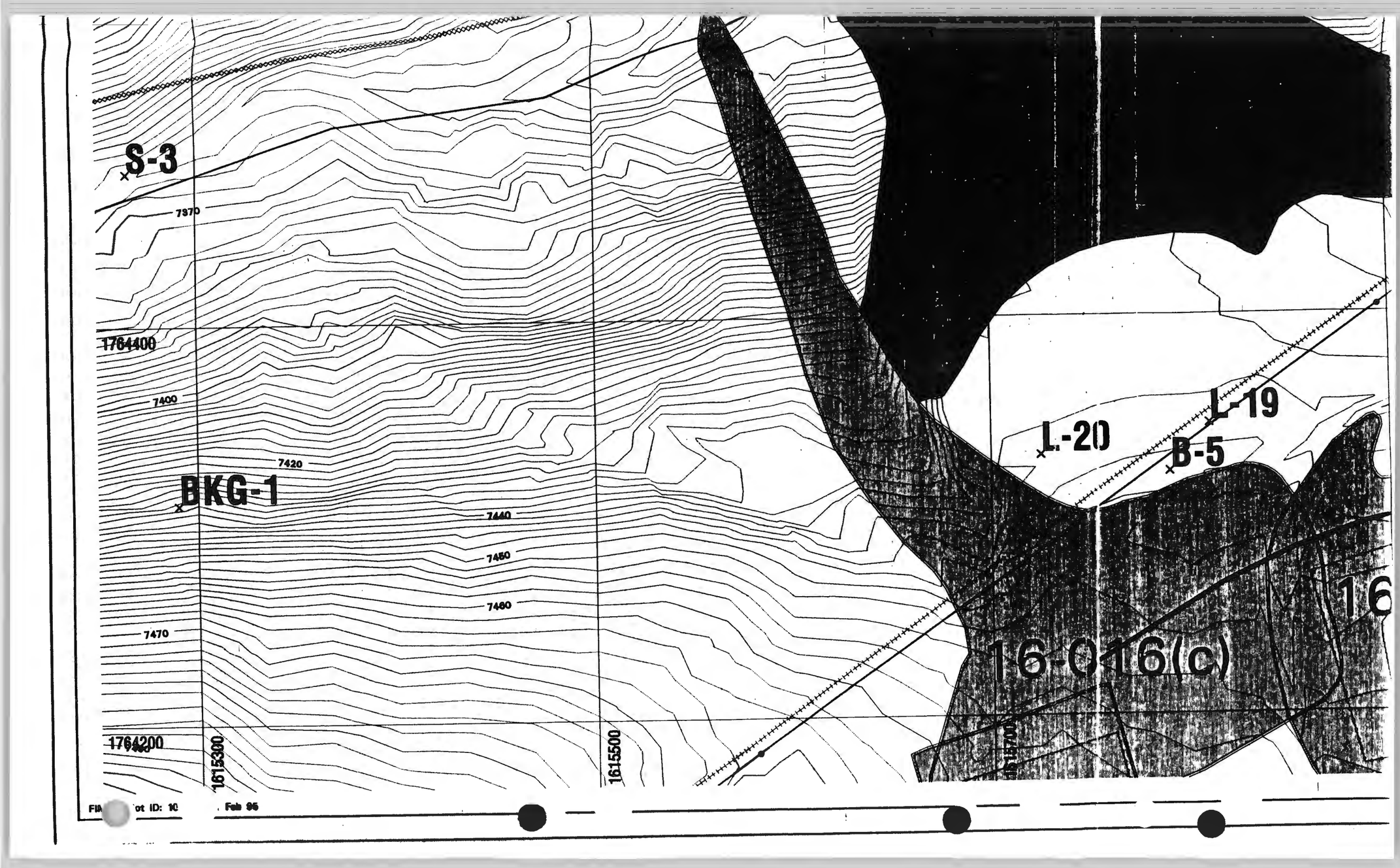
Los Alamos National Laboratory

Earth & Environmental Sciences Division

FIMAD Facility for Information Management, Analysis and Display
FIMAD is the electronic data repository for the Environmental Restoration Program at Los Alamos National Laboratory.

Produced by: Marcia Jones

Date: February 01, 1995 FIMAD Plot ID: 102930


S-3
7370
1764400
7400
7420
BKG-1
7440
7450
7460
7470
1764200
1615300
1615500
L-20
L-19
B-5
16-016(c)
16
Feb 95

4.0 SAMPLING AND ANALYSIS PLAN FOR PHASE 1 AND PHASE 2 CLOSURE SAMPLING

This chapter describes the strategy and methodology for the sampling and analysis activities to be implemented during closure of the waste pile. The sampling and analysis activities are divided into Phase 1 sampling (Section 4.1) and Phase 2 sampling (Section 4.2). During both Phase 1 and Phase 2, sampling activities will generate additional wastes that will also require sampling and analysis (Section 4.3). Field logistics are described in Section 4.4. Sample preservation and handling details are described in Section 4.5. Decontamination of sampling equipment and personal protective equipment is described in Section 4.6. Analytical requirements are described in Section 4.7. Quality assurance/quality control is described in Section 4.8. Sample collection procedures are described in Appendix G. The Standard Operating Procedure (SOP) for Soil and Water Sampling Operations, TA-16 High Explosive Exclusion Area is also included in Appendix G.

The sampling strategy is based on a combination of systematic sampling and judgmental sampling. EPA recommends systematic sampling when a population distribution is random or contains modest stratification (EPA 1992).

4.1 Strategy, Sample Point Location, and Number of Samples for Phase 1 Sampling and Analysis

The Phase 1 sampling, which will be conducted during the removal of the waste pile, will consist of the following:

- Sampling to establish background ranges for metals, radioactivity, and PAHs in nearby soils and tuff unaffected by Laboratory operations

- Sampling to establish baseline ranges for Appendix VIII hazardous constituents and radioactivity in soils and tuff at the top of the mesa

- Sampling of any soils and free liquids contained within containers or pockets around or inside the debris and soil during excavation of the waste pile and sampling of the soil and tuff at the staging area after excavation

- Sampling of the debris

Phase 1 sampling is designed to establish background and baseline concentrations, which will be compared with Phase 2 sample results to determine if clean closure has been met. In addition, Phase 1 sampling is designed to characterize any soil, tuff, debris, and free liquids to ensure proper disposition of the excavated waste. Sampling is designed to meet the most stringent waste acceptance criteria of the treatment, storage, or disposal facilities under consideration.

Additionally, visual inspections and spot testing for HE will be conducted as necessary to ensure safe waste pile removal and sample management.

4.1.1 Sampling to Establish Background Concentrations

A range of background concentrations for metals and radioactivity as well as PAHs (which are the natural products of forest fires) will be established for the soil and tuff below the waste pile. Background concentrations represent naturally occurring concentrations in the soil and tuff in locations that are unaffected by releases from Laboratory facilities.

Background for the soil and tuff below the waste pile will be defined as the 95% UTL calculated from concentrations of constituents measured in unaffected soil and tuff that is similar to that present near the MDA-P waste pile. The existing Laboratory database on background concentrations will be assessed to determine if sufficient data are available to provide a statistically meaningful UTL. If the available data are insufficient, additional samples will be collected near the waste pile in locations believed to be unaffected by releases from Laboratory facilities. If additional samples are required, discrete grab samples sufficient to calculate a meaningful UTL will be collected.

In response to previous NMED comments, a Background Sampling Plan is being developed for MDA-P. This plan will be submitted to NMED for approval.

4.1.2 Sampling to Establish Baseline

Before any waste is removed, baseline levels will be established for the soil at the top of the mesa in the approximate location of the closure waste handling/management areas (e.g., staging, decontamination, treatment, storage, and loading areas). Baseline levels will be established by collecting 10 samples from locations distributed over the waste handling/management area. Baseline levels will reflect the possible presence of contaminants derived from nearby Laboratory operations that are not related to MDA-P. Baseline concentrations are represented by the 95% UTL calculated from concentrations of Appendix VIII hazardous constituents and radioactive constituents measured in soil from these areas.

Following the completion of all waste removal operations and final equipment decontamination, the areas on top of the mesa will be resampled and the sampling data compared with baseline UTLs concentrations to determine if any releases occurred during the waste removal operations.

4.1.3 Sampling of the Waste Pile

During waste removal operations, the waste pile will be sampled for potential contaminants to characterize the waste for selection of treatment and disposal options. The material to be sampled includes excavated soil and tuff, as well as debris within the waste pile. Before excavation, this material will be visually inspected and spot-tested for HE to ensure safe handling.

4.1.3.1 Soil and Tuff

One composite sample will be taken from each 100 yd^3 of waste soil and tuff. Based on the estimated waste-pile volume (30,000 yd^3), a total of approximately 300 composite samples will be collected. Composite sampling will provide data on the average concentration of contaminants required for selecting treatment and disposal options.

Each composite sample will consist of grab samples collected from 3 to 10 locations within the 100 yd^3 of soil and tuff. A larger number of grab samples could result in excessive dilution of contaminant concentrations. Sufficient volume will be collected for each grab sample to ensure adequate composite sample volume for the prescribed analyses. The composite samples will

be collected from the soil before excavation or after the waste has been removed to the top of the mesa.

The leader of the sampling team will inspect the waste and select grab samples from any waste material that shows discoloration, elevated moisture content, or other evidence of potential contamination. Field instruments will be used to indicate if constituents are present in the waste during excavation. Contaminated soil will be segregated and sampled separately.

The number of samples was chosen to satisfy treatment, storage, and disposal requirements and is based on best professional judgment concerning the heterogeneity of the waste pile. Composite sampling allows more sample locations and better represents the total batch. Additional samples will be collected based on the judgment of the field team leader. By using systematic composite sampling combined with judgment-based sampling, the waste can be effectively segregated into and managed as unique and different wastestreams.

4.1.3.2 Debris

In accordance with 20 NMAC 4.1, Section 268.2(g), debris is defined as solid material exceeding a 60-mm particle size that is intended for disposal and that is a manufactured object, plant or animal matter, or natural geologic material. In addition, hazardous debris is defined as debris that contains a hazardous waste listed in 40 CFR Part 261, Subpart D, or that exhibits a characteristic of hazardous waste identified in 40 CFR Part 261, Subpart C.

The excavated debris is expected to consist of pieces of metal, concrete, wood, or other large items. Excavated debris will not be sampled directly; rather, the debris will be characterized for regulated constituents by analyzing rinsate liquid collected after it is decontaminated. However, an HE spot test will be conducted in accordance with the SOP for Soil and Water Sampling Operations, TA-16 High Explosive Exclusion Area (see Appendix G). This sampling will assess the effectiveness of the decontamination.

During excavation, the debris will be visually inspected for HE, then removed and decontaminated. The final rinsate water will be collected from the decontamination of the debris that is associated with each 100-yd^3 batch of debris. A composite sample will consist of grab

samples collected from selected containers of rinsate associated with a particular 100-yd^3 volume of debris. A total of approximately 300 composite samples of the final rinsate will be collected.

4.1.3.3 Free Liquid and Containers of Liquid

During excavation, free liquid may be found in pockets of the debris or containers. This liquid will be pumped into a suitable container and sampled.

Containers of liquid that may be found during excavation will be carefully removed from the waste pile and placed in a cool, shaded area for sampling. Information will be obtained from any labels that may be present on the container to help identify the contents. If the contents are unknown, the container will be sampled at a later time under appropriate controlled conditions (e.g., a fume hood, or supplied air).

4.2 Strategy, Sample Point Location, and Number of Samples for Phase 2 Sampling and Analysis

After the waste pile is removed, Phase 2 confirmatory sampling will be conducted to assess whether the concentrations of Appendix VIII hazardous or radioactive constituents in the remaining soil and tuff are below acceptable levels and to determine that the closure performance standard as described in Sections 6.1.1 and 6.1.1.2 has been met. Phase 2 sampling will include sampling of the soil and tuff within the MDA-P waste pile project boundary and sampling of the soil at the closure waste handling/management areas at the top of the mesa.

Additionally, visual inspections and spot testing for HE will be conducted as necessary to ensure safe sample management.

4.2.1 Sampling of the Soil Beneath and Downgradient of the Former Waste Pile

When all debris and obviously contaminated soil or tuff has been removed from the pile and any overexcavation has been completed, confirmatory samples will be collected from the exposed surface and downslope from the former waste pile at a depth of 0-12 in. to assess whether the concentrations of the remaining soil and tuff are below acceptable levels and the closure performance standard has been met. Discrete grab samples will be collected from locations

selected within a grid consisting of 10 m x 10 m cells (see Figure 4-1). The grid size selected is based on meeting the requirements of any risk assessment that may be required. The grid size is also based on requirements for any radiological land survey demonstration which may be required (NRC 1992). Only the grids located within the surveyed waste pile project boundary will be sampled. Until the boundary is surveyed and the number of grids are totalled, the total number of samples cannot be determined. For planning purposes it will be assumed that approximately 170 samples will be collected from approximately 170 grids. In addition, judgmental sampling may be done at locations that appear to be potentially contaminated, such as weathered fractures in the tuff. Additionally, field screening methods may be used to bias sample locations within the grid to more contaminated locations.

After the Phase 2 grid sampling has been completed and the data have been evaluated, the Laboratory will drill boreholes 10 feet beyond the vertical extent of contamination. The vertical extent of contamination will be defined as the depth below which organic constituents are no detected or inorganic constituent concentrations are below the background UTLs. Field screening, previous sampling results, and visual inspection will be used to bias the location of the boreholes in areas most likely to be contaminated. The Laboratory will obtain NMED approval for the number and location of boreholes to be used to define the vertical extent of contamination.

4.2.2 Sampling of the Soil Below the Closure Waste Handling/Management Areas at the Top of the Mesa

Following the completion of all waste removal operations and final equipment decontamination, the closure waste handling/management areas at the top of the mesa will be resampled and the sampling data compared with baseline concentrations to determine if any releases occurred during the waste removal operations. Ten discrete samples of surface soil will be collected from the waste handling/management area. If sample analysis indicates that contamination levels are above the preremoval baseline UTLs, contamination will be removed, and resampling will occur until preexisting baseline levels are reached.

4.3 Strategy, Sample Point Location, and Number of Samples for Sampling and Decontamination Wastes

In addition to the excavated materials, the removal operations will generate other wastes. These include decontamination liquids and sludges, personal protective equipment, disposable sampling equipment, and the wood and plastic used to construct the waste handling/management areas (e.g., staging, decontamination, treatment, waste storage areas).

4.3.1 Decontamination Liquids

One composite sample will be collected from each batch of decontamination liquid. If methanol or dilute acids are used for decontamination, process knowledge will be used to demonstrate that decontamination wastes do not exhibit the characteristic of ignitability or corrosivity.

4.3.2 Disposable Personal Protective Equipment and Sampling Equipment

Sampling and analysis of personal protective equipment and other equipment waste from the sampling activities is not feasible. Therefore, these wastes will be decontaminated to remove soil or mud before disposal. If any visible contamination remains after the decontamination process, these items will be characterized for RCRA constituents using the analytical results of the associated soil and tuff samples. If the items are not visibly contaminated, they will be managed as nonhazardous waste.

4.4 Field Logistics

The sampling sites will be examined before the start of field sampling to ensure that all required items are available. Coordination with the responsible group personnel at TA-16 is required for the use of storage and staging areas. Access to the waste pile site requires notification of TA-16 site and burn site personnel. Access to TA-16 requires a security clearance or an approved escort with a security clearance. Access to TA-16 will be restricted during burn operations. Site workers must have received all training specified in the Site-Specific Health and Safety Plan (SSHASP) for this project.

The material within the waste pile is inside an exclusion zone, so protective clothing must be worn if contact with waste is possible. Protective clothing requirements will be determined by the health and safety officer assigned to the project and will be described in the SSHASP to be prepared before sampling or excavating begins. Exclusion zones, access, and staging and decontamination areas will be designated as depicted in Figure 2-4 (see pocket at the end of Chapter 2.0). A boundary defining the exclusion zone will be set up around the waste pile as depicted in Figure 4-1 (see pocket at the end of Chapter 4.0).

A decontamination area for tools, equipment, and personnel will be designated (decontamination procedures are discussed in detail in Section 6.3 of this plan). All decontamination materials must be stored in containers with proper labels and identifying information. Efforts will be made to minimize the volume of decontamination materials. Personnel involved in performing the actual decontamination will be dressed in protective clothing one level of protection below that which the exclusion zone workers are required to wear.

Field measurements for radioactivity and organic vapors will be made and documented before, during, and after sampling activities at the waste pile. Measurements will be made using the calibrated instruments specified in the SSHASP. Qualified radiation protection and health and safety personnel are responsible for this monitoring. Results of monitoring will be used to evaluate possible hazards at the site, evaluate current conditions, and specify personal protective equipment.

4.5 Sample Preservation and Handling

The samples will require cooling with ice at the time of collection. Samples will be preserved in the field as soon after collection as is practical. Sample preservation for chemical analysis will conform to the requirements of EPA SW-846, Volume II, Part III (EPA 1992). Sample containers will be precleaned (typically by the original supplier) using EPA quality assurance protocols appropriate for the intended use of the sample container. Sample container requirements, preservation methods, and holding times are listed in Table 4-1.

Following sample collection, sample container lids shall be fixed tightly to the containers and the outside of the container carefully rinsed with deionized water and dried. The purpose of the rinse is to minimize the spread of contaminated materials on sample container surfaces. After rinsing

and drying, labels will be attached to the containers and the containers sealed with a custody seal, which will be initialed and dated by a member of the field team. The sample containers will then be placed in resealable polyethylene bags as secondary confinement in the event of leakage or breakage. The outside surfaces of the secondary sample containers will be monitored for radioactivity before packaging for transportation to the analytical laboratory.

Samples will be packaged and handled according to the SOP for Soil and Water Sampling Operations, TA-16 High Explosive Exclusion Area (see Appendix G). Samples will be packaged in shipping coolers and cooled to approximately 4° C, with adequate cushioning and absorbent materials to reduce the likelihood of breakage and to contain fluids should breakage occur. Sample custody, analytical request documentation, and any additional laboratory-required documentation will be placed in resealable polyethylene bags and taped inside the cooler lid. All samples will be screened onsite for gross alpha, beta and gamma radioactivity before packaging and shipment. If the sample is to be shipped offsite for analysis, appropriate labels and markings will be placed on top of the packing materials inside the cooler to make them obvious to anyone when opening the cooler. Sample coolers will be sealed with packing tape, and radioactivity measurements will be taken at the cooler. Results of this radiation screening will be clearly indicated on the outside of the cooler.

The MDA-P Closure Project Manager or designee is responsible for packaging and placarding in accordance with Department of Transportation regulations (when samples travel via ground transportation) or with International Air Transport Association regulations (when they are transported by commercial cargo aircraft). Appropriate waybills will be affixed to the shipping coolers for off-site shipment, and the samples will be transported to the analytical laboratory as quickly as is practical.

Samples will be analyzed by an off-site analytical laboratory.

4.5.1 Field Sample Documentation

Field sampling activities will be documented through the use of a closure sampling field log book, sample labels, chain-of-custody records and a request for analysis form. These documents and their uses are described below. All field records generated during sampling activities will be transmitted to the Environmental Restoration (ER) Records Processing Facility (RPF).

Table 4-1.
Sample Containers, Preservation Methods, and Holding Times

	Water and Aqueous Wastes			Sludge, Soil, and Nonaqueous Wastes		
Analysis	Container	Preservation	Holding Time	Container	Preservation	Holding Time
Metals	500-mL polyethylene (poly) or Nalgene (nalg)	HNO_3 to pH < 2. Cool to 4° C.	180 days	125-mL wide mouth poly or nalg	Cool to 4°C	6 months
Mercury	250-mL poly or nalg	reagent-grade HNO_3 to pH <2. Cool to 4°C	28 days	125-mL poly or nalg	Cool to 4°C	28 days
Volatile Organics	2 x 40-mL amber glass vial with Teflon-lined septum cap	4 drops conc. HCl per vial, cool to 4°C	14 days	2 x 40-mL amber glass vial with Teflon-lined septum cap or 125 mL wide-mouth amber glass or brass sleeve with no headspace	Cool to 4°C	14 days
Semivolatile Organics	1-L amber glass with Teflon-lined cap	Cool to 4°C	Extract in 7 days, analyze within 40 days	250-mL wide-mouth glass with Teflon-lined cap	Cool to 4°C	14 days
Reactive Cyanide and Sulfide & Total Cyanide	N/A	N/A	N/A	4-oz amber glass	Cool to 4°C	As quickly as possible
Gross Alpha, Beta Radioactivity, Gamma Spectroscopy	1-gal. poly or nalg	HNO_3 to pH <2 Does not need to be kept cool	6 months	16-oz wide-mouth poly or nalg	None Does not need to be kept cool	6 months
High Explosives	1-L amber glass with Teflon-lined cap	Cool to 4°C, store in dark	Extract within 7 days; analyze within 40 days after extraction	125-mL glass jar with Teflon cap	Cool to 4°C, store in dark	Extract within 7 days; analyze extract within 40 days after extraction
Chlorinated Pesticides and PCBs	1-L amber glass with Teflon-lined cap	Cool to 4°C	Extract within 7 days; analyze within 40 days after extraction	250-mL wide mouth glass with Teflon-lined cap	Cool to 4°C	Extract within 7 days; analyze within 40 days after extraction
Chlorinated Herbicides	1-L amber glass with Teflon-lined cap	Cool to 4°C	Extract within 7 days; analyze within 40 days after extraction	250-mL wide mouth glass with Teflon-lined cap	Cool to 4°C	Extract within 7 days; analyze within 40 days after extraction
Asbestos	N/A	N/A	N/A	125-mL poly jar	No preservation required	No holding time

4.5.2 Field Log Book

A closure sampling field log book will be kept containing all information pertinent to field sampling. The log book will have bound and consecutively numbered pages. The information entered into the log book should sufficiently reconstruct the sampling situation without relying on the sample collector's memory. Minimum entries will include

1) purpose of sample;
2) location of sample;
3) name, organization, and business address of persons collecting samples and making entries;
4) number and volume of sample and preservatives used (if any);
5) description of each sampling location, the sampling methodology, the equipment;
6) date and time of sample collection;
7) sample destination and transporter's name;
8) sketch of the sampling site;
9) log of photographs taken, if any;
10) field observations (ambient temperature, sky conditions, recent precipitation, etc.);
11) field measurements, if any (pH, flammability, conductivity, explosivity, etc.);
12) sample identification number(s); and
13) signature of person responsible for the log entry.

4.5.3 Sample Label

Sample labels will be affixed to each sample container. Each label must be either preprinted or completed in the field using waterproof, indelible ink (except for VOC samples, which will be labeled using ballpoint or other non-solvent-containing ink). Labels will be of a waterproof material or covered with waterproof transparent tape. The label must include the following information:

- MDA-P, TA-16
- Unique sample identification number
- Date and time of sample collection
- Sample location (e.g., batch number or sample location grid number)
- Type of analysis requested
- Preservative (if any)
- Printed name and initials of collector

The unique sample identification number will be determined before the start of field work. A unique number will be used for each sample, even if the sample consists of more than one sample container. The unique sample identification numbers will consist of hand-written numbers with unique identifiers such as sample location, date, and time. An example of a sample label is shown in Figure 4-2.

4.5.4 Chain of Custody/Request for Analysis Form

The Chain of Custody/Request for Analysis Form (Figure 4-3) documents a sample's history from collection through analysis and disposal. Upon collection in the field, every sample shall be recorded on the Chain of Custody/Request for Analysis Form using the unique sample identification number. The person(s) collecting the sample must be identified on the form. A sample is considered to be in a person's custody when it is in his or her physical possession, when it is in the person's view after being in his or her physical possession, or when the sample is in a secure area and maintained in a manner that any tampering would be evident. When custody of the sample(s) is passed from the sample collector to other personnel, the persons relinquishing and receiving custody must record their signature and the date and time on this form so that the custody record remains unbroken. When samples are consigned to a commercial shipper, the person having custody at that time signs as relinquisher; the shipper's waybill then becomes part of the custody record, and the receiving laboratory signs for receipt upon opening the sample cooler. Chain-of-custody records must remain part of the permanent documentation for field sampling activities.

LOS ALAMOS NATIONAL LABORATORY	
OU _____ TA _____	AFFIX BAR CODE STICKER HERE
LOCATION:	DATE:
LOCATION ID NO.:	TIME:
ANALYSIS:	PRESERVATIVE:
NAME (print): INITIALS:	

Figure 4-2. Example of a sample label

Los Alamos National Laboratory Environmental Restoration
CHAIN OF CUSTODY/REQUEST FOR ANALYSIS

Date: _____ COC _____

Technical Area _____ Send Lab Report to: _____ MS_____

Operable Unit _____

OU Contact _____ Date Lab Report Required _____

Contact Phone No. _____

Field Unique Sample #/ID (Write In Sample ID Number In space below.)	Date & Time Collected	G R A B	C O M P	Sample Container Volume/Matl	Matrix (Liquid, Soil, Core, Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS (Condition of receipt, etc.)

Relinquished by: (Signature) Affiliation:	Date:	Relinquished by: (Signature) Affiliation:	Date:	Relinquished by: (Signature) Affiliation:	Date:
Received by: (Signature) Affiliation:	Time:	Received by: (Signature) Affiliation:	Time:	Received by: (Signature) Affiliation:	Time:

POSSIBLE HAZARD IDENTIFICATION:
(Please indicate if sample(s) are hazardous materials and/or suspected to contain high levels of hazardous substances)

Radiological ___ Highly Toxic ___ Flammable ___ Skin Irritant ___ Non-hazard ___ Other ___

SAMPLE DISPOSAL:

Return to client ___ disposal by Lab ___ Archive ___ (Indicate number of month(s))

COMMENTS: _____

Original - SCF YELLOW - RPF PINK - FTL Copy LANL ER SOP 01.04 R2

Figure 4-3. Example Chain of Custody/Request for Analysis Form

The Chain of Custody/Request for Analysis Form also provides information for the analytical laboratory on sample size, type, volume and preservative; project identification and contact information; analytical tests to perform; project-specific quality control required; possible sample hazards, if known; and the requested disposition of the sample following analysis.

4.6 Decontamination of Sampling Equipment and Personal Protective Equipment

Sampling equipment will be cleaned before and after sampling with a detergent accepted by TA-16 site personnel and compatible with disposal site waste acceptance criteria. In addition, the personal protective equipment will be decontaminated before disposal. All decontamination procedures will take place within an exclusion zone or centralized decontamination area designated for that purpose. Methanol or dilute acid rinses may be used, if necessary, to achieve effective decontamination. Following the detergent wash, sampling equipment will be rinsed thoroughly with tap water and then several times with deionized water. Samples of the final deionized water rinse will be collected as rinsate blank samples.

4.7 Analytical Requirements

The requirements for clean closure will be met by demonstrating the absence of 20 NMAC 4.1, Section 261, Appendix VIII constituents above acceptable levels. Analytical methods were selected to meet the waste acceptance criteria for Evirocare of Utah, Inc. facility and the Chemical Waste Management Inc., Kettleman hazardous waste facility, which are off-site disposal facilities under consideration. In addition, analytical methods were selected that are capable of detecting Appendix VIII constituents reasonably expected to have been present in wastes disposed of at the waste pile. The proposed analytes include nonhazardous constituents that are not on the Appendix VIII hazardous constituent list. The clean-closure performance standard will not be applied to these non-Appendix VIII constituents.

Most of the constituents listed in Appendix VIII are not proposed for analysis for the waste pile closure. Most of the Appendix VIII constituents not selected fall into the following categories:

- Inorganic and organic compounds for which there are no analytical methods in SW-846 or standards
- General classes of compounds identified as not-otherwise-specified
- Chemicals whose common usage is inconsistent with operations at TA-16 and other TAs sending waste to the waste piles (e.g., pharmaceuticals, manufacture of organic chemicals)

Appendix H presents an evaluation of the Appendix VIII constituents. In addition, this appendix identifies the proposed methods, analytes, estimated quantitation limits, proposed RCRA Subpart S action levels, and ER Program SALs.

Test methods for chemical analysis will be performed according to procedures documented in SW-846. Minimum calibration, operation, and quality control requirements (bias, precision, blank, and matrix effects) for laboratory analyses shall be performed as listed in the individual analytical methods of SW-846 (EPA 1992).

4.7.1 Analytical Methods

The analytical methods and number of samples are identified in Table 4-2 for Phase 1 and Phase 2 sampling. This table does not include the number of decontamination liquid samples because the number of these samples depends on the number of batches to be disposed of (see Section 4.3.1). The analytical methods were selected to detect the potential constituents identified in Section 3.3 and the analytes required to satisfy the most stringent waste acceptance criteria of the off-site disposal facilities under consideration. The analytes required by the off-site disposal facilities include the following:

- TCLP metals (i.e., arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver)
- VOCs
- SVOCs

Table 4-2 Summary of Samples and Analyses

Analysis (EPA SW-846 Method except where otherwise noted)	Metals 6020(a) 1311(a)	Volatile Organics 8240A (b)	Semi-volatile Organics 3520A, 3540A/ 8270A (c)	Reactive Cyanide/ Sulfide 9010A, 9030A (d) (k)	Total Cyanide 9011/ 9010A 9012A (e)	High Explosives 8330	Gamma Spectro-scopy	Gross Alpha 9310 (f)	Gross Beta 9310 (f)	Asbestos NIOSH Method 7400 (g)	Organo-chlorine Pesticides and PCBs 8080A (g) (l)	Chlorinated Herbicides 8150B (g) (l)	pH 9040	Dioxin 8280 (g)
Phase 1 Number of Samples														
Background Soil and Tuff (h)	20	0	20	0	0	0	20	20	20	0	0	0	0	
Baseline Soil (Staging Area)	10	10	10	0	10	10	10	10	10	10	10	10	10	10
Waste Pile Soil/Tuff	300	300	300	75	0	300	300	300	300	300	75	75	75	75
Rinsate Water	300	300	300	0	300	300	300	300	300	300	75	75	75	75
Duplicate (i)	47	46	47	4	31	46	47	47	47	46	12	12	12	12
Rinsate Blank (j)	47	46	47	4	31	46	47	47	47	46	12	12	12	12
Matrix Spike (k)	32	31	32	4	16	31	32	32	32	30	8	8	8	8
Total Samples, Phase 1	756	733	733	87	388	733	756	756	756	732	182	182	182	182
Phase 2 Number of Samples (m)														
Soil/Tuff	170	170	170	0	170	170	170	170	170	170	170	170	0	170
Post-closure Baseline Soil (Staging Area)	10	10	10	0	10	10	10	10	10	10	10	10	0	10
Duplicate (i)	9	9	9	0	9	9	9	9	9	9	9	9	0	9
Rinsate Blank (j)	9	9	9	0	9	9	9	9	9	9	9	9	0	9
Matrix Spike (k)	9	9	9	0	9	9	9	9	9	9	9	9	0	9
Total Samples, Phase 2	207	207	207	0	207	207	207	207	207	207	207	207	0	207

Notes:

(a) Method 3005A and 3050A is digestion for water and soil, 6020 is the analytical method for most total metals. Method 7740 is the analytical method for total selenium Methods 7470 and 7471 are the analytical methods for total mercury Other methods may also be used(Method 6010A and 7000A series methods) as described in Section 4.6.1. Method 1311 is the TCLP method.

(b) Method 8260 may be substituted for 8240A.

(c) Method 3520A and 3540A are extraction methods for water and soil, 8270A is the analytical method.

(d) Determination of reactive cyanide is described in SW-846, Chapter 7, Section 7.3.3. This determination includes portions of Method 9010A. Determination of reactive sulfide is described in Section 7.3.4 This determination includes portions of Method 9030A.

(e) Method 9011 is digestion of soil for cyanide analyses, Methods 9010A and 9012A are the analytical methods for cyanide.

(f) Method 9310 is for water samples Soil samples will be measured using calibrated field instruments.

(g) Analyses for asbestos, organochlorine pesticides and PCB, dioxin, and chlorinated herbicides will be performed in Phase 2 only if they are detected in the Phase 1 sampling.

(h) The number of background samples will be identified in the Background Sampling Plan that will be submitted separately.

(i) Duplicates will be collected at a frequency of one per 20 soil or tuff samples, and one per 10 water samples.

(j) Equipment rinsate blanks will be collected at a frequency of one per 20 soil or tuff samples, and one per 10 water samples.

(k) Matrix spike samples will be collected at a frequency of one per sample delivery group per matrix, with a maximum of 20 samples per delivery group

(l) For soil/tuff samples will be taken from every fourth 100 yd^3 batch of waste that is to be deposited

(m) The number of samples is estimated based on the number of sample grids within the proposed waste pile project boundary. After the waste pile boundary is surveyed the number of grids will be totalled and the number of samples will be changed if necessary.

- organochlorine pesticides and PCBs
- chlorinated herbicides
- reactive cyanide and sulfide
- pH

During Phase 1, all background soil and tuff samples will be analyzed for total metals, SVOCs, and radionuclides. The SVOC analyses will be used to establish background for the PAHs.

During Phase 1, all baseline soil samples from the waste management areas at the top of the mesa will be analyzed for total metals, VOCs, SVOCs, total cyanide, HE, radionuclides, asbestos, organochlorine pesticides and PCBs, dioxin, and chlorinated herbicides.

During Phase 1, all soil and tuff samples from the waste pile will be analyzed for TC metals using the TCLP, VOCs, SVOCs, HE, radionuclides, and asbestos. However, only one-fourth of the soil and tuff samples will be analyzed for reactive cyanide and sulfide, organochlorine pesticides and PCBs, dioxin, chlorinated herbicides, and pH, because these analytes are not expected to be present and are only included to meet the waste acceptance criteria. The reactive cyanide and sulfide, organochlorine pesticides and PCBs, dioxin, chlorinated herbicides, and pH samples will be selected by collecting one sample from every fourth 100-yd^3 batch of waste.

During Phase 1, all debris rinsate samples, decontamination liquid samples, and free liquid samples collected from pockets within the debris or in containers will be analyzed for TC metals using total analyses, VOCs, SVOCs, total cyanide, HE, radionuclides, and asbestos. One-fourth of the debris rinsate samples will be analyzed for organochlorine pesticides and PCBs, dioxin, chlorinated herbicides, and pH because these analytes are not expected to be present and are only included to meet the waste acceptance criteria. The organochlorine pesticides and PCBs, dioxin, chlorinated herbicides, and pH samples will be selected by collecting one sample from containers of rinsate associated with every fourth 100 yd^3 batch of waste.

During Phase 2, two of the soil or tuff samples will be analyzed for the following constituents analyzed during Phase 1: total metals, VOCs, SVOCs, HE, radionuclides, asbestos, total cyanide, organochlorine pesticides and PCBs, dioxin, and chlorinated herbicides. The remaining Phase 2

soil or tuff samples will be analyzed for total metals, VOCs, SVOCs, HE, radionuclides, and total cyanide. If asbestos, organochlorine pesticides and PCBs, dioxin, or chlorinated herbicides are detected in the Phase 1 samples, then remaining Phase 2 samples will also be analyzed for these constituents.

Two of the Phase 2 liquid samples will be analyzed for the following constituents analyzed during Phase 1: total metals, VOCs, SVOCs, HE, radionuclides, asbestos, total cyanide, organochlorine pesticides and PCBs, dioxin, and chlorinated herbicides. The remaining Phase 2 liquid samples will be analyzed for total metals, VOCs, SVOCs, HE, radionuclides and total cyanide. If asbestos, organochlorine pesticides and PCBs, dioxin, or chlorinated herbicides are detected in the Phase 1 samples, then the remaining Phase 2 samples will also be analyzed for these constituents.

Analytical methods to be used are identified and described in the following paragraphs.

During Phase 1 sampling, the samples of the excavated waste collected for metal analyses will be analyzed using the TCLP. The TCLP is required to meet the waste acceptance criteria of most of the disposal facilities under consideration. During Phase 2 sampling, total analyses of the subsoils and tuff below the waste pile will be run instead of the TCLP. Total analyses are required for the comparison with the background UTLs, SALs, or PRGs.

Total metals analysis may be performed using a combination of inductively coupled plasma (ICP) and atomic absorption spectroscopy (AAS) methods. Prior to analysis, samples will be prepared by acid digestion. If soil samples contain two phases, the liquids will be separated from the solids with a 0.6- to 0.8-mm glass-fiber filter and the liquid and solid portions analyzed separately. EPA Method 3005A will be used for digestion of water samples and Method 3050A for digestion of soil samples, except for samples collected for cyanide analyses. The analytical methods to be used will be determined by the analytical laboratory based on instrument availability and required detection limits. It is currently expected that inductively coupled plasma-mass spectrometer (ICP-MS) analysis (EPA Method 6020) will be used for analysis of most metals. It is expected that a furnace AAS method will be used for analysis of selenium (EPA Method 7740), and cold-vapor AAS (EPA Methods 7470 and 7471) will be used for mercury analysis. Alternately, ICP-AAS (EPA Method 6010A) and other flame AAS methods (EPA 7000A series) may be used

as long as the estimated quantitation units (EQL) are at or below all SALs, except the proposed SAL for beryllium in water. This SAL is below the EQLs of current analytical methods. EPA Method 9011 will be used for the digestion of soil samples collected for total cyanide analyses. EPA Method 9010 or 9012 will be used to determine the total concentration of inorganic cyanide in liquid or solid samples.

Analysis of VOCs will be performed using purge and trap-gas gas chromatography/mass spectroscopy (GC/MS) by EPA Method 8240A. Mass spectra library searches for tentatively identified compounds will be performed.

Analysis of SVOCs will be performed using GC/MS (EPA Method 8270A). Liquid samples will be prepared for analysis using continuous liquid-liquid extraction (EPA Method 3520A). Soil or tuff samples will be prepared for analysis using soxhlet extraction (EPA Method 3540A) or sonication (EPA Method 3550). HE analysis will be performed using EPA Method 8330. Field screening for HE will be performed using the Laboratory's HE spot-test kit. Analysis for organochlorine pesticides and PCBs will be performed using EPA Method 8080A. Analysis of chlorinated herbicides will be performed using EPA Method 8150B. Analysis of dioxin will be performed using EPA Method 8280. Mass-spectra library searches for tentatively identified compounds will be performed.

Phase 1 soil and tuff samples will be analyzed for reactive cyanide and sulfide using the test methods presented in SW-846 (EPA 1992), Sections 7.3.3.2 and 7.3.4.2, respectively. The samples will be acidified to pH 2.0, and any gas that is generated will be trapped in an alkaline scrubber. The scrubber solution will then be analyzed for cyanide and sulfide using EPA Methods 9010A and 9030A, respectively. The test procedures will have required detection limits of 50 mg/kg cyanide and 100 mg/kg sulfide. The current EPA action levels for cyanide and sulfide for reactive wastes are 250 mg/kg and 500 mg/kg, respectively (EPA 1992).

Samples for asbestos analysis will be analyzed by a certified laboratory using the polarized light microscopy method, National Institute of Occupational Safety and Health Method 7400 (NIOSH 1984).

Phase 1 soil and tuff waste samples will be analyzed using TCLP as described in 20 NMAC 4.1, Part 261, Appendix II.

Radiological analysis will be performed using Laboratory procedures. Analysis for gross-alpha and gross-beta radioactivity will be performed using gas-flow proportional counting. Approximate detection limits for gross alpha are 5 pCi/L for water and 10 pCi/g for soil and sludge. Approximate detection limits for gross beta are 6 pCi/L for water and 12 pCi/g for soil and sludge. Gamma-emitting radionuclides will be analyzed by using gamma spectroscopy. Detection limits vary with radionuclides and range from 15 to 300 pCi/L for water and 0.1 to 2.0 pCi/g for soil. Typical detection limits vary from 0.1 to 0.2 pCi/L for water and 0.01 to 0.05 pCi/g for soil.

4.7.2 Laboratory Documentation

Documentation of sample acceptance at the analytical laboratory must be provided to the MDA-P Closure Project Manager following sample screening and log-in. This documentation may consist of signed copies of the chain-of-custody record or a letter detailing the field sample numbers accepted. Corresponding laboratory sample identification numbers should be provided to the Project Manager.

All laboratory analyst notebooks, log sheets, instrument printouts, charts, calculations, and other documents relevant to these samples analyses shall be identified and remain retrievable in the RPF. This information may be requested by the Project Manager or quality assurance (QA) officer for independent review and validation.

The analytical laboratory shall submit analytical results to the Project Manager. At a minimum, the analytical results shall contain the information shown in the Data Format Checklist presented in Figure 4-4. Copies of the analytical results will be appended to the Final Closure Report. Raw analytical results will be provided to NMED upon request. Analytical Results for radiological analysis including field screening results will be provided to NMED upon request.

DATA FORMAT CHECKLIST

INCLUDE ON LAB DATA SHEETS:

Location of Sample:

Type of Sample (Matrix):

Laboratory Sample Identification Number:

Client Sample Identification Number:

Date Sample Collected:

Date Sample Received by Laboratory:

Date Sample Extracted (if appropriate):

Date Sample Analyzed:

Name and Telephone Number of Analyst:

Name, Signature, and Telephone Number of Laboratory Manager:

Weight and Volume of Sample Received:

Analyte and Analytical Result With Units:

Method of Analysis:

Detection Limit:

List of Tentatively Identified Compounds at or Above Method Detection Limit (if appropriate):

QA/QC That Pertains to Sample:

INCLUDE IN A NARRATIVE SUMMARY:

QA/QC Summary Listing All Technical Problems Encountered and Listing All Samples Affected:

Summary of Results by Sample for all Parameters Identified in the Closure Plan:

Report Presence of Tentatively Identified Compounds:

FIGURE 4-4.

4.8 Quality Assurance/Quality Control

The Project Manager is responsible for implementation of QA policies and quality control (QC) procedures. A QA officer, independent of this sampling and analysis task, will assume a QA function and report to the Project Manager. The independent QA officer is responsible for conducting QA reviews, including second-level approvals of nonconformances and variances, primary approval of corrective actions and audits of field and laboratory activities and documentation. Results of all QA reviews will be reported to the Project Manager. QA review may be requested by the Project Manager or higher level management or may be initiated by the individual responsible for the QA function. The following subsections describe QA/QC requirements and procedures for sampling and analysis for the MDA-P closure.

4.8.1 Field QC

Field QC activities will include collection of QC samples in addition to the field documentation requirements discussed in Section 4.5.1. QC samples to be collected include duplicate samples, equipment rinsate blanks and matrix spike samples. Table 4-3 summarizes field QC samples discussed in this Closure Plan.

Duplicate samples of water and soil will be collected at a frequency of 1 duplicate sample per 20 environmental samples for each sample matrix. The field duplicate samples will be collected at the same locations as the corresponding environmental samples and will undergo the same analyses. The results of analysis of duplicate samples will be used to indicate the variability of the sampled matrix by calculating the relative percent difference (RPD) using the following formula:

$$RPD = 100 \times (C_1 - C_2) / C_{ave}$$

where C_1 is the concentration in the first sample, C_2 is the concentration in the duplicate sample, and C_{ave} is the mean of the concentrations in the first and duplicate samples. The RPD will be

Table 4-3.
Summary of Field Quality Control Samples

QC Sample Type	Sample Matrix	Applicable Analysis	Frequency	Purpose	Acceptance Criteria	Corrective Action
Matrix Spike	Water, Soil, Tuff	See Table 4-2	One per sample delivery group	Laboratory QC, determine matrix effects	(b)	(b)
Field Duplicate	Water, Soil, Tuff	See Table 4-2	One per 20 soil or tuff samples; one per 10 water samples.	Monitor sample variability	(c)	Advisory -- no action required
Equipment Rinsate Blank	Water, Soil, Tuff	See Table 4-2	One per 20 soil or tuff samples; one per 10 water samples.	Monitor decontamination effectiveness and sample cross contamination	(a)	Advisory -- no action required

(a) For volatiles and semivolatiles analysis, if blank shows detectable levels of any common laboratory contaminant, sample must exhibit that contaminant at a level equal to or greater than 10 times the quantitation limit to be considered detectable. For all other contaminants, sample must exhibit that contaminant at a level equal to or greater than 5 times the quantitation limit to be considered detectable.
(b) Acceptance criteria and corrective actions for matrix spike recovery will be specified in analytical laboratory QA plan.
(c) For water samples, the goal for relative percent difference is 25%. For soil or tuff samples, the goal for relative percent difference is 50%. These goals are based on the expected variability of the matrices to be sampled. Failure to meet these goals will not require corrective action, but may require evaluation of the cause of variability.

Field documentation is an integral part of QA/QC. Field documentation requirements and procedures are discussed in detail in Section 4.5.1 of this sample plan.

used as an indication of variability and will not be used to indicate the need for corrective actions.

Equipment rinsate blanks are used to assess sample contamination from improperly cleaned sample equipment. Rinsate blanks will be collected during decontamination of sampling equipment. The rinsate blank sample will be collected from the final deionized water rinse. If disposable sampling equipment is used, rinsate blanks will be collected by rinsing an unused sampler with deionized water. Equipment rinsate blank samples will be collected at a frequency of 1 for every 20 soil, tuff, and sludge samples, and 1 for every 10 water samples. Rinsate blanks will be assigned a unique sample identification number for tracking purposes but will not be identified as blanks to the analytical laboratory. Equipment blanks will undergo the same analyses as the environmental samples.

For aqueous-matrix spike samples, it will be necessary to collect twice the sample volume than is normally collected. The extra sample volume will be used by the analytical laboratory to make matrix spike (MS) and matrix spike-duplicate (MSD) samples. For solid-matrix spike samples, it will not be necessary to increase the normal sample volume. The results of the MS samples are used to evaluate the effects of the sample matrix on analytical method performance. Matrix spike samples will be submitted at a frequency of 1 per sample delivery group per matrix for chemical analysis. The maximum number of samples per delivery group is 20.

Instrument calibration and maintenance are field activities subject to QC procedures. Field equipment requiring calibration will be limited to radioactivity detection devices and organic vapor monitoring and other monitoring equipment specified in the SSHASP. This equipment will be calibrated and maintained using the manufacturer's instructions and appropriate standard operating procedures (SOP).

Field personnel will monitor for organic vapors in the waste pile area and may prescribe additional personal protective devices based on these measurements. Monitoring shall be conducted for nonspecific organic vapors using either a photoionization detector or a flame ionization detector. Before the start of field activities, the organic vapor analyzer will be calibrated by a trained technician using a calibration gas to check instrument response and ensure proper operation. Each day before monitoring at the site, the organic vapor analyzer shall be zeroed,

set in an area free from organic vapors, response-checked using a commercially available calibration gas, and then taken to the waste pile site for monitoring.

Validation of data obtained from field measurements will be performed by the MDA-P Closure Project Manager. The following reporting requirements for field data will be followed:

- Soil sample depths. Tape measurements will generally be made to the nearest 0.1 ft; however, the accuracy of the measurement depends on depth. Measurements made by known lengths of drill string will be made to the nearest 0.5 ft.

- Locations of sampling sites. Locations of sampling sites will be determined to the nearest 0.5 ft.

4.8.2 Laboratory QC

The analytical laboratory(ies) will operate under a QA program plan that meets the NMED requirements. The Laboratory Quality Assurance Project Plan will specify the laboratory procedures to be used for establishing the quality of all analytical data.

Laboratory review of analytical data will conform with EPA guidance documents and Laboratory SOPs. In addition, appropriate qualifiers will be assigned by the laboratory. Qualifier definition and assignment will be similar to the guidelines (EPA 1991a, b) specified in EPA's Contract Laboratory Program Statements of Work for Inorganic and Organic Analyses.

Samples exhibiting surrogate recoveries outside of acceptability limits will be reextracted and/or reanalyzed. In the event that surrogate results for both analyses are outside of acceptability limits, initial and rerun analyses will be reported by the laboratory. During reanalysis, if a different surrogate compound falls outside acceptability limits, additional reextraction and/or reanalysis will not be required. However, high surrogate recoveries associated with nondetected samples will not trigger reanalysis if the surrogate recovery does not exceed 10 percent of the upper control limit.

MS/MSD analyses with recoveries outside of acceptability limits will be reextracted and/or reanalyzed. In the event that results from the reanalysis are also outside of acceptability limits, data from both MS/MSD analyses will be reported by the laboratory. During reanalysis, if a different MS/MSD compound falls outside acceptability limits, additional reextraction and/or reanalysis will not be required.

The laboratory will ensure that the following criteria are met, as appropriate for the type of analysis:

- Sample custody documentation is complete.
- Instrument performance criteria has been met.
- Sample integrity has not been breached.
- Calibration criteria has been met.
- Parameter identification and quantification is correct.
- Holding times have been met.
- QC samples are within established guidelines.
- Method and instrument blanks meet acceptance criteria.
- Documentation is complete and correct (e.g., anomalies have been documented).

Additional details regarding standard QA procedures are provided in the analytical laboratory-specific QAPP.

4.8.3 Variances, Nonconformances, and Corrective Actions

Variances are deviations from approved work plans or procedures. Variance requests for field sampling and analysis procedures will be submitted to the MDA-P Closure Project Manager and approved before being implemented. Telephoned or verbal approval from the Project Manager is sufficient to proceed with the variance. All variances from field sampling and analysis procedures will be documented in the field log book. Variances from analytical laboratory procedures will be requested, approved, and documented as described in the Laboratory Quality Assurance Project Plan. The Project Manager will coordinate work plan changes with site operating personnel before authorizing approvals to proceed.

Nonconformances are uncontrolled deviations from approved procedures of project requirements that may be detected and identified by MDA-P Project personnel or QA personnel. Every nonconformance for field procedures that affects quality will be documented and reported to the Project Manager and project QA officer. Documentation will include identification of the person detecting the nonconformance, a description of the nonconformance, methods for correcting the nonconformance or a description of the variance granted and a schedule for completing corrective action, if any. Nonconformances for analytical laboratory procedures will be documented and reported as described in the Laboratory Quality Assurance Project Plan.

Corrective actions for field procedures will be implemented as described in the nonconformance report. Documentation of corrective action implementation will be submitted to the Project Manager and QA officer, through whom all corrective actions must be approved. Corrective actions for analytical laboratory procedures will be reported and approved as described in the Laboratory Quality Assurance Project Plan.

4.8.4 Data Validation/Reduction

Data validation is the systematic procedure of reviewing a body of data against a set of established criteria to provide a specified level of assurance of the data's validity before it is used. The primary concern of data review and validation is to evaluate reported data for usability. Phase 2 analytical results will be validated at DQO Analytical Level III (EPA 1992). Raw analytical data will be provided to NMED upon request. The validation process will include checks for

internal consistency, checks for transmittal errors, and checks for verification of laboratory capability. Evaluation of these criteria will involve review of the following:

- Duplicate field sample analysis
- Spiked addition recoveries
- Instrument calibrations
- Detection limits
- Intralaboratory comparisons
- Holding times
- Database entry accuracy
- Data normality outliers
- Accuracy of electronic data transfer

At the completion of the data validation process, the reviewer will summarize the results and specify the uses for which the data is suitable. Qualified data will be flagged, and qualifiers will be retained at all subsequent stages of data interpretation.

4.8.4.1 Data Review, Validation, and Verification Requirements

Review and validation of environmental data is a multistage process that involves all aspects of sample collection and analysis. Validation of investigation data will be performed by checking procedures used in the field and comparing the data with previous measurements. Data that cannot be validated will be so documented.

Analytic laboratory data will be validated by Laboratory or contractor personnel. The criteria used to evaluate the acceptability and qualification of data will closely follow EPA's functional guidelines for organics and inorganics and SW-846 (EPA 1992). If a standard EPA qualifier does not exist for a noncompliance category, a new qualifier will be generated or an existing one modified. Such qualifiers will be documented in program- or project-specific documents.

The following sections provide more detail on the criteria used in the data validation processes. When EPA guidelines are not available, the laboratory will use historical laboratory data or project-specific assigned criteria to establish the acceptability limits. The laboratory-defined

acceptability limits for accuracy for a particular method are based on the historical average percent recovery ±3 standard deviation units. Acceptability limits for precision are based on historical RPDs: acceptable RPDs range from 0 to the average historical RPD +3 standard deviation units.

Maximum allowable holding times are identified in SW-846 (EPA 1992) and are presented in Table 4-1. Holding times will be counted from the date of sample collection to the date of extraction/analysis. Criteria for qualifying data as a result of holding times are based on EPA guidance (EPA 1992). EPA guidance is specific with regard to positive (i.e., detected) results and is less specific for nondetected results. The EPA guidelines also state that data should be qualified on the basis of professional judgment.

EPA considers the following chemicals to be common laboratory contaminants:

- Acetone
- Methyl ethyl ketone (MEK; also known as 2-butanone)
- Methylene chloride
- Phthalate esters

For common laboratory contaminants and the major cations (i.e., Na, K, Mg, Fe, Ca, Al), the blank concentration shall not exceed 5 times the reporting detection limit. For other target analytes, the blank level shall not exceed the reporting limit. However, if a method blank contaminant is not a target analyte, analysis may proceed, provided that the cause of contamination is identified and immediate corrective action taken. During data validation, if field, equipment rinsate, or trip blanks samples for a site sampling event or for a sample delivery group contain detectable concentrations of common laboratory contaminants or the major cations, the analytical results will only be considered positive if the concentration exceeds 10 times the maximum concentration in the blank(s). Other compounds will be treated similarly, except that the allowed level will be 5 times the concentration detected in the field blank, equipment rinsate, or trip blank samples (EPA 1992).

During data validation, both initial and rerun surrogate results will be evaluated to determine which of the two sample analyses are more defensible. Defensibility is dependent upon the

degree of QC exceeded, sample target analyte results, and performance of reanalysis was performed within holding time. If two sets of surrogate results are reported and surrogate compounds are outside of criteria in the same direction (e.g., both high- or both low- percent recovery), a matrix interference effect has been substantiated. The data will be considered usable and the appropriate qualifier applied. In any case, the data report will list results from only one of the two analyses. The data validation report will discuss both sets of QC results (if applicable) and indicate why results were accepted or rejected.

If the laboratory control sample and the MS/MSD results are outside acceptability limits for the same spiking compound, the results of field samples for that method for the entire sample delivery group will be flagged as unusable for nondetects and as estimated for positive results.

Both field duplicates (organics and inorganics, aqueous samples only) and laboratory duplicates (inorganics only) will be analyzed. Duplicates will be evaluated on the basis of their RPDs in accordance with acceptance criteria. Positive results that do not meet the RPD criteria will be reextracted and/or reanalyzed. Both sets of results will be reported by the laboratory. During data validation, both initial and rerun duplicates will be evaluated to determine which of the two analyses is more defensible. The data report will list results from only one of the two duplicate analyses. The data validation report will discuss both sets of QC results (if applicable) and indicate why results were accepted or rejected.

RPDs are frequently large for data near the reporting limit because of analytical uncertainty at low concentrations. Therefore, alternative criteria are applied when values are below a certain multiplier of the reporting limit will be evaluated. Inorganic duplicate results within 5 times the reporting limit will be considered acceptable if the absolute difference between the sample and the duplicate is less than the reporting limit for the analyte. If one duplicate result is greater than 5 times the reporting limit and the other is less than the reporting limit, the same evaluation criteria will apply. If both results are less than the reporting limit, the duplicate precision will not be evaluated. For organic duplicate results, the same criteria will apply, except that 2 times the reporting limit will be the cutoff.

4.8.4.2 External Laboratory Data Validation

The following is a description of the external validation procedures and items that will be used to independently validate the laboratory data. The procedures will be performed on 10 percent of the data generated from the MDA-P Closure.

- Assembling all laboratory data for a sample deliver group (i.e., chain of custody documents, case narrative, laboratory data reports with surrogate recoveries and reporting detection limits, QA/QC summaries of MS/MSD, LCS, duplicate and method blank results)
- Reviewing chain of custody documents for completeness and correctness
- Reviewing laboratory analytical procedures employed for appropriateness and adherence to project requirements
- Reviewing analytical holding times (the elapsed time from sample collection to extraction, when applicable, and analysis)
- Reviewing method blank, trip blank, equipment rinsate and source water blank analytical results. Noting the detected analytes and their respective concentration
- Identifying and assessing the surrogate compounds, their spiking concentrations, the percent recoveries and relative percent differences (RPDs) between the MS/MSD analyses by method
- Assessing the LCS results, their spiking levels, the measured concentrations, the percent recoveries and the RPDs between the duplicate LCS (if required) analyses by method
- Reviewing the laboratory and field duplicate samples, the respective concentrations and the RPDs for each set by method.

The data validator may also review the following items if questions concerning the reliability of a data set arise: Contract performance, on-site laboratory audit results, and previous contract compliance issues.

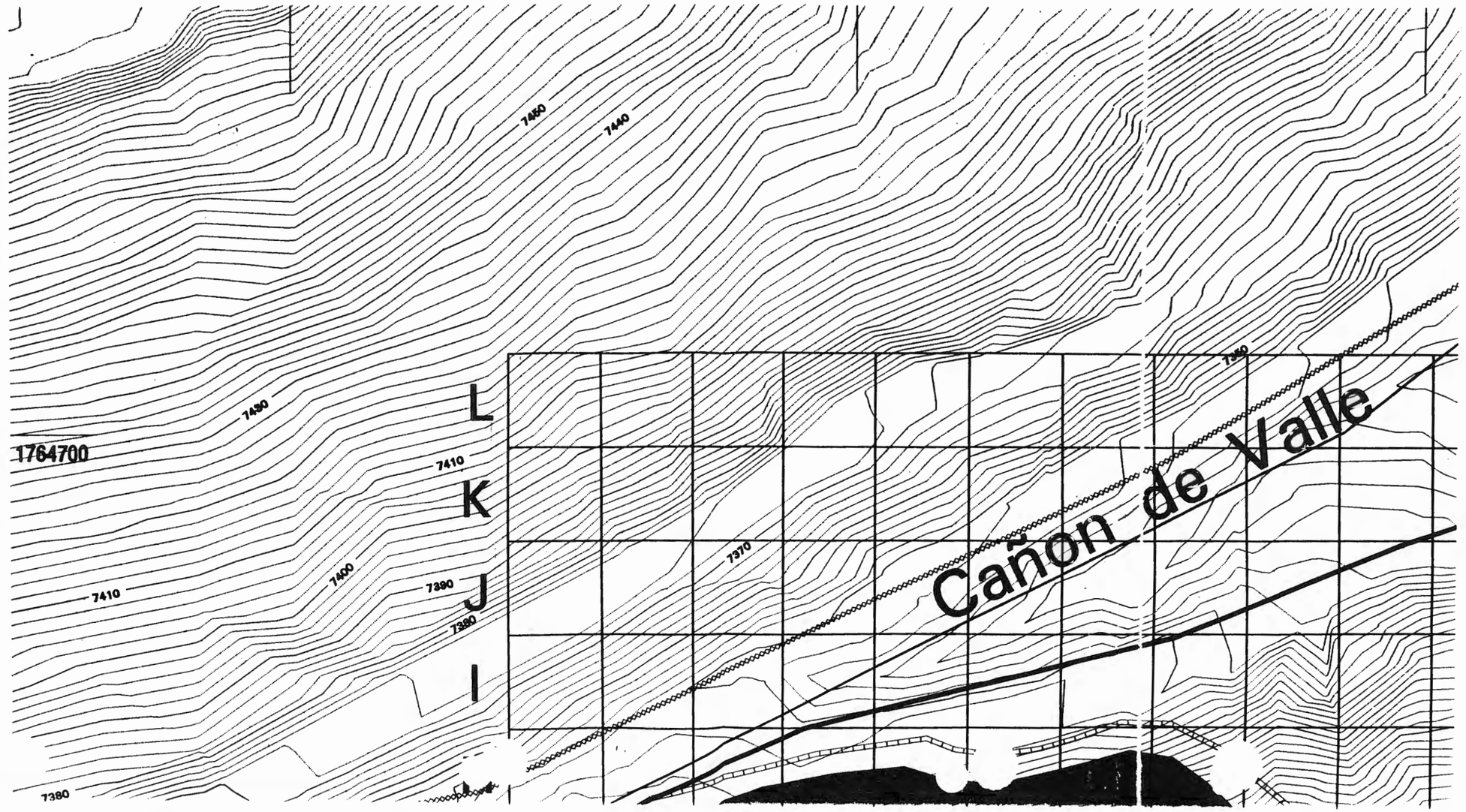
On the basis of a comparison of the data with established QC limits, qualifiers will be applied to the data as necessary to further validate a reported result.

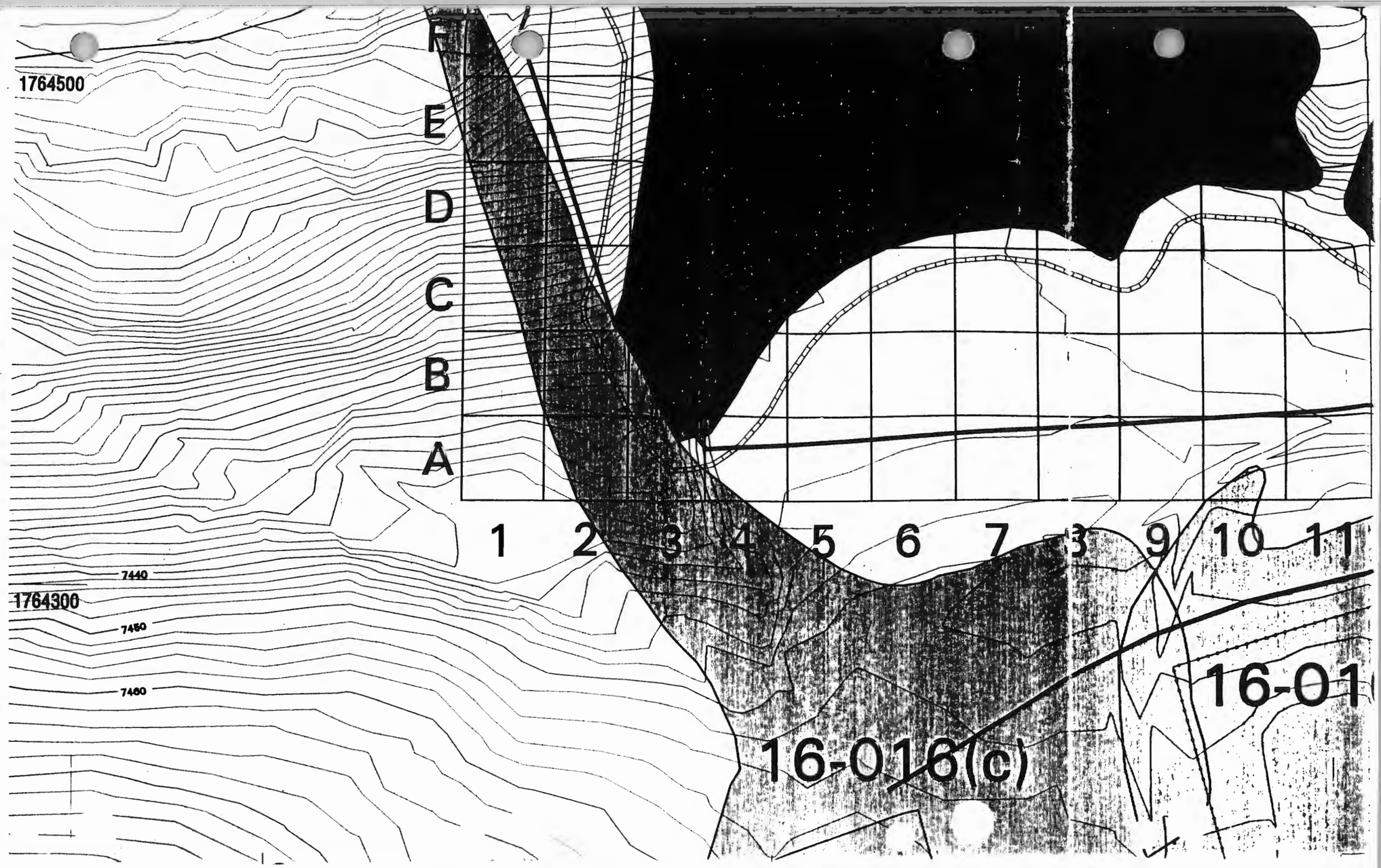
If questions arise during the validation process regarding the qualification of data, the Environmental Chemistry Group will review the item requiring resolution and decide on the appropriate course of action. In some cases, the analytical laboratory may be contacted for clarification or for submittal of missing or additional documentation. All requests shall be documented and placed in the project file.

Upon completion of validation, the data validator will prepare a validation report to be submitted to the data users. This report will include a narrative describing the usability of the data based on the results of validation along with an outline of specific QC problems and the basis on which individual data points were qualified. Copies of the data reporting forms will be attached to the Final Closure Report with validation qualifiers added.

All field and laboratory records/data will be transmitted to the ER RPF.

MDA-P SAMPLE GRID

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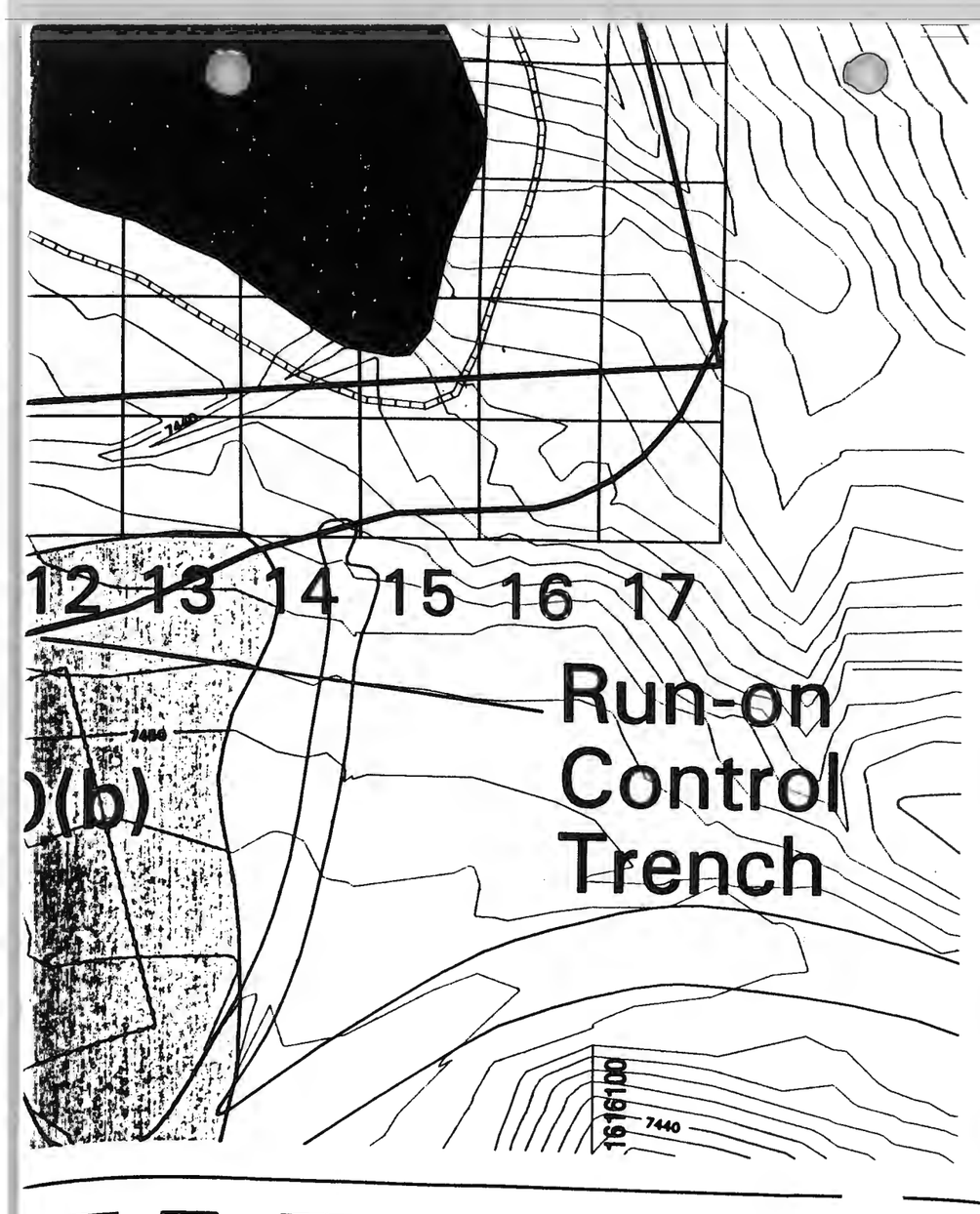
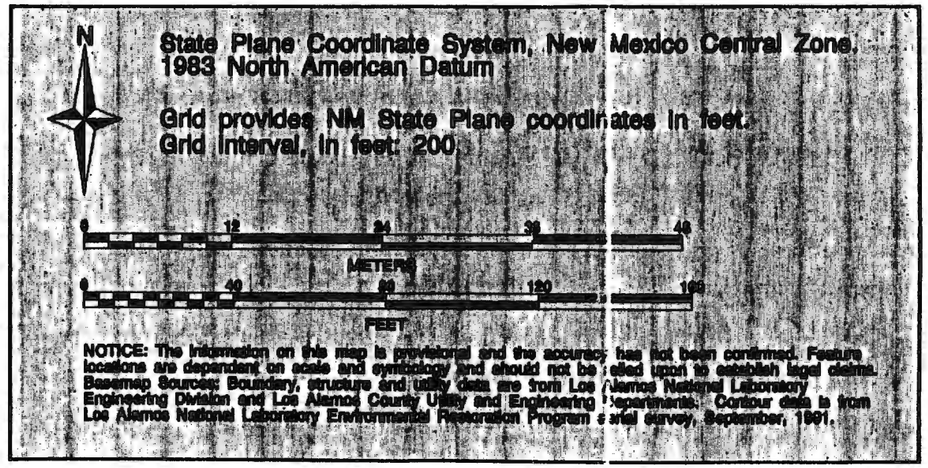
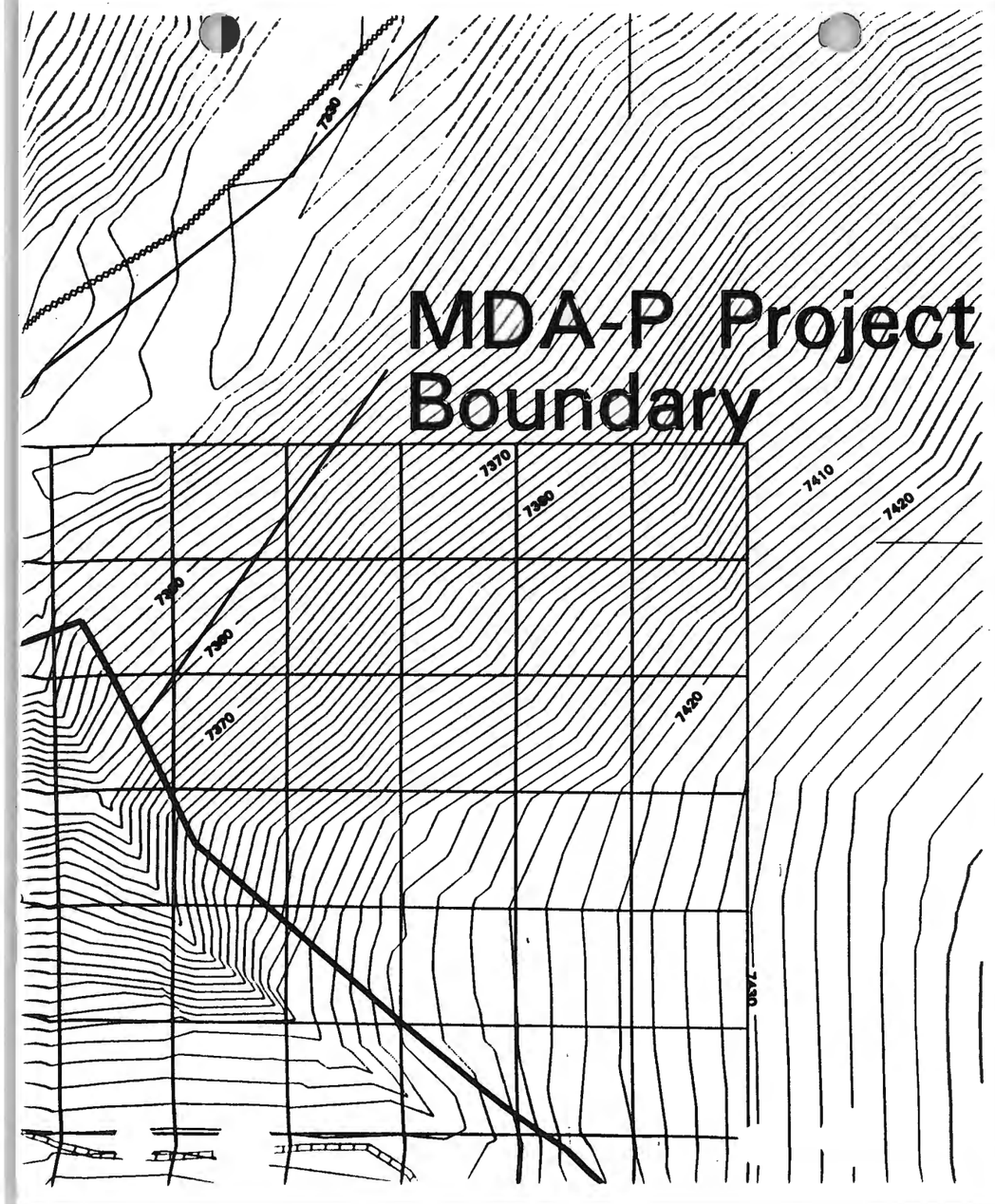


MDA-P Sample Grid
Figure 4-1



University of California
Los Alamos National Laboratory
Earth & Environmental Sciences Division
FIMAD Facility for Information Management, Analysis and Display
FIMAD is the electronic data repository for the Environmental Restoration Program at Los Alamos National Laboratory.

Produced by: Marcia Jones
Date: February 01, 1995 FIMAD Plot ID: 102932



Contours 2 ft

Drainage

Fence, Industrial

Exclusion Zone for Removal Operations

Fence, Security

10-m Grid

Road, Paved

MDA-P

PRS

5.0 GROUNDWATER MONITORING PROGRAM

On December 15, 1987, the Laboratory submitted an interim-status groundwater monitoring waiver for the laboratory including TA-16 to the NMED, as allowed under Section 265.90(c). According to Section 270.1(c), groundwater monitoring requirements under 20 NMAC 4.1, Part 264, Subpart F, are not applicable unless a postclosure permit is required. The Laboratory intends to petition NMED for a determination that a postclosure permit is not required because the closure meets the standards for closure by removal or decontamination in Section 264.258 in accordance with Section 270.1(c)(5)(ii).

The Laboratory understands that demonstrating that groundwater contamination has not occurred is a requisite for clean closure under interim status (see preamble to interim-status closure regulations, 52-FR 8705 [EPA 1987]). As described by EPA in OSWER Policy Directive No. 9476.00-14 (Lowrance 1988), interim-status units undergoing clean closure may use soil sample results to demonstrate that groundwater is uncontaminated without having a groundwater monitoring system in place. In order to clean-close without groundwater monitoring, the owner or operator must meet the decontamination standard contained in Section 270.1(c)(5) and (6) and must make a demonstration in accordance with the policy directive.

The Laboratory will evaluate the potential for groundwater contamination by the waste pile based on analytical results from deep boreholes and Phase 2 grid sampling as described in Section 4.2.1. These analytical results will be used to define the extent of vertical migration of potential contaminants in the vadose zone.

If the depth of contamination is excessive and meeting the requirements for clean closure becomes impractical, the Laboratory will propose interim measures to prevent migration of hazardous constituents and will apply for a postclosure permit.

6.0 CLOSURE AND POSTCLOSURE REQUIREMENTS

This chapter describes how the removal of the MDA-P waste pile will be conducted to meet the closure requirements in 20 NMAC 4.1. Specifically, this closure plan describes how the requirements for closure by removal or decontamination ("clean closure") will be met. After removal of the MDA-P waste pile, the clean closure requirements will be met if Appendix VIII hazardous constituents in the remaining soil or tuff are below acceptable levels as described in Section 6.1.1.2.

Section 6.1 describes general closure requirements, including the process for developing acceptable levels for demonstrating clean closure. Section 6.2 describes specific requirements applicable to closure of waste piles. Decontamination procedures are presented in Section 6.3 and Section 6.4 discusses postclosure requirements.

6.1 General Closure Requirements

This section describes how general closure requirements applicable to interim-status facilities will be met. As required by 20 NMAC 4.1 Part 270.1(c)(5), interim-status waste piles undergoing clean closure must meet the closure and decontamination standards for permitted units contained in 20 NMAC 4.1, Part 264.258(a).

6.1.1 Partial and/or Final Closure Activities [20 NMAC 4.1, Sections 265.111, 265.112, 264.258(a) and 270.1(c)(5)]

The Laboratory intends to close the waste pile in accordance with the clean closure requirements of 20 NMAC 4.1, Sections 265.111 and 264.258(a). To meet these requirements, the waste pile, including the waste residues and structures, will be removed and/or decontaminated, and disposed. All contaminated containment system components (liners, etc.), contaminated subsoils, and structures and equipment contaminated with waste will be removed and decontaminated. After the waste pile has been removed, the remaining soils and tuff containing hazardous constituents below acceptable levels may be left in place. All reusable equipment used during closure will be decontaminated.

6.1.1.1 Closure Performance Standard [20 NMAC 4.1, Section 265.111]

The waste pile will be closed in a manner that

- minimizes the need for further maintenance; and
- controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of hazardous or mixed waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to groundwater or surface waters or to the atmosphere.

This standard will be met by removal and off-site disposal of the waste pile. After removal of the waste pile, all debris, soil, equipment, and structures contaminated with Appendix VIII constituents above acceptable levels will have been removed or decontaminated. Acceptable levels are described in Section 6.1.1.2.

All equipment will be decontaminated using the procedures described in Section 6.3.1 or removed for final disposition. All residuals resulting from decontamination will be removed for final disposition as described in Section 6.3.2.

The closure performance standard does not apply to radioactive contaminants that may be present in the waste pile. Any actions necessary to protect human health and the environment from exposure to radionuclides at this site will not be addressed as part of this closure plan.

6.1.1.2 Closure/Decontamination Standard [20 NMAC 4.1, Sections 264.258(a) and 270.1(c)(5)]

The clean-closure performance standard will be met if Appendix VIII constituents in the Phase 2 shallow grid samples are below acceptable levels. These acceptable levels consist of

- background UTLs; or
- SALs (Appendix A); or
- PRGs (Appendix B).

The approach for determining whether the closure performance standard has been met is illustrated in Figure 6-1. This approach is based on two methodologies: comparison with SALs developed using the methodology outlined in the Laboratory Installation Work Plan (LANL 1993b) and development of PRGs using the methodology identified by the EPA (1991a and 1992a). As shown in Figure 6-1, the decision whether clean closure standards have been met can be made at several stages. The process is designed so that decisions can be made as early as possible. The major steps in the process are described briefly below.

The first step in the process is to review data to determine whether they meet QA/QC criteria. The QA/QC evaluation will be based on the Quality Assurance Project Plan. The level of uncertainty associated with estimated values (e.g., J-flagged data) and the potential effect this may have on the decision-making process will be discussed. Those data that do not meet the QA/QC criteria will be rejected. If the rejection of the data results in less than the minimum number of three samples within an exposure unit, additional sample(s) will be analyzed. Exposure units are discussed in Appendix B, Section B.2. If a risk assessment is required, a minimum of three samples are needed to develop a 95% upper confidence limit of the mean, which is used in estimating exposure and potential risk. Although a risk assessment could be conducted using one or two sample concentrations, the uncertainty associated with that analysis is greatly reduced by using at least three samples.

Measured concentrations of Appendix VIII hazardous constituents in soil and tuff meeting QA/QC criteria will then be compared with background concentrations of metals, radioactivity, and PAHs. Background will be defined as the 95% UTL calculated from concentrations of constituents measured in unaffected soil and tuff similar to that present near the MDA-P waste pile. If existing data are not sufficient to provide a statistically meaningful UTL, then additional samples will be collected near the waste pile in locations believed to be unaffected by releases from Laboratory facilities. Constituents in soil, subsoil, and tuff that are present at concentrations below the UTL will be eliminated from consideration.

Those constituents in soils and tuff that are present above the background UTL will then be compared with SALs. SALs are very conservative indicators of levels of contamination that could pose a health risk. Individual constituents at concentrations below SALs do not present a significant human health risk (i.e., the SAL comparison ratio [maximum concentration/SAL] for

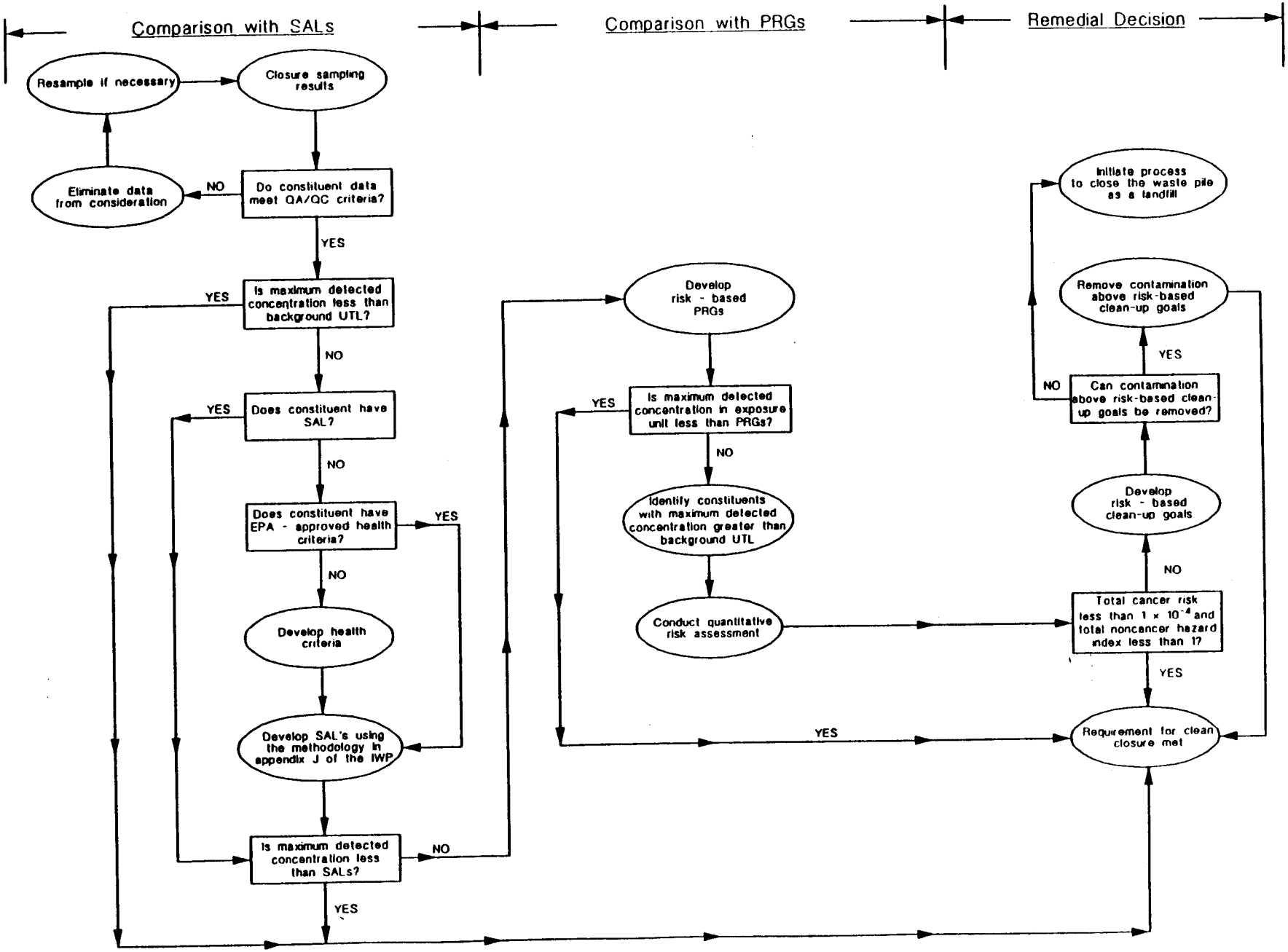


Figure 6-1. Process for Determining if Closure Performance Standard is Met

the individual constituent is less than 1). Thus, if the maximum concentration of a single constituent in soils and tuff is less than the SAL, then the clean-closure performance standard will be met for that constituent.

The additive effects of multiple constituents is similarly evaluated by adding the ratios of the SAL comparison values (maximum concentration/SAL) for each constituent with a similar toxic end point (e.g. cancer, kidney effects, liver effects). If the total value is less than 1, the additive effects of multiple constituents are not considered to present a human health risk. If multiple constituents are detected and the total sum of the SAL comparison ratios (maximum concentration/SAL) is less than 1 (LANL 1993b), then the clean closure standard will be met.

If the constituent does not have a SAL, a SAL will be developed using reference doses (RfDs) and/or cancer potency factors (CPFs) using the methodology presented in Appendix J of the IWP (LANL 1993b). RfDs and CPFs will be obtained from EPA's Health Effects Assessment Summary Tables (HEAST) and Integrated Risk Information System (IRIS). If an RfD or CPF is not available from either HEAST or IRIS, one will be requested from EPA's Environmental Criteria and Assessments Office. If there are no EPA-approved RfDs or CPFs, a health criterion will be developed using a similar constituent which has toxicological data.

If any constituent in soil or tuff exceeds SALs or the sum of the SAL comparison ratios exceeds a target value of 1, then site-specific risk-based PRGs will be developed for those constituents. Each PRG will be developed using site-specific input parameters based on a continued industrial land use scenario (Appendix B). If the maximum concentration of each selected constituent within an exposure unit exceeds its PRG (i.e., the PRG comparison ratio [maximum concentration/PRG] for the individual constituent exceeds 1) or the sum of the PRG comparison ratios for a specific target organ or effect (e.g., cancer risk) exceeds a target value of 1, then a baseline risk assessment will be conducted in accordance with EPA guidance (EPA 1989, EPA 1991a, EPA 1992). The baseline risk assessment will consider all potential pathways for continued industrial land use and all detected constituents greater than background UTL.

If the risk assessment shows that the total cancer risk is less than 1×10^{-4} and the total noncancer hazard index is less than 1, then the clean-closure performance standard will be met. If not, an amendment to the closure plan will be prepared that will provide for additional waste removal to

risk-based clean-up levels. This amendment must be approved by NMED before it is implemented.

Application of the above process to demonstrate clean closure will be documented in the Final Closure Report to be submitted to NMED, as described in Section 7.0.

6.1.1.3 Contents of Closure Plan [20 NMAC 4.1, Section 265.112(b)]

This closure plan identifies the steps necessary to perform final closure of the waste pile.

- Section 6.2.1 describes how the waste pile will be closed in accordance with the closure performance standard in Section 6.1.1.1 [20 NMAC 4.1, Section 265.112(b)(1)] and provides a general description of how final closure will be conducted [20 NMAC 4.1, Section 265.112(b)(2)].

- Section 6.2.2 identifies the maximum extent of operation that was not closed during the active life of the waste pile [20 NMAC 4.1, Section 265.112(b)(2)].

- Section 6.2.3 estimates the maximum inventory of hazardous waste in the waste pile during the active life of the waste pile [20 NMAC 4.1, Section 265.112(b)(3)].

- Section 6.2.4 provides a detailed description of the methods that will be used to remove hazardous or mixed wastes. This section also references specific sampling and analysis procedures that will be used [20 NMAC 4.1, Section 265.112(b)(3)].

- Sections 6.2.5 and 6.3.1 provide a detailed description of the steps needed to remove, decontaminate, store, and transport all hazardous waste residues and equipment. This section references methods for sampling and analysis and criteria for determining the extent of decontamination necessary to satisfy the closure performance standard [20 NMAC 4.1, Section 265.112(b)(4)].

- Section 6.2.6 provides a detailed description of other activities (including treatment of hazardous waste, if applicable) necessary to ensure that the closure performance standard is met [20 NMAC 4.1, Section 265.112(b)(5)].

- Section 6.2.7 provides a schedule for final closure of the waste pile. This schedule includes the total time required to close the waste pile and the time required to perform all of the activities described in Sections 6.2 and 6.3 [20 NMAC 4.1, Section 265.112(b)(6)].

- Section 6.3.2 provides a description of the methods that will be used to characterize, manage, store, and dispose of hazardous or mixed wastes. In addition, it identifies the off-site hazardous and mixed-waste management unit(s) to be used, if applicable, and the type(s) of unit(s) to be used. This section also references specific sampling and analysis procedures that will be used [20 NMAC 4.1, Section 265.112(b) (3)].

- Section 6.3.3. provides a description of the criteria to be used to determine the extent of decontamination necessary to meet the closure performance standard [20 NMAC 4.1, Section 265.112(b) (4)].

- Section 6.3.4 provides a description of the methods to be used for sampling and testing to demonstrate successful decontamination [20 NMAC 4.1, Section 265.112(b) (4)].

6.1.1.4 Amendment of Closure Plan [20 NMAC 4.1, Section 265.112(c)]

No changes in unit operating plans or design are expected that would require amendment to the closure plan. However, an amendment to the closure plan will be submitted to the NMED whenever

- a change occurs in the expected year of closure or

- an unexpected event is encountered during final closure activities that requires amendment to the closure plan. An unexpected event would include the discovery of hazardous waste or mixed-waste residuals that cannot be removed or decontaminated to meet the closure performance standard or additional excavation and sampling that may be required (e.g., removing contaminants in cracks or fractures).

The closure plan will be amended and submitted to the NMED within 60 days after the occurrence of an unexpected event that affects the closure plan. If the unexpected event occurs during the final closure period, the closure plan will be amended and submitted within 30 days after the unexpected event. In addition, if an approved plan is being amended, a written request to authorize a change to the approved plan will accompany the amended plan.

6.1.1.5 Notification of Closure [20 NMAC 4.1, Section 265.112(d)]

Submission of this closure plan constitutes notification to NMED of the Laboratory's intent to close this waste pile. The last receipt of hazardous waste at the waste pile occurred sometime in 1984.

6.1.1.6 Closure Activities Performed Prior to Notification of Closure [20 NMAC 4.1, Section 265.112(e)]

The Laboratory did not begin removal activities, including removal of hazardous wastes and decontamination or dismantling of equipment, prior to notification of final closure.

6.1.2 Time Allowed for Closure (20 NMAC 4.1, Section 265.113)

6.1.2.1 Extension of Closure Time Frame [20 NMAC 4.1, Sections 265.113(a),(b)]

The NMAC closure regulations require the Laboratory to remove all hazardous or mixed wastes within 90 days of closure plan approval and to complete final closure activities within 180 days after approval of the closure plan, unless a longer period has been approved.

For this project, an extension of the 90-day and 180-day closure time frames will be necessary. Removal of wastes and completion of closure activities as described in Sections 6.2.4, 6.2.5, and 6.2.6 will require at least 20 months if a risk assessment is not conducted. This extended time frame is required because of the logistics of removing relatively large amounts of waste from a steep incline and decontaminating the waste in an area that is limited in size. The time required for excavation and decontamination will depend on weather conditions and cannot be predicted with any high degree of accuracy. In addition, because the waste is potentially explosive, additional time will be necessary to implement the required safety measures. If a risk assessment is conducted, completion of closure activities will require at least 26 months. For these reasons, the Laboratory requests that NMED approve a 26-month closure time frame for waste removal and final closure. The anticipated closure schedule is presented in Section 6.2.7.

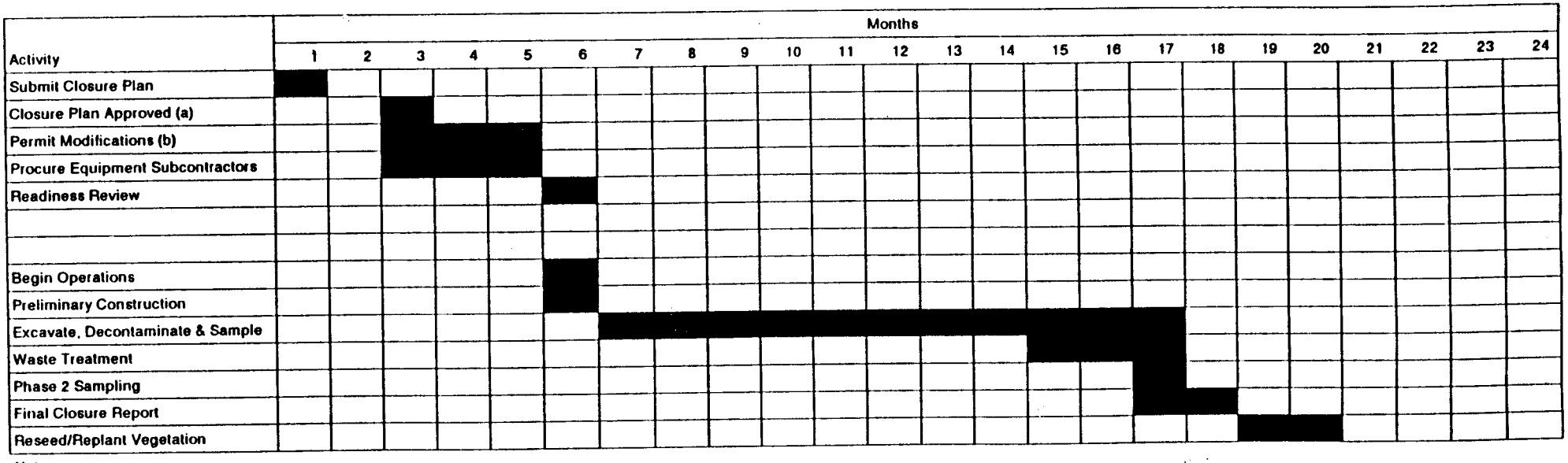
6.1.2.2 Time Frame for Demonstrations for Extensions [20 NMAC 4.1, Section 265.113(c)]

As indicated in Figures 6-2 and 6-3, at least 26 months will be required to remove wastes and complete closure activities if a risk assessment is conducted. If completion of final closure activities will take longer than 26 months from the time the closure plan is approved, the Laboratory will submit a closure plan amendment in accordance with 265.112(c).

6.1.3 Disposal or Decontamination of Equipment, Structures, Debris, and Soils (20 NMAC 4.1, Section 265.114)

During the final closure period, all equipment, structures, debris, and soil that is contaminated above acceptable levels must be properly disposed of or decontaminated. Contaminated equipment will be decontaminated in accordance with the procedures described in Section 6.3.1. Contaminated structures and soils will be identified, decontaminated, removed, and disposed of in accordance with the procedures described in Sections 6.2.4, 6.2.5, and 6.2.6. Section 6.3.2 describes how wastes generated during closure will be managed. Section 6.3.3 describes the criteria used to determine when decontamination and closure activities have met the closure performance standard. Section 6.3.4 describes the specific sampling and analysis procedures to be used to verify that all materials remaining onsite after closure meet the closure performance standard.

Project Schedule
Closure of MDA-P
Without Risk Assessment



Notes:

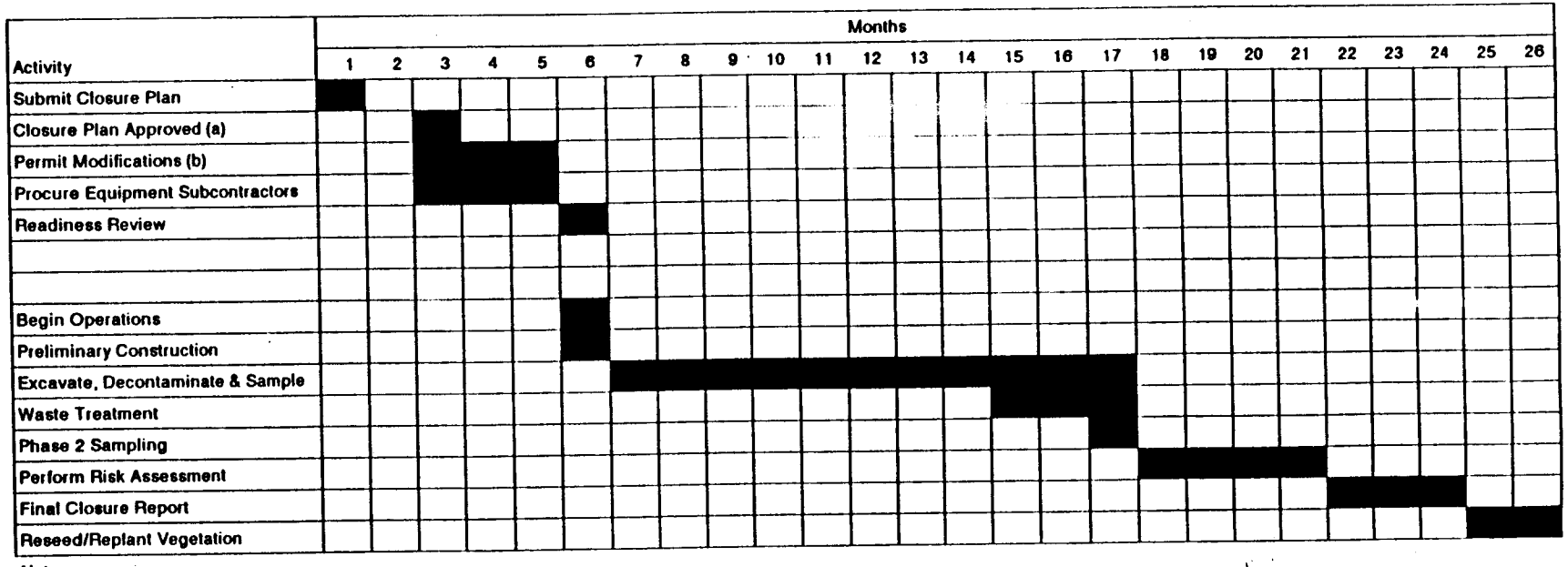
(a) Three months assumed for Closure Plan Approval

(b) Three months assumed for permit modifications

Figure 6-2. Estimated Project Schedule with No Risk Assessment

Project Schedule

Closure of MDA-P
With Risk Assessment



Notes:

(a) Three months assumed for Closure Plan Approval

(b) Three months assumed for permit modifications

Figure 6-3. Estimated Project Schedule with Risk Assessment

6.1.4 Certification of Closure (20 NMAC 4.1, Section 265.115)

Within 60 days of completion of the final closure activities described in this plan, a certification of closure will be submitted to the NMED. This certification will indicate that the MDA-P waste pile has been closed in accordance with the specifications in the approved closure plan. The closure certification will be submitted by registered mail and will be signed by the DOE Los Alamos Area Office Manager and the Laboratory Environment, Safety, and Health Division Director or their authorized representatives and by an independent, registered professional engineer. Exhibits 6-1 and 6-2 show examples of the closure certificates that will be submitted. In addition, documentation supporting the certifications will be furnished to the NMED at that time. This documentation will consist of the Final Closure Report described in Section 7.0.

6.1.5 Survey Plat [20 NMAC 4.1, Section 265.116]

This closure plan does not address closure of the waste pile as a landfill. Thus, submission of a survey plat indicating the location of landfill units is not required. If, during closure, it is determined that closing any areas as disposal units is necessary, the closure plan will be amended. The amended plan will include the survey plat requirements of 20 NMAC 4.1, Section 264.116.

6.1.6 Closure Cost Estimate [20 NMAC 4.1, Section 265.142]

A closure cost estimate is not required because federal facilities are exempt from this requirement per 20 NMAC 4.1, Section 265.140(c)

6.1.7 Financial Assurance for Closure [20 NMAC 4.1, Section 265.143]

Financial assurance mechanisms are not required because federal facilities are exempt from this requirement per 20 NMAC 4.1, Section 265.140(c).

The undersigned, the United States Department of Energy, Los Alamos Area Office as owner and former operator of the Material Disposal Area P waste pile (Facility), and the University of California, as the former operator of the Facility, located at Los Alamos National Laboratory, in Los Alamos County, New Mexico, hereby certify and state that they have permanently ceased the active operation of the Facility and have fully implemented all measures relating to the closure of the Facility as set forth in the closure plan approved by the New Mexico Environment Department for the Facility.

For the United States Department of Energy, Los Alamos Area Office (Owner/Operator):

_____
(Signature)

_____
(Name)

_____
(Title)

For the University of California (Operator):

_____
(Signature)

_____
(Name)

_____
(Title)

Exhibit 6-1. Example of Owner or Operator Closure Certification

I, _____ an independent Professional Engineer registered pursuant to the Professional Engineers registration laws of the State of New Mexico, hereby certify that I have reviewed the closure plan for the Material Disposal Area P waste pile (Facility) at Los Alamos National Laboratory, that I am familiar with the New Mexico Hazardous Waste Regulations that are applicable to the closure of such Facility, and that I personally have made visual inspection(s) of the aforementioned Facility, and that the closure of the aforementioned Facility has been performed in full and complete accordance with the Facility's Closure plan approved in writing by the Secretary, New Mexico Environment Department, on _____, 19_.

_____ _____
(Signature) (Date)

_____
(Professional Engineering License Number)

(Seal)

_____
(Business Address)

_____
(Telephone Number)

Exhibit 6-2. Example of Independent Registered Professional Engineer Closure Certification

6.1.8 Liability Requirements [20 NMAC 4.1, Section 265.147]

Liability coverage is not required because federal facilities are exempt from this requirement per 20 NMAC 4.1, Section 265.140(c).

6.2 Specific Closure Requirements for Waste Piles

6.2.1 Description of Closure of Each Unit and Final Closure [20 NMAC 4.1, Sections 265.112(b)(1) and (2), and 264.258(b)]

Phases 1 and 2 sampling and analysis are described in Section 4.0. Phases 3 and 4 sampling and analysis and additional waste removal, if required, will be presented in an amendment to this closure plan. Clean closure of the waste pile will include the following activities:

- Preparation of the site, including setting up the administrative, staging, and decontamination areas, tree removal (as necessary), and relocation of power-line poles

- Excavation of the debris and soil from the waste pile to the staging area at the top of the mesa

- Phase 1 sampling to establish background and baseline UTL's

- Phase 1 characterization sampling of the soil during the removal process and at the staging area

- Inspection and spot-testing of the debris and soil for HE contamination

- Segregation of potentially contaminated debris and soil based on physical characteristics and field instrument readings

- Segregation of radiologically contaminated debris and soil based on field screening

- Size reduction of the debris, if necessary to facilitate handling and decontamination

- Decontamination of the debris using steam/hot water at the decontamination pad to eliminate constituents of listed or characteristic waste

- Segregation of radiologically contaminated debris and potentially HE-contaminated debris after decontamination

- Open burning/detonation of potentially HE-contaminated, nonradioactive, non-hazardous debris and soil, to destroy any remaining HE contamination

- Onsite or offsite treatment of soils and decontamination wastes contaminated with barium or other constituents

- Off-site disposal of debris and soil

- Phase 2 confirmatory grid sampling of the soils/tuff beneath the waste pile to demonstrate that the clean-closure performance standard has been met

- Phase 2 deep borehole sampling to determine the vertical extent of contamination

- Phase 3 characterization sampling and analysis, if additional waste removal is necessary and if additional sampling is needed to better define the areas requiring removal

- Removal and disposal of additional soils/tuff, if closure performance standard has not been met

- Phase 4 confirmatory sampling and analysis of the soils/tuff to demonstrate that clean closure has been met if additional waste removal is necessary

- Stabilization of the site by back-filling and revegetation

- Dismantling the closure waste handling/management areas (e.g., staging, decontamination areas) and sampling soil beneath these areas to ensure that closure activities have not contaminated the area above baseline UTLs.

The Phase 1 characterization sampling and analysis activities are discussed in Section 4.1. Removal/decontamination and disposal are discussed in Section 6.2.4, 6.2.5, 6.2.6, and 6.3. Phase 2 confirmatory sampling and analysis activities are discussed in Section 4.2. Phase 3 (characterization sampling) and Phase 4 (confirmatory sampling and analysis) will be identified at a future date as discussed in Section 6.2.2. Stabilization is discussed in Section 6.2.6.

After the soil and debris in the waste pile have been removed, specific activities will be needed to demonstrate the clean closure requirements have been met (Section 6.1.1.2). These activities will depend on the extent of contamination, as determined through sampling and analysis. Demonstration of clean closure may include the following actions:

- Conduct Phase 2 confirmatory grid sampling and analysis.

- Evaluate the Phase 2 confirmatory grid sampling and analysis results as described in Section 6.1.1.2 to determine if the clean closure performance standards have been achieved or a risk assessment is necessary.

- If the clean closure performance standard has been met, submit the Final Closure Report as described in Section 7.0.

- If a risk assessment is needed, conduct the risk assessment in accordance with EPA guidance (EPA 1989, EPA 1991a, and EPA 1992b) and compare calculated risks with target risk levels for an industrial exposure scenario. If target risk levels are exceeded, risk-based clean-up goals will be developed. If these goals have not been met, additional waste will be removed to achieve clean closure.

- If additional waste will be removed, prepare an amendment to the closure plan that identifies the approach for completing closure and describes how the risk will be reduced to the acceptable levels. Submit an amendment to NMED for approval prior to implementation.

- This amendment will include either a Phase 3 or Phase 4 sampling and analysis plan. A Phase 3 site characterization sampling and analysis plan will be included if additional sampling is necessary to better define the areas requiring additional removal. A Phase 4 sampling and analysis plan will be included for confirmatory sampling of remaining soil after removal of the additional waste. If Phase 3 sampling is not necessary, this amendment will include a Phase 4 confirmatory sampling and analysis plan.

- Submit amendment to the closure plan to NMED for review and approval.

- Perform additional removal and disposal of waste and Phase 3 or Phase 4 sampling and analysis.

- If Phase 3 sampling was conducted, prepare the Phase 4 confirmatory sampling and analysis plan based on an evaluation of the results of the Phase 3 sampling.

- Submit Phase 4 confirmatory sampling and analysis plan to NMED for review and approval prior to implementation.

- After NMED approval, perform Phase 4 sampling and analysis.

- Evaluate the results of the Phase 4 confirmatory sampling and analysis based on comparison with the target cleanup levels. If the clean-closure performance standard has been achieved, submit Final Closure Plan as described in Section 7.0.

If at any time in this process clean closure of the waste pile is determined not to be feasible because of the nature and extent of contamination, the remaining waste pile will be closed as

a landfill as required by 20 NMAC 4.1, Section 265.258(b), and an amended closure/postclosure plan will be prepared and submitted to the NMED.

6.2.2 Identification of Maximum Extent of Operation [20 NMAC 4.1, Section 265.112(b)(2)]

The estimated maximum extent of operation of the waste pile is shown in Figure 1-1. The waste pile was operated from the early 1950's to 1984.

6.2.3 Estimate of the Maximum Inventory of Hazardous Waste [20 NMAC 4.1, Section 265.112(b)(3)]

The MDA-P waste pile contains an estimated 30,000 yd^3 of waste and debris. It is anticipated that 500 yd^3 of excavated soil will require treatment. This estimate is based on professional judgement and visual inspection of the waste pile.

6.2.4 Detailed Description of Removal of Waste Inventory [20 NMAC 4.1, Sections 265.112(b)(3) and (4)]

Prior to the excavation of the waste, several activities will occur. A staging area will be set up for the segregation of waste material (see Figure 2-4 in pocket at the end of Chapter 2.0). This staging area will be constructed of a 200-ft by 200-ft, 80-mil high-density polyethylene (HDPE) liner overlain by a protective layer of plywood or steel. Material will be placed at this staging area, inspected, sampled, and segregated based on physical characteristics. Immediately adjacent to this staging area, a decontamination pad will be constructed of concrete covered with an 80-mil HDPE liner. The liner will be overlain by a protective layer of plywood or steel. This decontamination pad will measure approximately 40 ft by 40 ft and will have 2-in. curbing to contain any liquids. During decontamination, plastic splash guards will be placed inside the curb of the decontamination pad to prevent liquids from coming into contact with surrounding soils. This decontamination pad will be placed inside a secondary containment system constructed of 80-mil HDPE with 4-in. curbing made of wood covered by the liner. During decontamination, the liquids in the decontamination pad will be vacuumed out into a container to prevent the liquid from overtopping curb levels. Nearby, two 40-ft by 40-ft evaporation ponds will be constructed

for the drying of treated soils. These ponds will be 2 ft deep and lined with two 80-mil HDPE liners, which are overlain by a protective layer of plywood or steel.

Two 40-ft mobile office trailers will be located at the work site for administrative and break activities. One trailer will be used as a lunch area and dressout area. The other trailer will be used for project management activities. These trailers will be connected to on-site electricity and phone lines.

Tree removal and clearing associated with the waste pile removal will begin as soon as the personnel decontamination facilities are in place. Four power poles that currently run through the affected work area will be relocated as directed by Laboratory engineers.

The waste will be excavated using a combination of several methods. The primary method of excavation will be a tracked backhoe with a 2-yd^3 bucket similar to a Caterpillar Model 310. The excavated material will be placed in 10-yd^3 dump trucks or suitable containers (e.g., roll off boxes) and transported to the segregation area.

During excavation and segregation of the waste material, size reduction may be required to facilitate handling and decontamination. The steel material will be cut using Port-O-Band™ saws or acetylene torches.

The excavation will be overseen by two safety officers. One safety officer, employed by the contractor, will be responsible for general safety. The second safety officer, employed by Laboratory TA-16 operations, will be responsible for evaluation of any HE contamination in the excavated material. Field screening procedures for detection of HE will be used at the discretion of the TA-16 safety officer. If detonatable quantities of HE or suspected HE are encountered, TA-16 personnel will be contacted to direct the removal of the HE. Prior to excavation or handling of debris, it will be visually inspected for HE and spot tested to ensure safety.

The second excavation method will involve the excavation of controlled bench cuts using tracked bulldozers (similar in size to a Caterpillar D-8) and tracked excavators. The benches will be cut into the face of the mesa to ensure safe excavation of material below the bench with the

backhoe. The material will be transported to the dump trucks using front-end loaders or may be loaded directly into the trucks with the backhoe.

A third method of excavation that might be necessary involves the operation of a dragline combined with winch lifting and crane lifts. A crane may also be used in combination with a clamshell or electric magnet.

Certain wastes (e.g., concrete blocks) that lie on the slope of the mesa may be removed by demolition with pneumatic air hammers mounted on tracked excavators or hand-held pneumatic air hammers. This material will be reduced to manageable sizes, loaded into dump trucks, and transported up the access road to the segregation area for handling and decontamination.

During excavation, material will be radiologically surveyed by health physics personnel under the direction of a Laboratory-qualified radiological control technician (RCT). Radiological waste is not expected but if found it will be separated from nonradioactive waste and placed in containers as directed by the Laboratory RCT.

After the waste pile is removed, excavation will continue into the underlying subsoils and tuff. Field instruments will be used while performing this overexcavation. Excavation will continue until the closure standards are thought to have been reached. This overexcavation is estimated to be approximately 2 ft deep. Field screening instruments and visual inspection will be used to determine the depth of the over-excavation. Some areas will be excavated to different depths than others.

All equipment that came in contact with waste will be decontaminated as described in Section 6.3.1. The wastes generated during closure will be managed and disposed of as described in Section 6.3.2.

6.2.5 Detailed Description of Closure of Waste Residues [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114]

The remaining soil and tuff potentially contaminated by the waste pile will be sampled as described in Section 4.2. The results of the Phase 2 shallow grid sampling will be used to

determine if the clean-closure performance standard has been met, as described in Section 6.1.1.2. If results indicate that the standard has not been met, removing contaminated soil and/or tuff may be necessary. The specific methods and procedures to be used for closure will depend on the extent of contamination. Any expected removal can be performed with wheel- or track-mounted excavation equipment. All equipment used to remove waste residues will be decontaminated as described in Section 6.3.1. MDA-P debris will be decontaminated using hot water and steam to remove any HE, as well as Appendix VIII constituents. After decontamination, the material will be tested and certified free of HE by the TA-16 safety officer.

After all equipment is decontaminated through steam cleaning the decontamination pad and evaporation ponds will be steam-cleaned. In addition, all structures and equipment that may have come into contact with waste will be disassembled and/or decontaminated as appropriate. All equipment, structures, liners, concrete, etc. will be visually inspected to ensure no visible contamination remains. A final rinsate sample will be collected and analyzed as described in Chapter 4.0. If Appendix VIII constituents are not detected in the final rinsate samples, then the debris will be sent to a RCRA Subtitle D disposal facility and the equipment, the decontamination pad, evaporation ponds, and other structures will be sent to RCRA Subtitle D disposal facilities or reused if appropriate.

All contaminated soil and tuff will be packaged, labeled, stored, and transported in accordance with approved Laboratory waste management procedures. Wastes determined to be hazardous, mixed, or low-level radioactive will be transported to a treatment, storage, or disposal facility as described in Section 6.3.2. Selection of the disposal site will depend on the waste characteristics, waste acceptance criteria, and disposal costs.

After all equipment, pads, and ponds are removed, the subsoils below these areas will be sampled and analyzed as described in Chapter 4.0. As described in Section 6.1.1.2, the analytical results of the Phase 2 grid samples will be compared with acceptable levels to determine if further activities are needed to demonstrate clean closure. It may be possible to compare results directly with SALs or risk-based PRGs to demonstrate that closure standards have been met. Alternatively, it may be necessary to perform a risk assessment. The risk assessment may indicate that existing levels of constituents are acceptable or that additional removal is necessary.

If removal is necessary, an amendment to the closure plan will be prepared that identifies how additional waste will be removed. This plan must be submitted to NMED for approval prior to implementation. Phase 3 site characterization sampling may be necessary to better define the contaminated areas that require removal. Phase 4 confirmatory sampling and analyses will be required to ensure that the contamination has been removed to acceptable levels. After the clean closure performance standards have been met, the closure waste handling/management areas will be dismantled and the soil beneath these areas will be sampled to ensure that the closure activities have not contaminated the area above the baseline UTLs. Any contamination above the baseline UTLs will be removed and confirmatory samples will be collected. Following completion and certification of clean closure under 20 NMAC 4.1, the site will be stabilized by placing topsoil and backfill as appropriate. The area will be reseeded and replanted with native vegetation. The area will be periodically inspected to ensure the replanting is successful.

The results of the radiological and chemical analysis of samples will also be used to determine site-specific health and safety requirements for subsequent closure activities. Preventing atmospheric release of RCRA constituents, as needed to meet the closure performance standard under 20 NMAC 4.1 265.111, will be addressed in the development of risk-based cleanup levels.

6.2.6 Detailed Description of Other Necessary Activities [20 NMAC 4.1, Sections 265.112(b)(5) and 265.114]

Steam cleaning will be used to remove barium, toxic metals, and other hazardous constituents from the debris. If the debris is visibly uncontaminated after decontamination, it will be considered uncontaminated with barium, toxic metals, and other hazardous constituents. Results of visual inspections and decontamination will be documented.

After steam cleaning, debris with inaccessible areas or with extreme deterioration will be placed on the burn pad for flashing by TA-16 personnel to ensure destruction of any potential HE.

Burning of combustible waste and flashing of steel components will be conducted at the TA-16 burn pad adjacent to the waste pile. Burning will be conducted under an existing burn permit

from the NMED Air Quality Bureau. During burning operations at TA-16, no personnel access will be allowed to MDA-P. TA-16 burn schedules and the contractor schedules will be coordinated to minimize project delays and TA-16 operation delays.

On-site treatment of contaminated soils or liquids will be conducted in tanks meeting the requirements of 20 NMAC 4.1, Sections 264.192 through 264.199. The treatment will occur in less than 90 days and is exempted from permit requirements as described in 20 NMAC 4.1, Section 262.34. These tanks will be used for the closure of the MDA-P waste pile only. The life span of these tanks is limited to the duration of the closure which is expected to be 20 months. As identified in 20 NMAC 4.1, Section 264.193(g), these tanks will be designed and operated to prevent migration of hazardous waste or constituents to the ground water or surface water. All tanks will be inspected daily to ensure no hazardous constituents can spread to the environment. All tanks will be covered with tarps at the end of each day's use. On-site treatment is expected to consist of stabilizing barium-contaminated soils. The soil will be loaded into a hopper and placed in a mixer. It is expected that 12-yd^3 batches will be mixed using mix equipment similar to a Maxon Paddle Mixer or possibly a 10-yd^3 cement mixer truck. The mixer will be placed in a secondary containment system consisting of an 80-mil HDPE liner with 4-in. curbing made of wood. The equipment will be supported with a concrete pad. The mixer and containment structure will be inspected daily and repaired as necessary to ensure no hazardous constituents can spread to the environment. All equipment will be covered with tarps after the end of each day's use. After rain events, water in treatment tanks will be pumped into containers and sampled and managed based on analytical results. The material will be mixed with a 40% solution of ammonium sulfate. An estimated 15-gal. or less of ammonium sulfate solution will be required for each cubic yard of waste. The mixture is expected to produce a moisture-free stabilized soil that will pass the paint-filter test (EPA 1992). After stabilization, the mixture will be placed in the evaporation ponds with a front-end loader for 24 hours to ensure it is dry enough to transport to the disposal facility. After successful sampling results indicate the soil no longer exhibits the TC for barium, the waste will be sent to a permitted off-site solid waste disposal facility. Water and sludge collected during decontamination will be mixed and stabilized with the soil.

Limited treatability studies will be conducted by on-site personnel or Laboratory-approved laboratories to confirm the stabilization formula prior to full-scale treatment. Two 100 mL samples

will be collected for the treatability study. The sample with the highest level of contaminants will be selected for the treatability study. If the treatability study is conducted onsite, the NMED Director will be notified in writing no less than 45 days before conducting the study. Treatability studies will be conducted in accordance with 20 NMAC 4.1 Section 261.4(e) and (f).

Surface water run-on will be controlled during the closure of this waste pile. The asphalt trench at the top of the waste pile will be used to prevent water from running into the waste pile. The asphalt trench will be inspected and repaired as necessary to prevent water run-on from entering the waste pile. This water will be discharged to the stream below under existing storm-water discharge requirements for TA-16. Areas where excavations are currently in progress or with newly exposed surfaces will be covered during storm events with tarps or some other type of covering to minimize rain water from entering these areas.

Water run-off will be collected in plastic-lined trenches at the base of excavation sites and along the entire base of the waste pile and pumped into containers. This run-off water will be sampled and analyzed for the waste constituents present in the waste pile as discussed in Chapter 4.0. This water will be managed based on sampling results. Additional trenches will be added as needed to ensure all run-off is collected.

Waste handling and management units will be lined with 80-mil HPDE liners and curbed to prevent infiltration from rainwater. These units will be covered during storms with tarps. Any storm water entering the units will be collected, sampled, and managed according to sample results.

Excavated waste will be placed in lined containers such as rolloff boxes and transported to the segregation area. This 200-ft by 200-ft segregation area will be constructed near the waste pile and lined with an 80-mil HDPE liner protected by an earth cover. This segregation area will be used for temporary storage of soils/debris in rolloff boxes or other containers and temporary storage of liquids in drums. This area will also be used to store excavation equipment and contain the soil treatment tanks. This area will have a 4-in. curb to serve as secondary containment and will prevent water runoff and runon. The treatment tank used for soil stabilization will be within this segregation area and separately bermed. This berm will serve as secondary containment to prevent contamination of the earth cover. The liquids stored in the

segregation area will be temporarily stored in a separately bermed area. All containers including rolloff boxes, drums, tanks, etc. will be properly labeled as required to 40 NMAC Section 262.34. The approximate location of this segregation area is shown on Figure 2-4.

Two temporary storage areas outside of MDA-P will be used to store treated debris and soils. Before being shipped, this material will be stored until sampling results have been received. If analysis indicates treatment standards were not met, the waste will be returned to the segregation area for additional treatment. These storage areas will be lined with an 80-mil HDPE liner and curbed with 4-in. wood. The liner will be protected with plywood or steel. The approximate location of these storage areas is shown in Figure 2-4.

6.2.7 Schedule for Closure of Each Unit [20 NMAC 4.1, Section 265.112(b)(6)]

The estimated schedule for clean closure of the MDA-P waste pile is presented in Figures 6-2 and 6-3. Figure 6-2 presents the schedule for demonstrating clean closure if a risk assessment is not required. Figure 6-3 presents the schedule for demonstrating clean closure if a risk assessment is required.

If a risk assessment is not required, the total time to complete closure is estimated to be 20 months. If a risk assessment is necessary but additional waste removal is not required, the total time to complete closure is estimated to be 26 months. If additional removal is required, then a revised closure schedule will be included in the amendment to the closure plan. This schedule assumes no unanticipated delays by regulatory authorities or TA-16 site operations.

6.3 Decontamination Procedures [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114]

Decontamination efforts during closure of the MDA-P waste pile will involve decontamination of sampling equipment, waste removal equipment, waste containers, and the materials used to construct the staging, decontamination, treatment and container storage areas.

6.3.1 Procedures for Cleaning Equipment and Removing Contaminated Soils [20NMAC 4.1, Section 265.112(b)(4) and 265.114]

Decontamination will take place at the decontamination pad. Before starting the decontamination process, the condition of the decontamination pad liner will be evaluated to determine if it is in suitable condition. The liner will be inspected for tears, holes, and integrity of any seams. If the liner is judged to be in unsatisfactory condition, a new liner will be installed.

Sampling equipment and any other small equipment that comes into contact with contaminated material will be decontaminated after use. Decontamination of small equipment will be performed as follows:

1) Equipment will be thoroughly scrubbed using a nonhazardous detergent solution approved by TA-16 personnel. Detergent strength will be per the manufacturer's recommendations. All visible signs of contamination will be removed.

2) Equipment will be thoroughly rinsed with clean tap water so that no detergent is left on the equipment.

3) If necessary and if approved by TA-16, the equipment will be rinsed with methanol or dilute acid. In general, the use of methanol or acids will be avoided; these will only be used if the detergent is ineffective in removing all contamination.

4) Equipment will be rinsed with deionized water.

5) If the equipment is not to be used immediately, it will be allowed to air dry and will be wrapped with clean polyethylene or with aluminum foil, with the dull side of the foil toward the equipment.

6) Equipment decontamination liquids will be sampled and analyzed as described in Section 4.3.1.

Large equipment will be decontaminated by steam cleaning using water or a nonhazardous detergent solution approved by TA-16 personnel. This equipment will be steam-cleaned until all visible contamination is removed and then rinsed with clean tap water. A sample of the final water rinse will be collected to verify decontamination.

After all equipment decontamination is complete, the materials used to construct the staging, decontamination, treatment, and container storage areas will be decontaminated by steam cleaning, followed by rinsing with clean water. Next, the liners will be decontaminated in place by steam cleaning, followed by rinsing with clean water. If the liners are not radioactive and are visibly contaminated, they will be disposed of as nonradioactive, nonhazardous waste.

Decontamination wastes (i.e., liquids and sludges) will be placed in appropriate containers. The containers will be lined with material (e.g., polyethylene) that is compatible with the detergent and any contaminants expected to be present in the decontamination wastes.

After the waste containers are sealed, all visible contamination (e.g., soil) will be removed from the surface by wiping with detergent-soaked rags. If the waste is radioactive, the surface of the waste container will be radiologically surveyed to determine if total and removable contamination meets target limits. If not, additional decontamination will be performed.

6.3.2 Management of Generated Wastes [20 NMAC 4.1, Sections 265.112(b)(3) and 265.114]

Wastes that may be generated during closure of the MDA-P waste pile include debris, soil and tuff, personal protective clothing, disposable sampling equipment, decontamination liquids, and construction materials (i.e., concrete pads and liners). These wastes will be characterized based on the sampling and analysis as described in Section 4.1, 4.2 and 4.3.

Based on existing waste characterization data (see Chapter 3.0), the excavated debris and equipment used during closure is expected to be easily decontaminated with steam and rendered nonhazardous. Certain generated soils and water are expected to exhibit the TC for barium and will be managed as hazardous waste.

If wastes or debris exhibit a characteristic identified in 20 NMAC 4.1, Part 261, Subpart C, or are listed waste identified in Subpart D, they will be managed as hazardous waste.

If Appendix VIII constituents are not detected in the final rinsate samples, then the debris will be sent to a RCRA Subtitle D disposal facility and the equipment, the decontamination pad,

evaporation ponds, and other structures will be sent to RCRA Subtitle D disposal facilities or reused if appropriate.

The wastes generated during closure will be packaged, labeled, and transported in accordance with Laboratory-approved waste management procedures.

Wastes determined through sampling and analysis to be hazardous wastes will be packaged and transported in accordance with the requirements of 20 NMAC 4.1, Part 262, Subpart C, the waste acceptance criteria of the designated disposal facility, and the Department of Transportation (DOT) requirements. Storage of hazardous wastes will be in a segregated and controlled staging area. These hazardous wastes will be managed according to characterization results and treated onsite or offsite. Loading and unloading of containers holding hazardous waste will be conducted inside controlled exclusion zones.

Wastes that are determined through sampling and analysis to be hazardous wastes will be transported to an off-site facility for treatment, storage, or disposal. Off-site facilities that may be used for hazardous wastes include Chemical Waste Management Inc.'s Kettleman Hazardous Waste Facility in California and the Rollins Environmental Services facilities at Deer Park, Texas and Baton Rouge, Louisiana. If none of the off-site facilities can accept the wastes, the wastes will be taken to a permitted-status storage facility at TA-54, Area L and stored until a suitable off-site facility is available. If TA-54 is not permitted to manage wastes that are generated, a revised RCRA Part A permit modification request will be submitted to the NMED.

Wastes that are determined through sampling and analysis to be nonhazardous, low-level radioactive wastes will be transported to TA-54, Area G or to an off-site facility for treatment, storage, or disposal. Off-site facilities that may be used for this purpose include the Envirocare of Utah, Inc. facility near Clive, Utah; the U.S. Ecology site at the U.S. DOE Hanford site near Richland, Washington; the U.S. DOE Hanford site itself; and the U.S. DOE Nevada Test Site near Mercury, Nevada.

Wastes that are determined to be mixed wastes will be transported to the Envirocare of Utah, Inc. facility for treatment, storage, or disposal. They also may be treated onsite in tanks as described in Section 6.2.6. If the off-site facility cannot accept the wastes and if onsite treatment is not

approved, the wastes will be taken to a interim-status storage facility at TA-54, Area L and stored until a suitable off-site facility is available. If any of the mixed wastes to be stored exceed land disposal restriction treatment standards, storage will be addressed in the Federal Facility Compliance Agreement for the Laboratory.

Selection of the disposal site will depend on the waste characteristics, waste acceptance criteria, and disposal costs.

6.3.3 Criteria for Determining the Extent of Decontamination Necessary [20 NMAC 4.1, Sections 265.112(b)(4) and 265.114]

Criteria for decontamination will depend on the type of material being decontaminated. Criteria for equipment decontamination are qualitative based on how and where the equipment is used. Reusable sampling equipment will be decontaminated following use, primarily to avoid cross-contamination of samples. Other equipment, including disposable equipment, that comes into contact with the waste piles or the soils/tuff beneath the waste pile will be decontaminated. Any other equipment used in the control area established in accordance with the SSHASP will also be decontaminated. All equipment will be decontaminated to remove contaminants known or suspected to be present. The equipment decontamination procedures described in Section 6.3.1 are designed to remove the potential constituents identified in Chapter 3.0.

6.3.4 Methods for Sampling and Testing to Demonstrate Success of Decontamination [20 NMAC 4.1, Section 265.112(b)(4) and 265.114]

Decontaminated equipment will not be sampled to determine the effectiveness of chemical decontamination. Rather, effectiveness will be based on knowledge of the contaminants present, known effectiveness of the decontamination agents used, removal of all visible evidence of contamination, and collection of rinsate samples, as described in Section 6.3.1. These rinsate samples will be analyzed as described in Section 4.7.1.

Equipment and waste containers that are radiologically contaminated will be surveyed following decontamination to verify that any radioactivity is below Laboratory release limits.

6.4 General Postclosure Care Requirements

[20 NMAC 4.1, Sections 264.258(b), 265.116 - 265.120, 265.144, and 265.145 and 265.147]

As currently described in this closure plan, the MDA-P waste pile will not be closed as a landfill. As a result, postclosure care requirements are not applicable per 20 NMAC 4.1, Section 265.110(b). If, during closure, it is determined that all hazardous waste residues cannot practicably be removed to below PRGs, an amended closure plan will be submitted to close the waste pile as a landfill as required by 20 NMAC 4.1 Section 264.258(b). If so, an amended postclosure plan will be prepared that addresses the applicable requirements of 20 NMAC 4.1, Sections 264.116 through 264.120. The amended postclosure plan will be prepared and submitted to the NMED within 90 days of determination of the need for such a plan.

If a postclosure plan is necessary, a postclosure cost estimate (20 NMAC 4.1, Section 264.144), a financial assurance mechanism for postclosure care (20 NMAC 4.1, Section 264.145), and liability requirements (20 NMAC 4.1, Section 265.147) will not be required because federal facilities are exempt from those requirements per 20 NMAC 4.1, Section 264.140(c).

7.0 CLOSURE REPORTS

Upon completion of closure activities, a Final Closure Report will be submitted to the Secretary of the NMED. Copies of all analytical reports will be appended to the Final Closure Report. The Final Closure Report will include the results of the Phase 1 and Phase 2 sampling and analysis and the details regarding the disposition of the waste that was removed. If a risk assessment was necessary, the Final Closure Report will include results of the risk assessment. If additional waste removal is required, the Final Closure Report will include results of the Phase 3 sampling and analysis, if any, and Phase 4 sampling and analysis.

The Final Closure Report will include the following information:

1) The certifications described in Section 6.1.4

2) Any variance from the activities described in the approved closure plan and the reason for the variance, any nonconformance reports for field and/or laboratory procedures that affect data quality, and documentation of corrective action implementation for nonconformances of field and laboratory procedures

3) A tabular summary of Phase 1 analytical results and Phase 2 analytical results, showing

   a. sample identification;

   b. sampling location;

   c. the data reported;

   d. detection limit for each datum;

   e. identification of analytical method.

4) Laboratory data analysis sheets

5) A QA/QC statement on the adequacy of the analyses and the decontamination demonstration

6) The location of supporting documentation, including

   a. field log books;

   b. QA/QC documentation; and

   c. chain-of-custody records.

7) Disposition and disposal location of all regulated and nonregulated residuals

8) A certification of the accuracy of the report

9) A demonstration of equivalency with closure requirements under 20 NMAC 4.1, Part 264.228 in accordance with 20 NMAC 4.1, Part 270.1(c)(5)(ii)

10) A demonstration that groundwater contamination has not occurred and that EPA policy guidance requirements have been met, as described in Chapter 5

11) An evaluation of the Phase 2 grid confirmatory analytical results, including

   a. comparison with QA/QC criteria;

   b. comparison with background UTLs, if applicable;

   c. comparison with SALs;

   d. for those constituents without previously established SALs, comparison with calculated SALs based on health criteria;

   e. comparison of baseline UTLs established before and after closure; and

f. evaluation of the vertical extent of contamination based on the analytical results from the deep boreholes.

12) A PRG comparison of those Phase 2 grid confirmatory analytical results that exceeded SALs

13) The results of the risk assessment, if a risk assessment was necessary, including a comparison of the calculated risks against target risk levels

14) Development of risk-based clean-up levels

15) Phase 3 and Phase 4 sampling and analysis plans and the analytical results, if Phase 3 and Phase 4 sampling was necessary, including

a. a description of and a figure showing sampling locations;

b. a tabular summary of the analytical results including the information in items 3 a-e above; and

c. figures delineating the estimated areas requiring removal of decontamination based on Phase 2 and 3 sampling and the figures delineating the areas actually removed.

16) An evaluation of the Phase 4 confirmatory analytical results based on comparison with the risk-based clean-up levels that were used to determine whether the clean-closure performance standard was met

17) The approach for completing closure, including

a. the approach for demonstrating clean closure based on the comparison of the analytical results with SALs or PRGs, or, if a risk assessment is necessary, on the evaluation of the analytical results and target risk values; or

b. the approach for completing closure if clean closure is not feasible (e.g., amending the closure plan for landfill closure).

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APPENDIX A

DERIVATION OF SCREENING ACTION LEVELS (EXCERPTED FROM APPENDIX J OF THE INSTALLATION WORK PLAN FOR ENVIRONMENTAL RESTORATION. TABLES J-1, J-2, AND J-3 HAVE BEEN SUBSTITUTED WITH THE MOST CURRENT SCREENING ACTION LEVELS FROM THE FACILITY FOR INFORMATION MANAGEMENT AND DISPLAY (FIMAD)

1.0 INTRODUCTION

Screening assessments are performed at Los Alamos National Laboratory (the Laboratory) to identify the presence of contaminants of concern at potential release sites (PRSs). Contaminants of concern are constituents whose concentration levels in one or more environmental medium are above a level of concern defined by medium-specific screening action levels (SALs). The screening assessment begins with the identification of potential constituents and environmental media of concern based on knowledge of the history and processes that occurred at a PRS. Existing or new environmental data collected during the Resource Conservation and Recovery Act (RCRA) field investigation (RFI) are then compared with SALs for the constituents identified.

The principal test carried out during screening assessments is the comparison of sampling data with SALs. If SALs are not exceeded, the PRS may be recommended for no further action (NFA). If SALs are exceeded, further evaluation, either statistical or by sampling, is required at the PRS. However, some additional screening may be necessary if two or more constituents are present to determine the potential for combined effects. When SALs are lower than background concentrations, constituent concentrations are compared with background distributions as an additional step in screening assessment. Table J-1* presents a summary of SALs for nonradiological potential chemicals of concern. The SALs for radionuclides are presented in Table J-2.

SALs will be used only for screening assessments and are not to be used as cleanup criteria in a corrective measures study or corrective measures implementation. If the results of the screening assessment show that chemical-specific levels are exceeded, more site-specific data and analysis may be needed.

2.0 SCREENING ACTION LEVELS FOR NONRADIOLOGICAL CONSTITUENTS

The Environmental Restoration (ER) Program at the Laboratory takes its primary direction from EPA guidance (EPA 1989, 0088). Subsequent guidance, Corrective Action for Solid Waste Management Units (Subpart S) (EPA 1990, 0432), a proposed regulation under RCRA, presents a methodology for calculating action levels to determine the need for further evaluation of contamination in various environmental media (i.e., groundwater, surface water, air, and soil). The action levels are calculated using chemical-specific toxicity values and default exposure parameters. In order to comply with the Hazardous and Solid Waste Amendments (HSWA) Module for the Laboratory, SALs have been developed that follow the Subpart S methodology for exposure parameter defaults but that incorporate more recent toxicity values available from the Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS) data base (EPA 1993, 1062) and Health Effects Assessment Summary Tables (HEAST) (EPA 1992, 0833), which are updated periodically.

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*In this appendix, the tables are located after the text.

2.1 Assumptions

A summary of the nonradiological SAL values is presented in Table J-1. These values are based on the methodology presented under proposed Subpart S (EPA 1990, 0432) and on toxicity values (i.e., reference doses (RfDs) and carcinogenic slope factors) from the IRIS data base (EPA 1993, 1062) or the HEAST (EPA 1992, 0833). Table J-3 contains the toxicological information used for establishing nonradiological SALs. The constituents included in Tables J-1 and J-3 are those on the EPA's Target Analyte List (EPA 1991, 0814), Target Compound List (EPA 1991, 1074), and potential high-explosive compounds used at the Laboratory. Other constituents may need to be added as the results of site characterization become available. Tables J-1 and J-3 will be updated annually to reflect any modified toxicity values.

SAL derivations are based on the following assumptions and equations contained in proposed Subpart S:

1. To take the most conservative approach in deriving soil SALs that consider systemic (i.e., noncarcinogenic) effects, the model assumes that a 16-kg child ingests soil at a rate of 200 mg/day.. For carcinogenic constituents in soil, the long-term exposure of an adult is modeled. For this calculation, it is assumed that a 70-kg adult ingests soil at a rate of 100 mg/day over a 70-yr exposure duration.

2. A modification of the Subpart S methodology has been introduced to account for exposure to organic compounds volatilizing from soil. The modification is applied to account for potential inhalation exposure, as presented in more recent EPA guidance for calculating preliminary remediation goals (EPA 1991, 0302). The Laboratory's Environmental Restoration (ER) Program has selected this approach because SALs for volatile substances calculated using this modified approach are lower (i.e., more conservative) than those calculated using the unmodified Subpart S method. For the purpose of calculating SALs, volatile constituents are defined as those with a molecular weight less than 200 and a Henry's Law Constant greater than 1×10^{-5} atm/m^3-mole (EPA 1991, 0302).

   The equation for calculating SALs for volatile constituents has been expanded to account for potential inhalation exposure (equations are given in Section 2.2, below). The soil-to-air volatilization factor was calculated based on an equation given by EPA (1991, 0302) and chemical-specific parameters (Strenge and Peterson 1989, 0837; EPA 1988, 0747). The default particulate emission factor was used in SAL calculations for volatile constituents to maintain consistency with the equation given in EPA guidance (EPA 1991, 0302), although this factor is so low that it does not affect the calculated SALs. To calculate SALs for volatile constituents that have systemic effects, the investigators use a model in which a 16-kg child ingests soil at a rate of 200 mg/day and inhales 20 m^3/day of air. The SAL calculation for carcinogenic volatile constituents models exposure of a 70-kg adult over a 70-yr exposure duration, with a soil ingestion rate of 100 mg/day and an

inhalation rate of 20 m^3/day.

3. In deriving SALs for constituents in water, it is assumed that a 70-kg adult ingests water at a rate of 2 L/day over a 70-yr exposure duration. These SALs apply to constituents in both groundwater and surface water.

4. In deriving SALs for constituents in air, it is assumed that a 70-kg adult inhales air at the rate of 20 m^3/day, 70-yr exposure duration.

5. Proposed Subpart S specifies the use of maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act as action levels for groundwater constituents. Subpart S also indicates that state water quality standards established pursuant to the Clean Water Act, Section 303c, will be used as action levels for surface water constituents when these standards have been established for the surface water body in question. When numeric water quality standards have not been established by the state, Subpart S specifies that MCLs will be used as action levels if the state designates the surface water as a drinking water source.

In keeping with Subpart S, when the MCL value or state groundwater standard is not available, the value calculated using the specified exposure assumptions for water (No. 3 above) will be used as the SAL. Although not specifically stated, it is consistent with Subpart S to use the same SAL criteria for both groundwater and surface water constituents. For surface water constituents, these criteria may be more stringent than required because New Mexico has not designated surface waters to be evaluated as drinking water sources.

2.2 Equations

2.2.1 General Equations for Calculating SALs

2.2.1.1 Systemic Toxicants

$$SAL = \frac{THI \times RfD \times BW \times CF}{I \times A} \qquad (1)$$

where

SAL = mg/kg for soil, ug/L for water, ug/m^3 for air ;

THI = target hazard index: 1;

RfD = chronic reference dose (mg/kg-day): oral RfD used for soil and water SALs, inhalation RfD used for air SALs;

BW = body weight: 16 kg for child (for soil SALs), 70 kg for adult (for water and air SALs);

CF = conversion factor: 10^6 mg/kg for soil SALs, 10^3 ug/mg for water and air SALs;

I = intake rate: 200 mg/day for soil SALs, 2 L/day for water SALs, 20 m^3/day for air SALs;

A = absorption factor: 1.

2.2.1.2 Carcinogenic Constituents

$$SAL = \frac{R \times BW \times LT \times CF}{SF \times I \times A \times ED} \quad (2)$$

where

SAL = mg/kg for soil, µg/L for water µg/m^3 for air;

R = target risk: 10^{-6} for Class A and B carcinogens, 10^{-5} for Class C carcinogens;

BW = body weight: 70 kg;

LT = assumed lifetime: 70 yr;

CF = conversion factor: 10^6 mg/kg for soil SALs, 10^3 µg/mg for water and air SALs;

SF = slope factor (mg/kg-day)$^{-1}$: oral SF used for soil and water SALs; inhalation SF used for air SAL;

I = intake rate: 100 mg/day for soil SALs, 2 L/day for water SALs, 20 m^3/day for air SALs;

A = absorption factor: 1;

ED = exposure duration: 70 yr.

2.2.2 Equations for Calculating Soil SALs for Volatile Constituents

2.2.2.1 Systemic Toxicants

$$SAL = \frac{THI \times BW}{\{[1/RfD_o \times CF \times ING] + [1/RfD_i \times INH \times (1/VF + 1/PEF)]\}} \quad (3)$$

where,

SAL = mg/kg for soil, µg/L for water, µg/m^3 for air;

THI = target hazard index: 1;

BW = body weight: 16 kg;

RfD_o = chronic oral reference dose: mg/kg-day;

CF = conversion factor: 10^{-6} kg/mg;

ING = soil ingestion rate: 200 mg/day;

RfD_i = chronic inhalation reference dose: mg/kg-day;

INH = inhalation rate: 20 m^3/day;

VF = soil-to-air volatilization factor (chemical-specific): m^3/kg, calculated using equation given by EPA (1991, 0302) and chemical-specific parameters (Strenge and Peterson 1989, 0837; EPA 1988, 0747);

PEF = particulate emission factor: 4.63 x 10^9 m^3/kg (EPA 1991, 0302).

2.2.2.2 Carcinogenic Constituents

$$SAL = \frac{R \times BW \times LT}{ED \times \{[SF_o \times CF \times ING] + [SF_i \times INH \times (1/VF + 1/PEF)]\}} \quad (4)$$

where,

SAL	=	mg/kg for soil, µg/L for water, µg/m^3 for air;
R	=	target risk: 10^{-6} for Class A and B carcinogens, 10^{-5} for Class C carcinogens;
BW	=	body weight: 70 kg;
LT	=	assumed lifetime: 70 yr;
ED	=	exposure duration: 70 yr;
SF_o	=	oral slope factor (mg/kg-day)$^{-1}$;
CF	=	conversion factor: 10^{-6} kg/mg;
ING	=	soil ingestion rate: 100 mg/day;
SF_i	=	inhalation slope factor (mg/kg-day)$^{-1}$;
INH	=	inhalation rate: 20 m^3/day;

VF and PEF as defined above.

2.3 Derivation of SALs When Chronic Toxicological Data Are Lacking

When SALs are needed for evaluating and comparing specific noncarcinogenic contaminants and adequate chronic toxicological information for the compound of interest does not exist, an interim conservative estimated value is derived by extrapolating from acute toxicological data.

2.4 Derivation of SALs for Other Media and Substances

Values analogous to SALs may be needed for evaluating substances that involve unique exposure considerations (e.g., substances found on structural surfaces and debris, shrapnel, high explosives, asbestos). The methods that will be used to evaluate these substances are discussed in the following paragraphs.

2.4.1 Structural Surfaces and Debris

Proposed Subpart S does not provide guidance on the derivation of SALs for potentially contaminated structural surfaces or debris (e.g., concrete, wood). These values may be needed for evaluating currently unused buildings. The structural surfaces of unused buildings may contain removable nonradiological constituents because these surfaces have not been subjected to weathering. SALs for these structural surfaces may be derived using wipe test data and appropriate assump-

tions on dust resuspension rates, inhalation and ingestion rates, and exposure period. These SALs for structural surfaces will be derived on an as-needed basis when characterization data become available.

Plausible exposure routes for structural materials (i.e., demolition debris), either buried or at the land surface, are through human contact with the surrounding media (soil, water, air) because some constituents may already have been released into the surrounding media as the result of weathering. Therefore, nonradiological contamination from exposed and buried structural debris can be evaluated by comparing SALs with constituent levels in surrounding media.

2.4.2 High Explosives and Asbestos

Shrapnel and unexploded high explosives present in some operable units need special consideration. The primary health hazard associated with these materials is injury by explosion. The toxicity of chemicals that might be released from these materials will be evaluated for individual constituents using appropriate SALs for soil, water, air, and structural surfaces. SALs for some high explosives and constituents of high explosives known to have been used at the Laboratory and for which toxicity data exist are presented in Tables J-1 and J-3. The SALs for high explosives were developed using Subpart S methodology. The work plans for individual operable units address characterization of sites with respect to shrapnel and high explosives, as needed.

Another special substance that needs criteria for screening decisions is asbestos. The SAL approach developed for evaluating most other constituents is not appropriate for asbestos; the Laboratory is seeking criteria consistent with federal and state guidance so that asbestos-contaminated soils can be evaluated.

3.0 SCREENING ACTION LEVELS FOR RADIOACTIVE CONSTITUENTS

As described above, SALs for many RCRA-regulated nonradioactive constituents have been recommended in, or derived using, proposed Subpart S regulations. However, radioactive compounds are not regulated under RCRA, and Subpart S regulations do not address radioactive constituents. To ensure that radioactive and nonradioactive compounds are addressed similarly and to simplify integrating RCRA, DOE, and CERCLA requirements for radioactive compounds, SALs for radioactive compounds have been derived in a manner similar to that used for deriving action levels in proposed Subpart S.

Section 3.1 presents the rationale for developing SALs for radioactive constituents in soil. Sections 3.2 and 3.3 discuss the methodology and assumptions used to derive SALs for radioactive constituents in soil and water, respectively.

3.1 Rationale for Deriving SALs for Radioactive Constituents in Soils

In developing SALs for radioactive constituents, it is necessary to consider all relevant and applicable standards for protecting human health. For radionuclides in the environment, guidance assumes that the protection standards that govern human health generally protect other biotic species (NCRP 1991, 0986; International Atomic Energy Agency 1992, 0983). The limits of radiation exposure to humans are governed by listing an upper bound of a radiation dose established in the radiation

protection standards that corresponds to an acceptable health risk. The upper-bounded radiation dose limit may not be exceeded but may be reduced by using health physics principles and DOE's as low as reasonably achievable (ALARA) guidance (DOE 1990, 0779).

Because current radiation protection standards [e.g., national emission standards for hazardous air pollutants (EPA 1992, 1061) and MCLs (EPA 1993, 1071)] are based on radiation dose limits rather than on corresponding cancer slope factors or risk levels, as are nonradioactive compounds enumerated in Subpart S, SALs for radioactive compounds are based on radiation dose levels considered to be "acceptable" to individuals in the general public. The national and international radiation communities and DOE (NCRP 1988, 0778; DOE 1990, 0080) have set a limit of 100 mrem/yr as a maximum acceptable radiation dose to individuals in the general public from all contaminant pathways, radionuclides, and exposure sources. Radiation dose to the public is further limited to 25 mrem/yr from individual facilities or sources (e.g., DOE 1988, 0266; EPA 1977, 1064). The radiation dose limits to the general public apply to cumulative exposure from multiple radioactive constituents through multiple pathways, whereas action levels for nonradioactive compounds in Subpart S have been derived for a single contaminant via a single exposure pathway.

The Laboratory has proposed SALs for radionuclides in soils at an annual dose limit of 10 mrem/yr (above background levels) from a single radioactive constituent via all pathways for radionuclides for which media-specific concentration limits are not specified in other regulations (e.g., MCLs). The proposed conservative dose limit of 10 mrem/yr was chosen as a SAL based on the following criteria (discussed in full in Chapter 4, Section 4.2.2.2):

- fraction of 100 mrem/yr and 25 mrem/yr regulatory standards,
- specified in DOE Order 5400.5 (DOE 1990, 0080) as a reporting level,
- generally within detection limits for current field instruments, and
- discernible from background radiation levels in the US (Table J-4).

Even if radionuclide levels exceed a SAL, consideration of ALARA may lead to further investigation or cleanup.

3.2 SALs for Radioactive Constituents in Soil

Preliminary SALs have been derived for several radionuclides that may be encountered in contaminated soils at the Laboratory (Table J-2). The following methodology and assumptions were used in deriving these SALs:

- The RESRAD computer code (Gilbert et al. 1989, 0754), Version 4.6, was used to derive the SALs. This code is DOE's choice of methodology required by DOE Order 5400.5 to be used in the derivation of cleanup criteria for radionuclides in soils at DOE sites.

- A residential scenario, which included exposure to the following sources through the following pathways, was used to derive a SAL for each radionuclide: (1) external exposure from gamma emitters in soil, (2) inhalation of contaminated dust and radon gas, (3) ingestion of contaminated soil and plants grown on the site, and (4) consumption of municipal water (which probably is not contaminated because of the great depth to the main aquifer in Los Alamos).

- The input data used in the RESRAD calculations typify the range of soil properties encountered on Laboratory mesa tops (Dornes 1992, 1066; 1992, 1067; 1992, 1068; 1993, 1069). The volume of contaminated soil is assumed to extend down 3 m from the surface and cover an area of 500 m^2. When site-specific data were not available, default values in the model were used. These default values were derived from averaged soil data obtained from both the Laboratory and the general literature (Gilbert et al. 1989, 0754).

3.3 SALs for Radioactive Constituents in Water

SALs for radionuclides in water are based on regulations given in 40 CFR 141.16 (EPA 1992, 1072) and the proposed national primary drinking water regulations for radionuclides (EPA 1991, 0887), which govern MCLs in community drinking water supplies. For alpha-emitting radionuclides, the proposed standards state that

- the maximum contaminant level for ^{226}Ra and ^{228}Ra is 20 pCi/L and

- the maximum contaminant level for gross alpha activity (excluding ^{226}Ra, radon, and uranium) is 15 pCi/L.

For beta- and gamma-emitting radionuclides, the proposed standards state that

- the maximum contaminant level for ^{228}Ra is 20 pCi/L and

- average annual concentrations of beta particle and gamma radioactivity (excluding ^{228}Ra) in drinking water shall not produce an effective dose equivalent greater than 4 mrem/yr. The proposed regulations also apply the 4-mrem/yr effective dose equivalent limit to tritium and ^{90}Sr. However 40 CFR 141.16 lists specific MCLs for these beta emitters. The MCLs are 20,000 pCi/L for tritium and 8 pCi/L for ^{90}Sr.

The EPA's Federal Guidance Report No. 11 (EPA 1988, 0982) tabulates dose conversion factors for intakes of radionuclides. Federal Guidance Report No. 11 is currently used to derive the SALs for radionuclides in water at the Laboratory. The effective dose equivalent factors contained in this document are consistent with the dose conversion factors published by DOE (DOE 1988, 0266) and EPA (EPA 1988, 0982). The following calculations are used to derive concentration limits of radionuclides that may be present in water at the Laboratory. Limits for other radionuclides may be derived using the methodology discussed below.

For beta- and gamma-emitting radionuclides, the yearly dose limit of 4 mrem/yr is converted to a SAL by dividing the annual dose limit by the water intake rate and effective dose equivalent factor, as shown below:

$$SAL = \frac{DL \times CF}{IR \times DCF_{b-g}} \qquad (5)$$

where

SAL	=	screening action level for beta-gamma emitters in picocuries per liter.
DL	=	annual dose limit of 4 mrem/yr,
CF	=	conversion factor, 10^6 pCi/µCi,
IR	=	water intake rate of 2 L/day or 730 L/yr,
DCF_{b-g}	=	ingestion effective dose equivalent factor for beta-gamma emitters, millirems per microcurie (dose conversion factors for ingestion are listed in Table 2.2 of Federal Guidance Report 11 in units of *Sv/Bq*. To convert to millirem per microcurie, these values were divided by 3.7 x 10^9).

Alpha-emitting radionuclides have a 15-pCi/L limit that excludes ^{226}Ra, uranium, and radon. Limits for uranium isotopes and other alpha emitters can be derived based on the 4-mrem/yr method used for beta-gamma emitters. Derived water SALs for radionuclide constituents are presented in Table J-2.

The method for applying the water SALs parallels the one proposed by the EPA to apply MCLs to drinking water (EPA 1991, 0887). For alpha emitters, ^{226}Ra, and uranium, the SALs would be applied by

- counting samples for gross alpha. If the gross alpha measurement is less than 15 pCi/L, the SALs for gross alpha, ^{226}Ra, and uranium are not exceeded.

- If the gross alpha measurement is greater than or equal to 15 pCi/L, the activity of ^{226}Ra and/or uranium in the sample is compared with the SALS. The "adjusted" gross alpha (less ^{226}Ra and/or uranium) is then computed. If this value is less than 15 pCi/L, the adjusted SAL for gross alpha is not exceeded.

- If multiple alpha-emitting radionuclides are present, they will be addressed as described in Section 4.

For beta-gamma emitters, the SALs will be applied by

- analyzing the samples for individual beta-gamma emitters and comparing the results with the SALs.

- addressing multiple beta-gamma-emitting radionuclides, if present, as described in Section 4.

4.0 ADDRESSING MULTIPLE CONSTITUENTS

Proposed Subpart S does not address how to evaluate several constituents with concentrations close to but below SALs in a single environmental medium. If multiple constituents do not exceed but are near their SALS, it is possible that in combination they could prove deleterious to human health. It is difficult to determine the interaction a mixture of chemicals will have on an organism. For example, a mixture of chemicals may produce an additive response that is simply the sum of their individual responses. However, more complicated interactions can include synergism, potentiation, and antagonism. Without research on a given combination of chemicals, predicting a possible toxic response from a mixture is highly uncertain.

As the first step in determining multiple effects, a simple additive equation based on concentration data normalized by SALs will be used. This approach assumes that there are no chemical interactions. Constituents are first grouped according to the environmental medium (soil, water, air) and toxicological effects (systemic toxicants, carcinogens, radionuclides). Then, SALs for all constituents are normalized to 1 so that concentration data can be treated as proportions of the respective SALs. If the sum of proportions for the different potential contaminants of concern is greater than 1, the effect of the multiple constituents is considered adverse and further action may be taken (i.e., baseline risk assessment); otherwise, NFA is proposed. The equation for calculating the appropriate normalized sum is

$$M = \max_{samples} \left\{ \sum_{PCOCs} C_i / SAL_i \right\} , \qquad (6)$$

where

M	=	maximum sum of proportions,
C_i	=	concentration of the ith chemical for a given sample, and
SAL_i	=	chemical-specific SAL for the ith chemical.

The maximum is taken over all samples such that the normalized sum of concentrations represents concentration data from within a single sample. The decision rule is restated in terms of a comparison of the maximum normalized sum of concentrations (M) with one.

The choice of potential contaminants of concern to include in the calculation also needs to be addressed. If all potential contaminants of concern are included, exceedance is very likely. However, the ER Program proposes not to include those potential contaminants of concern for which observed concentrations are within background levels when making this calculation.

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General Equations for Calculating SALS

Systemic Toxicants

SAL = (THI x RfD x BW x CF)/(I x A), where

SAL = soil screening action level (mg/kg for soil SALs; ug/L for water SALs; $\mu g/m^3$ for air SALs).
THI = target hazard index: 1.
RfD = chronic reference dose (mg/kg/day): oral RfD used for soil and water SALs; inhalation RfD used for air SALs.
BW = body weight: 15 kg for child (used for soil SAL); 70 kg for adult (used for water and air SALs).
CF = conversion factor: 10^6 mg/kg for soil SAL; 1,000 ug/mg for water and air SALs.
I = intake assumption: 200 mg/day for soil SAL (child); 2 L/day for water SAL; 20 m^3/day for air SAL.
A = absorption factor: 1.

Carcinogenic Constituents

SAL = (R x BW x LT x CF)/(SF x I x A x ED), where

R = target risk: 10^{-6} for Class A and B carcinogens; 10^{-5} for Class C carcinogens.
BW = body weight: 70 kg.
LT = assumed lifetime: 70 yr.
CF = conversion factor: 10^6 mg/kg for soil SAL; 1000 ug/mg for water and air SALs.
SF = slope factor $(mg/kg/day)^{-1}$: oral SF used for soil and water SALs; inhalation SF used for air SALs.
I = intake assumption: 100 mg/day for soil SAL; 2 L/day for water SAL; 20 m^3/day for air SAL.
A = absorption factor: 1.
ED = exposure duration: 70 yr.

Equations for Calculating Soil SALs for Volatile Contaminants

Systemic Toxicants

SAL = (THI x BW)/((1/RfD_O x 10^{-6} kg/mg x ING) + (1/RfD_I x INH x (1/VF + 1/PEF)), where

THI = target hazard index: 1.
BW = body weight: 15 kg.
RfD_O = chronic oral reference dose (mg/kg/day).
RfD_I = chronic inhalation reference dose (mg/kg/day).
ING = ingestion intake assumption: 200 mg/day.

VF = soil-to-air volatilization factor (m^3/kg; chemical-specific).
INH = inhalation intake assumption: 20 m^3/day.
PEF = particulate emission factor (4.63 x 10^9 m^3/kg;) (EPA 1991, 0302).

Carcinogens

SAL = (R x BW x LT/ED x [(SF_O x 10^{-6} kg/mg x ING) + (SF_I x INH x (1/VF + 1/PEF))], where

R = target risk: 10^{-6} for Class A and B carcinogens; 10^{-5} for Class C carcinogens.
BW = body weight: 70 kg.
LT = assumed lifetime: 70 yr.
ED = exposure duration: 70 yr.
SF_O = oral slope factor $(mg/kg/day)^{-1}$.
ING = ingestion intake assumption: 100 mg/day.
SF_I = inhalation slope factor $(mg/kg/day)^{-1}$.
INH = inhalation intake assumption: 20 m^3/day.
VF and PEF as defined above.

TABLE J-4

PUBLISHED US AVERAGE EFFECTIVE DOSE EQUIVALENT RATES[a] AND ESTIMATES FOR THE LOS ALAMOS AREA FROM NATURAL BACKGROUND RADIATION[b]

Radiation Source	US Average (mrem/yr)	Los Alamos (mrem/yr)
Cosmic Rays	27	58
Cosmogenic Radiation	1	1
External Terrestrial	23	39
Radionuclides in Body	40	40
Inhaled Radionuclides	200	200
Rounded Total	300	340

a. The US average data are from Table 9.7 (NCRP 1990. 0985. p. 148).

b. With the exception of the cosmogenic source, the Los Alamos data come from "Environmental Surveillance at Los Alamos during 1990" (Environmental Protection Group 1992. 0740). The cosmic and external terrestrial components were based on measurements; the balance of the values in the report were obtained from the National Council on Radiation Protection (NCRP 1990. 0985).

CURRENT FIMAD SALs

SUITE	ANALYTE	MATRIX	SAL	UNITS
HE	1,3,5-TNB (trinitrobenzene)	AIR		UG/M3
HE	1,3,5-TNB (trinitrobenzene)	CRQL-SOIL		MG/KG
HE	1,3,5-TNB (trinitrobenzene)	CRQL-WATER		UG/L
HE	1,3,5-TNB (trinitrobenzene)	SOIL	4	MG/KG
HE	1,3,5-TNB (trinitrobenzene)	WATER	1.8	UG/L
HE	1,3-DNB (dinitrobenzene)	AIR		UG/M3
HE	1,3-DNB (dinitrobenzene)	CRQL-SOIL		MG/KG
HE	1,3-DNB (dinitrobenzene)	CRQL-WATER		UG/L
HE	1,3-DNB (dinitrobenzene)	SOIL	8	MG/KG
HE	1,3-DNB (dinitrobenzene)	WATER	3.5	UG/L
HE	2,4,6-TNT (trinitrotoluene)	AIR		UG/M3
HE	2,4,6-TNT (trinitrotoluene)	CRQL-SOIL		MG/KG
HE	2,4,6-TNT (trinitrotoluene)	CRQL-WATER		UG/L
HE	2,4,6-TNT (trinitrotoluene)	SOIL	40	MG/KG
HE	2,4,6-TNT (trinitrotoluene)	WATER	12	UG/L
HE	2,4-DNT (dinitrotoluene)	AIR		UG/M3
HE	2,4-DNT (dinitrotoluene)	CRQL-SOIL	0.33	MG/KG
HE	2,4-DNT (dinitrotoluene)	CRQL-WATER	10	UG/L
HE	2,4-DNT (dinitrotoluene)	SOIL	1	MG/KG
HE	2,4-DNT (dinitrotoluene)	WATER	0.05	UG/L
HE	2,6-DNT (dinitrotoluene)	AIR		UG/M3
HE	2,6-DNT (dinitrotoluene)	CRQL-SOIL	0.33	MG/KG
HE	2,6-DNT (dinitrotoluene)	CRQL-WATE	10	UG/L
HE	2,6-DNT (dinitrotoluene)	SOIL	1	MG/KG
HE	2,6-DNT (dinitrotoluene)	WATER	0.05	UG/L
HE	2-Amino-4,6-dinitrotoluene	AIR		UG/M3
HE	2-Amino-4,6-dinitrotoluene	CRQL-SOIL		MG/KG
HE	2-Amino-4,6-dinitrotoluene	CRQL-WATER		UG/L
HE	2-Amino-4,6-dinitrotoluene	SOIL		MG/KG
HE	2-Amino-4,6-dinitrotoluene	WATER		UG/L
HE	4-amino-2,6-DNT (aminodinitrotoluene)	AIR		UG/M3

HE	4-amino 2,6-DNT (aminodinitrotoluene)	CRQL-SOIL		MG/KG
HE	4-amino-2,6-DNT (aminodinitrotoluene)	CRQL-WATER		UG/L
HE	4-amino-2,6-DNT (aminodinitrotoluene)	SOIL		MG/KG
HE	4-amino-2,6-DNT (aminodinitrotoluene)	WATER		UG/L
HE	Ammonium nitrate	AIR		UG/M3
HE	Ammonium nitrate	CRQL-SOIL		MG/KG
HE	Ammonium nitrate	CRQL-WATER		UG/L
HE	Ammonium nitrate	SOIL		MG/KG
HE	Ammonium nitrate	WATER		UG/L
HE	Barium nitrate (soluble barium)	AIR	0.49	UG/M3
HE	Barium nitrate (soluble barium)	CRQL-SOIL	40	MG/KG
HE	Barium nitrate (soluble barium)	CRQL-WATER	200	UG/L
HE	Barium nitrate (soluble barium)	SOIL	5600	MG/KG
HE	Barium nitrate (soluble barium)	WATER	2000	UG/L
HE	CEF (tris(2-chloroethyl)-phosphate)	AIR		UG/M3
HE	CEF (tris(2-chloroethyl)-phosphate)	CRQL-SOIL		MG/KG
HE	CEF (tris(2-chloroethyl)-phosphate)	CRQL-WATER		UG/L
HE	CEF (tris(2-chloroethyl)-phosphate)	SOIL		MG/KG
HE	CEF (tris(2-chloroethyl)-phosphate)	WATER		UG/L
HE	DPA (diphenylamine)	AIR		UG/M3
HE	DPA (diphenylamine)	CRQL-SOIL		MG/KG
HE	DPA (diphenylamine)	CRQL-WATER		UG/L
HE	DPA (diphenylamine)	SOIL	2000	MG/KG
HE	DPA (diphenylamine)	WATER	880	UG/L
HE	HMX (cyclotetramethylenetetranitramine)	AIR		UG/M3
HE	HMX (cyclotetramethylenetetranitramine)	CRQL-SOIL		MG/KG
HE	HMX (cyclotetramethylenetetranitramine)	CRQL-WATER		UG/L
HE	HMX (cyclotetramethylenetetranitramine)	SOIL	4000	MG/KG
HE	HMX (cyclotetramethylenetetranitramine)	WATER	1800	UG/L
HE	Nitrocellulose (nontoxic)	AIR		UG/M3
HE	Nitrocellulose (nontoxic)	CRQL-SOIL		MG/KG
HE	Nitrocellulose (nontoxic)	CRQL-WATER		UG/L
HE	Nitrocellulose (nontoxic)	SOIL		MG/KG

HE	Nitrocellulose (nontoxic)	WATER		UG/L
HE	Nitromethane	AIR		UG/M3
HE	Nitromethane	CRQL-SOIL		MG/KG
HE	Nitromethane	CRQL-WATER		UG/L
HE	Nitromethane	SOIL		MG/KG
HE	Nitromethane	WATER		UG/L
HE	Nitrotoluenes	AIR		UG/M3
HE	Nitrotoluenes	CRQL-SOIL		MG/KG
HE	Nitrotoluenes	CRQL-WATER		UG/L
HE	Nitrotoluenes	SOIL	800	MG/KG
HE	Nitrotoluenes	WATER	350	UG/L
HE	NP (bis(2,2-dinitropropyl) acetal/formal)	AIR		UG/M3
HE	NP (bis(2,2-dinitropropyl) acetal/formal)	CRQL-SOIL		MG/KG
HE	NP (bis(2,2-dinitropropyl) acetal/formal)	CRQL-WATER		UG/L
HE	NP (bis(2,2-dinitropropyl) acetal/formal)	SOIL		MG/KG
HE	NP (bis(2,2-dinitropropyl) acetal/formal)	WATER		UG/L
HE	PETN (pentaerythritol tetranitrate)	AIR		UG/M3
HE	PETN (pentaerythritol tetranitrate)	CRQL-SOIL		MG/KG
HE	PETN (pentaerythritol tetranitrate)	CRQL-WATER		UG/L
HE	PETN (pentaerythritol tetranitrate)	SOIL	1600	MG/KG
HE	PETN (pentaerythritol tetranitrate)	WATER	700	UG/L
HE	RDX (trimethylenetrinitramine)	AIR		UG/M3
HE	RDX (trimethylenetrinitramine)	CRQL-SOIL		MG/KG
HE	RDX (trimethylenetrinitramine)	CRQL-WATER		UG/L
HE	RDX (trimethylenetrinitramine)	SOIL	64	MG/KG
HE	RDX (trimethylenetrinitramine)	WATER	3.2	UG/L
HE	TATB (triaminotrinitrobenzene)	AIR		UG/M3
HE	TATB (triaminotrinitrobenzene)	CRQL-SOIL		MG/KG
HE	TATB (triaminotrinitrobenzene)	CRQL-WATER		UG/L
HE	TATB (triaminotrinitrobenzene)	SOIL		MG/KG
HE	TATB (triaminotrinitrobenzene)	WATER		UG/L
HE	Tetryl (N-methyl-N,2,4,6 tetranitrobenzeneamine)	AIR		UG/M3
HE	Tetryl (N-methyl-N,2,4,6 tetranitrobenzeneamine)	CRQL-SOIL		MG/KG

HE	Tetryl (N-methyl-N,2,4,6-tetranitrobenzeneamine)	CRQL-WATER		UG/L
HE	Tetryl (N-methyl-N,2,4,6-tetranitrobenzeneamine)	SOIL	800	MG/KG
HE	Tetryl (N-methyl-N,2,4,6-tetranitrobenzeneamine)	WATER	350	UG/L
INORG	Aluminum	AIR		UG/M3
INORG	Aluminum	CRQL-SOIL	40	MG/KG
INORG	Aluminum	CRQL-WATER	200	UG/L
INORG	Aluminum	SOIL		MG/KG
INORG	Aluminum	WATER		UG/L
INORG	Antimony	AIR		UG/M3
INORG	Antimony	CRQL-SOIL	12	MG/KG
INORG	Antimony	CRQL-WATER	60	UG/L
INORG	Antimony	SOIL	32	MG/KG
INORG	Antimony	WATER	6	UG/L
INORG	Arsenic	AIR	0.00023	UG/M3
INORG	Arsenic	CRQL-SOIL	2	MG/KG
INORG	Arsenic	CRQL-WATER	10	UG/L
INORG	Arsenic	SOIL		MG/KG
INORG	Arsenic	WATER	50	UG/L
INORG	Barium	AIR	0.49	UG/M3
INORG	Barium	CRQL-SOIL	40	MG/KG
INORG	Barium	CRQL-WATER	200	UG/L
INORG	Barium	SOIL	5600	MG/KG
INORG	Barium	WATER	2000	UG/L
INORG	Beryllium	AIR	0.00042	UG/M3
INORG	Beryllium	CRQL-SOIL	1	MG/KG
INORG	Beryllium	CRQL-WATER	5	UG/L
INORG	Beryllium	SOIL		MG/KG
INORG	Beryllium	WATER	4	UG/L
INORG	Cadmium	AIR	0.00056	UG/M3
INORG	Cadmium	CRQL-SOIL	1	MG/KG
INORG	Cadmium	CRQL-WATER	5	UG/L
INORG	Cadmium	SOIL	80	MG/KG
INORG	Cadmium	WATER	5	UG/L

INORG	Calcium	AIR		UG/M3
INORG	Calcium	CRQL-SOIL	1000	MG/KG
INORG	Calcium	CRQL-WATER	5000	UG/L
INORG	Calcium	SOIL		MG/KG
INORG	Calcium	WATER		UG/L
INORG	Chromium (Total)	AIR		UG/M3
INORG	Chromium (Total)	CRQL-SOIL	10	MG/KG
INORG	Chromium (Total)	CRQL-WATER	50	UG/L
INORG	Chromium (Total)	SOIL		MG/KG
INORG	Chromium (Total)	WATER	100	UG/L
INORG	Chromium III	AIR		UG/M3
INORG	Chromium III	CRQL-SOIL	2	MG/KG
INORG	Chromium III	CRQL-WATER	10	UG/L
INORG	Chromium III	SOIL	80000	MG/KG
INORG	Chromium III	WATER		UG/L
INORG	Chromium VI	AIR	0.000083	UG/M3
INORG	Chromium VI	CRQL-SOIL	2	MG/KG
INORG	Chromium VI	CRQL-WATER	10	UG/L
INORG	Chromium VI	SOIL	400	MG/KG
INORG	Chromium VI	WATER		UG/L
INORG	Cobalt	AIR		UG/M3
INORG	Cobalt	CRQL-SOIL	10	MG/KG
INORG	Cobalt	CRQL-WATER	50	UG/L
INORG	Cobalt	SOIL		MG/KG
INORG	Cobalt	WATER		UG/L
INORG	Copper	AIR		UG/M3
INORG	Copper	CRQL-SOIL	5	MG/KG
INORG	Copper	CRQL-WATER	25	UG/L
INORG	Copper	SOIL	3000	MG/KG
INORG	Copper	WATER	1300	UG/L
INORG	Cyanide	AIR		UG/M3
INORG	Cyanide	CRQL-SOIL	2	MG/KG
INORG	Cyanide	CRQL-WATER	10	UG/L

INORG	Cyanide	SOIL	1600	MG/KG
INORG	Cyanide	WATER	200	UG/L
INORG	Iron	AIR		UG/M3
INORG	Iron	CRQL-SOIL	20	MG/KG
INORG	Iron	CRQL-WATER	100	UG/L
INORG	Iron	SOIL		MG/KG
INORG	Iron	WATER		UG/L
INORG	Lead	AIR		UG/M3
INORG	Lead	CRQL-SOIL	0.6	MG/KG
INORG	Lead	CRQL-WATER	3	UG/L
INORG	Lead	SOIL	400	MG/KG
INORG	Lead	WATER	50	UG/L
INORG	Magnesium	AIR		UG/M3
INORG	Magnesium	CRQL-SOIL	1000	MG/KG
INORG	Magnesium	CRQL-WATER	5000	UG/L
INORG	Magnesium	SOIL		MG/KG
INORG	Magnesium	WATER		UG/L
INORG	Manganese	AIR	0.05	UG/M3
INORG	Manganese	CRQL-SOIL	3	MG/KG
INORG	Manganese	CRQL-WATER	15	UG/L
INORG	Manganese	SOIL	11000	MG/KG
INORG	Manganese	WATER	180	UG/L
INORG	Mercury	AIR	0.3	UG/M3
INORG	Mercury	CRQL-SOIL	0.04	MG/KG
INORG	Mercury	CRQL-WATER	0.2	UG/L
INORG	Mercury	SOIL	24	MG/KG
INORG	Mercury	WATER	2	UG/L
INORG	Molybdenum	AIR		UG/M3
INORG	Molybdenum	CRQL-SOIL		MG/KG
INORG	Molybdenum	CRQL-WATER		UG/L
INORG	Molybdenum	SOIL	400	MG/KG
INORG	Molybdenum	WATER	170	UG/L
INORG	Nickel	AIR	0.0042	UG/M3

INORG	Nickel	CRQL-SOIL	8	MG/KG
INORG	Nickel	CRQL-WATER	40	UG/L
INORG	Nickel	SOIL	1600	MG/KG
INORG	Nickel	WATER	100	UG/L
INORG	Nitrate	AIR		UG/M3
INORG	Nitrate	CRQL-SOIL		MG/KG
INORG	Nitrate	CRQL-WATER		UG/L
INORG	Nitrate	SOIL	130000	MG/KG
INORG	Nitrate	WATER	10000	UG/L
INORG	Nitrite	AIR		UG/M3
INORG	Nitrite	CRQL-SOIL		MG/KG
INORG	Nitrite	CRQL-WATER		UG/L
INORG	Nitrite	SOIL	8000	MG/KG
INORG	Nitrite	WATER	1000	UG/L
INORG	Potassium	AIR		UG/M3
INORG	Potassium	CRQL-SOIL	1000	MG/KG
INORG	Potassium	CRQL-WATER	5000	UG/L
INORG	Potassium	SOIL		MG/KG
INORG	Potassium	WATER		UG/L
INORG	Selenium	AIR		UG/M3
INORG	Selenium	CRQL-SOIL	1	MG/KG
INORG	Selenium	CRQL-WATER	5	UG/L
INORG	Selenium	SOIL	400	MG/KG
INORG	Selenium	WATER	50	UG/L
INORG	Silver	AIR		UG/M3
INORG	Silver	CRQL-SOIL	2	MG/KG
INORG	Silver	CRQL-WATER	10	UG/L
INORG	Silver	SOIL	400	MG/KG
INORG	Silver	WATER	170	UG/L
INORG	Sodium	AIR		UG/M3
INORG	Sodium	CRQL-SOIL	1000	MG/KG
INORG	Sodium	CRQL-WATER	5000	UG/L
INORG	Sodium	SOIL		MG/KG

INORG	Sodium	WATER		UG/L
INORG	Strontium	AIR		UG/M3
INORG	Strontium	CRQL-SOIL		MG/KG
INORG	Strontium	CRQL-WATER		UG/L
INORG	Strontium	SOIL	48000	MG/KG
INORG	Strontium	WATER	21000	UG/L
INORG	Thallium	AIR		UG/M3
INORG	Thallium	CRQL-SOIL	2	MG/KG
INORG	Thallium	CRQL-WATER	10	UG/L
INORG	Thallium	SOIL	6.4	MG/KG
INORG	Thallium	WATER	2	UG/L
INORG	Vanadium	AIR		UG/M3
INORG	Vanadium	CRQL-SOIL	10	MG/KG
INORG	Vanadium	CRQL-WATER	50	UG/L
INORG	Vanadium	SOIL	560	MG/KG
INORG	Vanadium	WATER	240	UG/L
INORG	Zinc	AIR		UG/M3
INORG	Zinc	CRQL-SOIL	4	MG/KG
INORG	Zinc	CRQL-WATER	20	UG/L
INORG	Zinc	SOIL	24000	MG/KG
INORG	Zinc	WATER	10000	UG/L
RAD	Americium-241	SOIL	17	PCI/G
RAD	Americium-241	WATER	15	PCI/L
RAD	Carbon-14	SOIL	46	PCI/G
RAD	Carbon-14	WATER	2600	PCI/L
RAD	Cerium-144	SOIL	64	PCI/G
RAD	Cerium-144	WATER		PCI/L
RAD	Cesium-134	SOIL	1.8	PCI/G
RAD	Cesium-134	WATER	75	PCI/L
RAD	Cesium-137	SOIL	4	PCI/G
RAD	Cesium-137	WATER	110	PCI/L
RAD	Cobalt-57	SOIL	40	PCI/G
RAD	Cobalt-57	WATER	4600	PCI/L

RAD	Cobalt-60	SOIL	0.9	PCI/G
RAD	Cobalt-60	WATER	200	PCI/L
RAD	Gross Alpha Particle Activity	SOIL		PCI/G
RAD	Gross Alpha Particle Activity	WATER	15	PCI/L
RAD	Iodine-129	SOIL	41	PCI/G
RAD	Iodine-129	WATER	20	PCI/L
RAD	Manganese-54	SOIL	3.4	PCI/G
RAD	Manganese-54	WATER	2000	PCI/L
RAD	Plutonium-238	SOIL	20	PCI/G
RAD	Plutonium-238	WATER	15	PCI/L
RAD	Plutonium-239	SOIL	18	PCI/G
RAD	Plutonium-239	WATER	15	PCI/L
RAD	Radium-226	SOIL	5	PCI/G
RAD	Radium-226	WATER	20	PCI/L
RAD	Radium-228	SOIL	5	PCI/G
RAD	Radium-228	WATER	20	PCI/L
RAD	Ruthenium-106	SOIL	14	PCI/G
RAD	Ruthenium-106	WATER	200	PCI/L
RAD	Sodium-22	SOIL	1.3	PCI/G
RAD	Sodium-22	WATER	480	PCI/L
RAD	Strontium-90	SOIL	5.9	PCI/G
RAD	Strontium-90	WATER	8	PCI/L
RAD	Technetium-99	SOIL	38	PCI/G
RAD	Technetium-99	WATER		PCI/L
RAD	Thorium-228	SOIL	1.5	PCI/G
RAD	Thorium-228	WATER	15	PCI/L
RAD	Thorium-230	SOIL	5	PCI/G
RAD	Thorium-230	WATER	15	PCI/L
RAD	Thorium-232	SOIL	5	PCI/G
RAD	Thorium-232	WATER	15	PCI/L
RAD	Tritium	SOIL	810	PCI/G
RAD	Tritium	WATER	2000	PCI/L
RAD	Uranium (depleted)	SOIL		PCI/G

RAD	Uranium (depleted)	WATER		PCI/L
RAD	Uranium (natural)	SOIL		PCI/G
RAD	Uranium (natural)	WATER		PCI/L
RAD	Uranium-233	SOIL	86	PCI/G
RAD	Uranium-233	WATER		PCI/L
RAD	Uranium-234	SOIL	86	PCI/G
RAD	Uranium-234	WATER		PCI/L
RAD	Uranium-235	SOIL	18	PCI/G
RAD	Uranium-235	WATER		PCI/L
RAD	Uranium-238	SOIL	59	PCI/G
RAD	Uranium-238	WATER		PCI/L
SVOA	1,2-Dichlorobenzene	AIR	200	UG/M3
SVOA	1,2-Dichlorobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	1,2-Dichlorobenzene	CRQL-WATER	10	UG/L
SVOA	1,2-Dichlorobenzene	SOIL	1600	MG/KG
SVOA	1,2-Dichlorobenzene	WATER	600	UG/L
SVOA	1,2,4-Trichlorobenzene	AIR	9	UG/M3
SVOA	1,2,4-Trichlorobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	1,2,4-Trichlorobenzene	CRQL-WATER	10	UG/L
SVOA	1,2,4-Trichlorobenzene	SOIL	160	MG/KG
SVOA	1,2,4-Trichlorobenzene	WATER	70	UG/L
SVOA	1,3-Dichlorobenzene	AIR		UG/M3
SVOA	1,3-Dichlorobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	1,3-Dichlorobenzene	CRQL-WATER	10	UG/L
SVOA	1,3-Dichlorobenzene	SOIL	7200	MG/KG
SVOA	1,3-Dichlorobenzene	WATER	600	UG/L
SVOA	1,4-Dichlorobenzene	AIR	800	UG/M3
SVOA	1,4-Dichlorobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	1,4-Dichlorobenzene	CRQL-WATER	10	UG/L
SVOA	1,4-Dichlorobenzene	SOIL	29	MG/KG
SVOA	1,4-Dichlorobenzene	WATER	75	UG/L
SVOA	1,4-Methan azulene, decahydro-4,4,8	AIR		UG/M3
SVOA	1,4-Methan azulene, decahydro-4,4,8	CRQL-SOIL		MG/KG

SVOA	1,4 Methan azulene, decahydro 4,4,8	CRQL-WATER		UG/L
SVOA	1,4 Methan azulene, decahydro-4,4,8	SOIL		MG/KG
SVOA	1,4 Methan azulene, decahydro 4,4,8	WATER		UG/L
SVOA	2,2-Oxybis(1-chloropropane)	AIR		UG/M3
SVOA	2,2-Oxybis(1-chloropropane)	CRQL-SOIL		MG/KG
SVOA	2,2-Oxybis(1-chloropropane)	CRQL-WATER		UG/L
SVOA	2,2-Oxybis(1-chloropropane)	SOIL		MG/KG
SVOA	2,2-Oxybis(1-chloropropane)	WATER		UG/L
SVOA	2,4,5-T	AIR		UG/M3
SVOA	2,4,5-T	CRQL-SOIL		MG/KG
SVOA	2,4,5-T	CRQL-WATER		UG/L
SVOA	2,4,5-T	SOIL	800	MG/KG
SVOA	2,4,5-T	WATER	350	UG/L
SVOA	2,4,5-TP	AIR		UG/M3
SVOA	2,4,5-TP	CRQL-SOIL		MG/KG
SVOA	2,4,5-TP	CRQL-WATER		UG/L
SVOA	2,4,5-TP	SOIL	640	MG/KG
SVOA	2,4,5-TP	WATER	280	UG/L
SVOA	2,4,5-Trichlorophenol	AIR		UG/M3
SVOA	2,4,5-Trichlorophenol	CRQL-SOIL	0.8	MG/KG
SVOA	2,4,5-Trichlorophenol	CRQL-WATER	25	UG/L
SVOA	2,4,5-Trichlorophenol	SOIL	8000	MG/KG
SVOA	2,4,5-Trichlorophenol	WATER	3500	UG/L
SVOA	2,4,6-Trichlorophenol	AIR	0.32	UG/M3
SVOA	2,4,6-Trichlorophenol	CRQL-SOIL	0.33	MG/KG
SVOA	2,4,6-Trichlorophenol	CRQL-WATER	10	UG/L
SVOA	2,4,6-Trichlorophenol	SOIL	64	MG/KG
SVOA	2,4,6-Trichlorophenol	WATER	3.2	UG/L
SVOA	2,4-D	AIR		UG/M3
SVOA	2,4-D	CRQL-SOIL		MG/KG
SVOA	2,4-D	CRQL-WATER		UG/L
SVOA	2,4-D	SOIL	800	MG/KG
SVOA	2,4-D	WATER	70	UG/L

SVOA	2,4-DB	AIR		UG/M3
SVOA	2,4-DB	CRQL-SOIL		MG/KG
SVOA	2,4-DB	CRQL-WATER		UG/L
SVOA	2,4-DB	SOIL	640	MG/KG
SVOA	2,4-DB	WATER	280	UG/L
SVOA	2,4-Dichlorophenol	AIR		UG/M3
SVOA	2,4-Dichlorophenol	CRQL-SOIL	0.33	MG/KG
SVOA	2,4-Dichlorophenol	CRQL-WATER	10	UG/L
SVOA	2,4-Dichlorophenol	SOIL	240	MG/KG
SVOA	2,4-Dichlorophenol	WATER	100	UG/L
SVOA	2,4-Dimethylphenol	AIR		UG/M3
SVOA	2,4-Dimethylphenol	CRQL-SOIL	0.33	MG/KG
SVOA	2,4-Dimethylphenol	CRQL-WATER	10	UG/L
SVOA	2,4-Dimethylphenol	SOIL	1600	MG/KG
SVOA	2,4-Dimethylphenol	WATER	700	UG/L
SVOA	2,4-Dinitrophenol	AIR		UG/M3
SVOA	2,4-Dinitrophenol	CRQL-SOIL	0.8	MG/KG
SVOA	2,4-Dinitrophenol	CRQL-WATER	25	UG/L
SVOA	2,4-Dinitrophenol	SOIL	160	MG/KG
SVOA	2,4-Dinitrophenol	WATER	70	UG/L
SVOA	2-(2,4-Dichlorophenoxy)-propionic acid	AIR		UG/M3
SVOA	2-(2,4-Dichlorophenoxy)-propionic acid	CRQL-SOIL		MG/KG
SVOA	2-(2,4-Dichlorophenoxy)-propionic acid	CRQL-WATER		UG/L
SVOA	2-(2,4-Dichlorophenoxy)-propionic acid	SOIL		MG/KG
SVOA	2-(2,4-Dichlorophenoxy)-propionic acid	WATER		UG/L
SVOA	2-Chloronaphthalene	AIR		UG/M3
SVOA	2-Chloronaphthalene	CRQL-SOIL	0.33	MG/KG
SVOA	2-Chloronaphthalene	CRQL-WATER	10	UG/L
SVOA	2-Chloronaphthalene	SOIL	6400	MG/KG
SVOA	2-Chloronaphthalene	WATER	2800	UG/L
SVOA	2-Chlorophenol	AIR		UG/M3
SVOA	2-Chlorophenol	CRQL-SOIL	0.33	MG/KG
SVOA	2-Chlorophenol	CRQL-WATER	10	UG/L

SVOA	2-Chlorophenol	SOIL	400	MG/KG
SVOA	2-Chlorophenol	WATER	170	UG/L
SVOA	2-Methyl-4,6-dinitrophenol	AIR		UG/M3
SVOA	2-Methyl-4,6-dinitrophenol	CRQL-SOIL		MG/KG
SVOA	2-Methyl-4,6-dinitrophenol	CRQL-WATER		UG/L
SVOA	2-Methyl-4,6-dinitrophenol	SOIL		MG/KG
SVOA	2-Methyl-4,6-dinitrophenol	WATER		UG/L
SVOA	2-Methylnaphthalene	AIR		UG/M3
SVOA	2-Methylnaphthalene	CRQL-SOIL	0.33	MG/KG
SVOA	2-Methylnaphthalene	CRQL-WATER	10	UG/L
SVOA	2-Methylnaphthalene	SOIL		MG/KG
SVOA	2-Methylnaphthalene	WATER		UG/L
SVOA	2-Methylphenol (o-cresol)	AIR		UG/M3
SVOA	2-Methylphenol (o-cresol)	CRQL-SOIL	0.33	MG/KG
SVOA	2-Methylphenol (o-cresol)	CRQL-WATER	10	UG/L
SVOA	2-Methylphenol (o-cresol)	SOIL	4000	MG/KG
SVOA	2-Methylphenol (o-cresol)	WATER	1700	UG/L
SVOA	2-Nitroaniline (o-nitroaniline)	AIR	0.2	UG/M3
SVOA	2-Nitroaniline (o-nitroaniline)	CRQL-SOIL	0.8	MG/KG
SVOA	2-Nitroaniline (o-nitroaniline)	CRQL-WATER	25	UG/L
SVOA	2-Nitroaniline (o-nitroaniline)	SOIL		MG/KG
SVOA	2-Nitroaniline (o-nitroaniline)	WATER		UG/L
SVOA	2-Nitrophenol	AIR		UG/M3
SVOA	2-Nitrophenol	CRQL-SOIL	0.33	MG/KG
SVOA	2-Nitrophenol	CRQL-WATER	10	UG/L
SVOA	2-Nitrophenol	SOIL		MG/KG
SVOA	2-Nitrophenol	WATER		UG/L
SVOA	2H-1-Benzopyran-2-one	AIR		UG/M3
SVOA	2H-1-Benzopyran-2-one	CRQL-SOIL		MG/KG
SVOA	2H-1-Benzopyran-2-one	CRQL-WATER		UG/L
SVOA	2H-1-Benzopyran-2-one	SOIL		MG/KG
SVOA	2H-1-Benzopyran-2-one	WATER		UG/L
SVOA	3,3-Dichlorobenzidine	AIR		UG/M3

SVOA	3,3 Dichlorobenzidine	CRQL-SOIL	0.33	MG/KG
SVOA	3,3-Dichlorobenzidine	CRQL-WATER	10	UG/L
SVOA	3,3 Dichlorobenzidine	SOIL	1.6	MG/KG
SVOA	3,3-Dichlorobenzidine	WATER	0.078	UG/L
SVOA	3-Nitroaniline (m-nitroaniline)	AIR		UG/M3
SVOA	3-Nitroaniline (m-nitroaniline)	CRQL-SOIL	0.8	MG/KG
SVOA	3-Nitroaniline (m-nitroaniline)	CRQL-WATER	25	UG/L
SVOA	3-Nitroaniline (m-nitroaniline)	SOIL	240	MG/KG
SVOA	3-Nitroaniline (m-nitroaniline)	WATER	110	UG/L
SVOA	4-Bromophenyl-phenylether	AIR		UG/M3
SVOA	4-Bromophenyl-phenylether	CRQL-SOIL	0.33	MG/KG
SVOA	4-Bromophenyl-phenylether	CRQL-WATER	10	UG/L
SVOA	4-Bromophenyl-phenylether	SOIL		MG/KG
SVOA	4-Bromophenyl-phenylether	WATER		UG/L
SVOA	4-Chloro-3-methylphenol (p-chloro-m-cresol)	AIR		UG/M3
SVOA	4-Chloro-3-methylphenol (p-chloro-m-cresol)	CRQL-SOIL	0.33	MG/KG
SVOA	4-Chloro-3-methylphenol (p-chloro-m-cresol)	CRQL-WATER	10	UG/L
SVOA	4-Chloro-3-methylphenol (p-chloro-m-cresol)	SOIL	16000	MG/KG
SVOA	4-Chloro-3-methylphenol (p-chloro-m-cresol)	WATER	7000	UG/L
SVOA	4-Chloro-o-polyoxyacetic acid	AIR		UG/M3
SVOA	4-Chloro-o-polyoxyacetic acid	CRQL-SOIL		MG/KG
SVOA	4-Chloro-o-polyoxyacetic acid	CRQL-WATER		UG/L
SVOA	4-Chloro-o-polyoxyacetic acid	SOIL		MG/KG
SVOA	4-Chloro-o-polyoxyacetic acid	WATER		UG/L
SVOA	4-Chloroaniline	AIR		UG/M3
SVOA	4-Chloroaniline	CRQL-SOIL	0.33	MG/KG
SVOA	4-Chloroaniline	CRQL-WATER	10	UG/L
SVOA	4-Chloroaniline	SOIL	320	MG/KG
SVOA	4-Chloroaniline	WATER	140	UG/L
SVOA	4-Chlorophenyl phenyl ether	AIR		UG/M3
SVOA	4-Chlorophenyl phenyl ether	CRQL-SOIL	0.33	MG/KG
SVOA	4-Chlorophenyl phenyl ether	CRQL-WATER	10	UG/L
SVOA	4-Chlorophenyl phenyl ether	SOIL		MG/KG

SVOA	4-Chlorophenyl phenyl Lether	WATER		UG/L
SVOA	4-Methylphenol (p-cresol)	AIR		UG/M3
SVOA	4-Methylphenol (p-cresol)	CRQL-SOIL	0.33	MG/KG
SVOA	4-Methylphenol (p-cresol)	CRQL-WATER	10	UG/L
SVOA	4-Methylphenol (p-cresol)	SOIL	400	MG/KG
SVOA	4-Methylphenol (p-cresol)	WATER	180	UG/L
SVOA	4-Nitroaniline (p-nitroaniline)	AIR		UG/M3
SVOA	4-Nitroaniline (p-nitroaniline)	CRQL-SOIL	0.8	MG/KG
SVOA	4-Nitroaniline (p-nitroaniline)	CRQL-WATER	25	UG/L
SVOA	4-Nitroaniline (p-nitroaniline)	SOIL	240	MG/KG
SVOA	4-Nitroaniline (p-nitroaniline)	WATER	110	UG/L
SVOA	4-Nitrophenol	AIR		UG/M3
SVOA	4-Nitrophenol	CRQL-SOIL	0.8	MG/KG
SVOA	4-Nitrophenol	CRQL-WATER	25	UG/L
SVOA	4-Nitrophenol	SOIL	5000	MG/KG
SVOA	4-Nitrophenol	WATER	2200	UG/L
SVOA	4,6-Dinitro-2-methylphenol	AIR		UG/M3
SVOA	4,6-Dinitro-2-methylphenol	CRQL-SOIL		MG/KG
SVOA	4,6-Dinitro-2-methylphenol	CRQL-WATER		UG/L
SVOA	4,6-Dinitro-2-methylphenol	SOIL		MG/KG
SVOA	4,6-Dinitro-2-methylphenol	WATER		UG/L
SVOA	(4,6-dinitro-o-cresol),	AIR		UG/M3
SVOA	(4,6-dinitro-o-cresol),	CRQL-SOIL	0.8	MG/KG
SVOA	(4,6-dinitro-o-cresol),	CRQL-WATER	25	UG/L
SVOA	(4,6-dinitro-o-cresol),	SOIL		MG/KG
SVOA	(4,6-dinitro-o-cresol),	WATER		UG/L
SVOA	Acenaphthene	AIR		UG/M3
SVOA	Acenaphthene	CRQL-SOIL		MG/KG
SVOA	Acenaphthene	CRQL-WATER		UG/L
SVOA	Acenaphthene	SOIL	4800	MG/KG
SVOA	Acenaphthene	WATER	2100	UG/L
SVOA	Acenaphthylene	AIR		UG/M3
SVOA	Acenaphthylene	CRQL-SOIL	0.33	MG/KG

SVOA	Acenaphthylene	CRQL-WATER	10	UG/L
SVOA	Acenaphthylene	SOIL		MG/KG
SVOA	Acenaphthylene	WATER		UG/L
SVOA	Aldrin	AIR	0.0002	UG/M3
SVOA	Aldrin	CRQL-SOIL		MG/KG
SVOA	Aldrin	CRQL-WATER		UG/L
SVOA	Aldrin	SOIL	0.04	MG/KG
SVOA	Aldrin	WATER	0.002	UG/L
SVOA	Alpha-BHC	AIR	0.00056	UG/M3
SVOA	Alpha-BHC	CRQL-SOIL		MG/KG
SVOA	Alpha-BHC	CRQL-WATER		UG/L
SVOA	Alpha-BHC	SOIL	0.1	MG/KG
SVOA	Alpha-BHC	WATER	0.0056	UG/L
SVOA	Aniline	AIR	1	UG/M3
SVOA	Aniline	CRQL-SOIL		MG/KG
SVOA	Aniline	CRQL-WATER		UG/L
SVOA	Aniline	SOIL	120	MG/KG
SVOA	Aniline	WATER	6.1	UG/L
SVOA	Anthracene	AIR		UG/M3
SVOA	Anthracene	CRQL-SOIL	0.33	MG/KG
SVOA	Anthracene	CRQL-WATER	10	UG/L
SVOA	Anthracene	SOIL	24000	MG/KG
SVOA	Anthracene	WATER	10000	UG/L
SVOA	Azobenzene	AIR	0.032	UG/M3
SVOA	Azobenzene	CRQL-SOIL		MG/KG
SVOA	Azobenzene	CRQL-WATER		UG/L
SVOA	Azobenzene	SOIL	6.4	MG/KG
SVOA	Azobenzene	WATER	0.32	UG/L
SVOA	Benzeneacetic acid	AIR		UG/M3
SVOA	Benzeneacetic acid	CRQL-SOIL		MG/KG
SVOA	Benzeneacetic acid	CRQL-WATER		UG/L
SVOA	Benzeneacetic acid	SOIL		MG/KG
SVOA	Benzeneacetic acid	WATER		UG/L

SVOA	Benzidine	AIR	0.00001	UG/M3
SVOA	Benzidine	CRQL-SOIL		MG/KG
SVOA	Benzidine	CRQL-WATER		UG/L
SVOA	Benzidine	SOIL	0.003	MG/KG
SVOA	Benzidine	WATER	0.0002	UG/L
SVOA	Benzo[a]anthracene	AIR		UG/M3
SVOA	Benzo[a]anthracene	CRQL-SOIL	0.33	MG/KG
SVOA	Benzo[a]anthracene	CRQL-WATER	10	UG/L
SVOA	Benzo[a]anthracene	SOIL	1	MG/KG
SVOA	Benzo[a]anthracene	WATER	0.1	UG/L
SVOA	Benzo[a]pyrene	AIR		UG/M3
SVOA	Benzo[a]pyrene	CRQL-SOIL	0.33	MG/KG
SVOA	Benzo[a]pyrene	CRQL-WATER	10	UG/L
SVOA	Benzo[a]pyrene	SOIL	0.1	MG/KG
SVOA	Benzo[a]pyrene	WATER	0.2	UG/L
SVOA	Benzo[b]fluoranthene	AIR		UG/M3
SVOA	Benzo[b]fluoranthene	CRQL-SOIL	0.33	MG/KG
SVOA	Benzo[b]fluoranthene	CRQL-WATER	10	UG/L
SVOA	Benzo[b]fluoranthene	SOIL	1	MG/KG
SVOA	Benzo[b]fluoranthene	WATER	0.2	UG/L
SVOA	Benzo[g,h,i]perylene	AIR		UG/M3
SVOA	Benzo[g,h,i]perylene	CRQL-SOIL	0.33	MG/KG
SVOA	Benzo[g,h,i]perylene	CRQL-WATER	10	UG/L
SVOA	Benzo[g,h,i]perylene	SOIL		MG/KG
SVOA	Benzo[g,h,i]perylene	WATER		UG/L
SVOA	Benzo[k]fluoranthene	AIR		UG/M3
SVOA	Benzo[k]fluoranthene	CRQL-SOIL	0.33	MG/KG
SVOA	Benzo[k]fluoranthene	CRQL-WATER	10	UG/L
SVOA	Benzo[k]fluoranthene	SOIL	1	MG/KG
SVOA	Benzo[k]fluoranthene	WATER	0.2	UG/L
SVOA	Benzoic Acid	AIR		UG/M3
SVOA	Benzoic Acid	CRQL-SOIL	100	MG/KG
SVOA	Benzoic Acid	CRQL-WATER	0	UG/L

SVOA	Benzoic Acid	SOIL	320000	MG/KG
SVOA	Benzoic Acid	WATER	140000	UG/L
SVOA	Benzyl alcohol	AIR		UG/M3
SVOA	Benzyl alcohol	CRQL-SOIL		MG/KG
SVOA	Benzyl alcohol	CRQL-WATER		UG/L
SVOA	Benzyl alcohol	SOIL	24000	MG/KG
SVOA	Benzyl alcohol	WATER	11000	UG/L
SVOA	Beta-BHC	AIR	0.018	UG/M3
SVOA	Beta-BHC	CRQL-SOIL		MG/KG
SVOA	Beta-BHC	CRQL-WATER		UG/L
SVOA	Beta-BHC	SOIL	4	MG/KG
SVOA	Beta-BHC	WATER	0.19	UG/L
SVOA	Bis-(2-chloroethoxy)methane	AIR		UG/M3
SVOA	Bis-(2-chloroethoxy)methane	CRQL-SOIL	0.33	MG/KG
SVOA	Bis-(2-chloroethoxy)methane	CRQL-WATER	10	UG/L
SVOA	Bis-(2-chloroethoxy)methane	SOIL		MG/KG
SVOA	Bis-(2-chloroethoxy)methane	WATER		UG/L
SVOA	Bis-(2-chloroethyl)ether	AIR	0.0029	UG/M3
SVOA	Bis-(2-chloroethyl)ether	CRQL-SOIL	0.33	MG/KG
SVOA	Bis-(2-chloroethyl)ether	CRQL-WATER	10	UG/L
SVOA	Bis-(2-chloroethyl)ether	SOIL	0.12	MG/KG
SVOA	Bis-(2-chloroethyl)ether	WATER	0.032	UG/L
SVOA	(bis[2-chloroisopropyl]ether)	AIR	1	UG/M3
SVOA	(bis[2-chloroisopropyl]ether)	CRQL-SOIL	0.33	MG/KG
SVOA	(bis[2-chloroisopropyl]ether)	CRQL-WATER	10	UG/L
SVOA	(bis[2-chloroisopropyl]ether)	SOIL	100	MG/KG
SVOA	(bis[2-chloroisopropyl]ether)	WATER	0.5	UG/L
SVOA	Bis-(2-ethylhexyl)phthalate	AIR		UG/M3
SVOA	Bis-(2-ethylhexyl)phthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Bis-(2-ethylhexyl)phthalate	CRQL-WATER	10	UG/L
SVOA	Bis-(2 ethylhexyl)phthalate	SOIL	50	MG/KG
SVOA	Bis-(2-ethylhexyl)phthalate	WATER	6	UG/L
SVOA	Butyl benzyl phthalate	AIR		UG/M3

SVOA	Butyl benzyl phthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Butyl benzyl phthalate	CRQL-WATER	10	UG/L
SVOA	Butyl benzyl phthalate	SOIL	16000	MG/KG
SVOA	Butyl benzyl phthalate	WATER	100	UG/L
SVOA	Carbazole	AIR		UG/M3
SVOA	Carbazole	CRQL-SOIL	0.33	MG/KG
SVOA	Carbazole	CRQL-WATER	10	UG/L
SVOA	Carbazole	SOIL	35	MG/KG
SVOA	Carbazole	WATER	1.8	UG/L
SVOA	Chlordane	AIR	0.0027	UG/M3
SVOA	Chlordane	CRQL-SOIL	0.017	MG/KG
SVOA	Chlordane	CRQL-WATER	0.05	UG/L
SVOA	Chlordane	SOIL	0.54	MG/KG
SVOA	Chlordane	WATER	2	UG/L
SVOA	Chlorophenoxyacetic acid (2-methy-4)	AIR		UG/M3
SVOA	Chlorophenoxyacetic acid (2-methy-4)	CRQL-SOIL		MG/KG
SVOA	Chlorophenoxyacetic acid (2-methy-4)	CRQL-WATER		UG/L
SVOA	Chlorophenoxyacetic acid (2-methy-4)	SOIL	40	MG/KG
SVOA	Chlorophenoxyacetic acid (2-methy-4)	WATER	18	UG/L
SVOA	Chrysene	AIR		UG/M3
SVOA	Chrysene	CRQL-SOIL	0.33	MG/KG
SVOA	Chrysene	CRQL-WATER	10	UG/L
SVOA	Chrysene	SOIL	96	MG/KG
SVOA	Chrysene	WATER	0.2	UG/L
SVOA	Dalapon	AIR		UG/M3
SVOA	Dalapon	CRQL-SOIL		MG/KG
SVOA	Dalapon	CRQL-WATER		UG/L
SVOA	Dalapon	SOIL	2400	MG/KG
SVOA	Dalapon	WATER	200	UG/L
SVOA	DDD	AIR		UG/M3
SVOA	DDD	CRQL-SOIL	0.03	MG/KG
SVOA	DDD	CRQL-WATER	0.1	UG/L
SVOA	DDD	SOIL	2.9	MG/KG

SVOA	DDD	WATER	0.15	UG/L
SVOA	DDE	AIR	0.01	UG/M3
SVOA	DDE	CRQL-SOIL	0.03	MG/KG
SVOA	DDE	CRQL-WATER	0.1	UG/L
SVOA	DDE	SOIL	2.1	MG/KG
SVOA	DDE	WATER	0.1	UG/L
SVOA	DDT	AIR	0.01	UG/M3
SVOA	DDT	CRQL-SOIL	0.03	MG/KG
SVOA	DDT	CRQL-WATER	0.1	UG/L
SVOA	DDT	SOIL	2.1	MG/KG
SVOA	DDT	WATER	0.1	UG/L
SVOA	Delta-BHC	AIR		UG/M3
SVOA	Delta-BHC	CRQL-SOIL		MG/KG
SVOA	Delta-BHC	CRQL-WATER		UG/L
SVOA	Delta-BHC	SOIL		MG/KG
SVOA	Delta-BHC	WATER		UG/L
SVOA	Dibenzo[a,h]anthracene	AIR		UG/M3
SVOA	Dibenzo[a,h]anthracene	CRQL-SOIL	0.33	MG/KG
SVOA	Dibenzo[a,h]anthracene	CRQL-WATER	10	UG/L
SVOA	Dibenzo[a,h]anthracene	SOIL	0.1	MG/KG
SVOA	Dibenzo[a,h]anthracene	WATER	0.3	UG/L
SVOA	Dibenzofuran	AIR		UG/M3
SVOA	Dibenzofuran	CRQL-SOIL	0.33	MG/KG
SVOA	Dibenzofuran	CRQL-WATER	10	UG/L
SVOA	Dibenzofuran	SOIL		MG/KG
SVOA	Dibenzofuran	WATER		UG/L
SVOA	Dicamba	AIR		UG/M3
SVOA	Dicamba	CRQL-SOIL		MG/KG
SVOA	Dicamba	CRQL-WATER		UG/L
SVOA	Dicamba	SOIL	2400	MG/KG
SVOA	Dicamba	WATER	1100	UG/L
SVOA	Dieldrin	AIR		UG/M3
SVOA	Dieldrin	CRQL-SOIL		MG/KG

SVOA	Dieldrin	CRQL-WATER		UG/L
SVOA	Dieldrin	SOIL	0.044	MG/KG
SVOA	Dieldrin	WATER	0.002	UG/L
SVOA	Diethylphthalate	AIR		UG/M3
SVOA	Diethylphthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Diethylphthalate	CRQL-WATER	10	UG/L
SVOA	Diethylphthalate	SOIL	64000	MG/KG
SVOA	Diethylphthalate	WATER	5000	UG/L
SVOA	Dimethylformamide	AIR	30	UG/M3
SVOA	Dimethylformamide	CRQL-SOIL		MG/KG
SVOA	Dimethylformamide	CRQL-WATER		UG/L
SVOA	Dimethylformamide	SOIL	8000	MG/KG
SVOA	Dimethylformamide	WATER	3500	UG/L
SVOA	Dimethylphthalate	AIR		UG/M3
SVOA	Dimethylphthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Dimethylphthalate	CRQL-WATER	10	UG/L
SVOA	Dimethylphthalate	SOIL	800000	MG/KG
SVOA	Dimethylphthalate	WATER	350000	UG/L
SVOA	Di-n-butyl phthalate	AIR		UG/M3
SVOA	Di-n-butyl phthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Di-n-butyl phthalate	CRQL-WATER	10	UG/L
SVOA	Di-n-butyl phthalate	SOIL	8000	MG/KG
SVOA	Di-n-butyl phthalate	WATER	3500	UG/L
SVOA	Di-n-octyl phthalate	AIR		UG/M3
SVOA	Di-n-octyl phthalate	CRQL-SOIL	0.33	MG/KG
SVOA	Di-n-octyl phthalate	CRQL-WATER	10	UG/L
SVOA	Di-n-octyl phthalate	SOIL	1600	MG/KG
SVOA	Di-n-octyl phthalate	WATER	700	UG/L
SVOA	Dinoseb	AIR		UG/M3
SVOA	Dinoseb	CRQL-SOIL		MG/KG
SVOA	Dinoseb	CRQL-WATER		UG/L
SVOA	Dinoseb	SOIL	80	MG/KG
SVOA	Dinoseb	WATER	7	UG/L

SVOA	Endosulfan	AIR		UG/M3
SVOA	Endosulfan	CRQL-SOIL		MG/KG
SVOA	Endosulfan	CRQL-WATER		UG/L
SVOA	Endosulfan	SOIL	4	MG/KG
SVOA	Endosulfan	WATER	1.8	UG/L
SVOA	Endosulfan sulfate	AIR		UG/M3
SVOA	Endosulfan sulfate	CRQL-SOIL		MG/KG
SVOA	Endosulfan sulfate	CRQL-WATER		UG/L
SVOA	Endosulfan sulfate	SOIL	4	MG/KG
SVOA	Endosulfan sulfate	WATER	1.8	UG/L
SVOA	Endrin	AIR		UG/M3
SVOA	Endrin	CRQL-SOIL		MG/KG
SVOA	Endrin	CRQL-WATER		UG/L
SVOA	Endrin	SOIL	24	MG/KG
SVOA	Endrin	WATER	2	UG/L
SVOA	Ethyl acetate	AIR		UG/M3
SVOA	Ethyl acetate	CRQL-SOIL		MG/KG
SVOA	Ethyl acetate	CRQL-WATER		UG/L
SVOA	Ethyl acetate	SOIL	72000	MG/KG
SVOA	Ethyl acetate	WATER	32000	UG/L
SVOA	Ethylene glycol	AIR		UG/M3
SVOA	Ethylene glycol	CRQL-SOIL		MG/KG
SVOA	Ethylene glycol	CRQL-WATER		UG/L
SVOA	Ethylene glycol	SOIL	160000	MG/KG
SVOA	Ethylene glycol	WATER	70000	UG/L
SVOA	Fluoranthene	AIR		UG/M3
SVOA	Fluoranthene	CRQL-SOIL	0.33	MG/KG
SVOA	Fluoranthene	CRQL-WATER	10	UG/L
SVOA	Fluoranthene	SOIL	3200	MG/KG
SVOA	Fluoranthene	WATER	1400	UG/L
SVOA	Fluorene	AIR		UG/M3
SVOA	Fluorene	CRQL-SOIL	0.33	MG/KG
SVOA	Fluorene	CRQL-WATER	10	UG/L

SVOA	Fluorene	SOIL	3200	MG/KG
SVOA	Fluorene	WATER	1400	UG/L
SVOA	Heptachlor	AIR	0.0008	UG/M3
SVOA	Heptachlor	CRQL-SOIL		MG/KG
SVOA	Heptachlor	CRQL-WATER		UG/L
SVOA	Heptachlor	SOIL	0.16	MG/KG
SVOA	Heptachlor	WATER	0.4	UG/L
SVOA	Heptachlor epoxide,	AIR	0.0004	UG/M3
SVOA	Heptachlor epoxide,	CRQL-SOIL		MG/KG
SVOA	Heptachlor epoxide,	CRQL-WATER		UG/L
SVOA	Heptachlor epoxide,	SOIL	0.077	MG/KG
SVOA	Heptachlor epoxide,	WATER	0.2	UG/L
SVOA	Hexachlorobenzene	AIR	0.0022	UG/M3
SVOA	Hexachlorobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	Hexachlorobenzene	CRQL-WATER	10	UG/L
SVOA	Hexachlorobenzene	SOIL	0.44	MG/KG
SVOA	Hexachlorobenzene	WATER	1	UG/L
SVOA	Hexachlorobutadiene	AIR	0.45	UG/M3
SVOA	Hexachlorobutadiene	CRQL-SOIL	0.33	MG/KG
SVOA	Hexachlorobutadiene	CRQL-WATER	10	UG/L
SVOA	Hexachlorobutadiene	SOIL	90	MG/KG
SVOA	Hexachlorobutadiene	WATER	4.5	UG/L
SVOA	Hexachlorocyclopentadiene	AIR	0.07	UG/M3
SVOA	Hexachlorocyclopentadiene	CRQL-SOIL	0.33	MG/KG
SVOA	Hexachlorocyclopentadiene	CRQL-WATER	10	UG/L
SVOA	Hexachlorocyclopentadiene	SOIL	560	MG/KG
SVOA	Hexachlorocyclopentadiene	WATER	50	UG/L
SVOA	Hexachloroethane	AIR	2.5	UG/M3
SVOA	Hexachloroethane	CRQL-SOIL	0.33	MG/KG
SVOA	Hexachloroethane	CRQL-WATER	10	UG/L
SVOA	Hexachloroethane	SOIL	80	MG/KG
SVOA	Hexachloroethane	WATER	25	UG/L
SVOA	Hexadecanoic acid	AIR		UG/M3

SVOA	Hexadecanoic acid	CRQL-SOIL		MG/KG
SVOA	Hexadecanoic acid	CRQL-WATER		UG/L
SVOA	Hexadecanoic acid	SOIL		MG/KG
SVOA	Hexadecanoic acid	WATER		UG/L
SVOA	Indeno[1,2,3-cd]pyrene	AIR		UG/M3
SVOA	Indeno[1,2,3-cd]pyrene	CRQL-SOIL	0.33	MG/KG
SVOA	Indeno[1,2,3-cd]pyrene	CRQL-WATER	10	UG/L
SVOA	Indeno[1,2,3-cd]pyrene	SOIL	1	MG/KG
SVOA	Indeno[1,2,3-cd]pyrene	WATER	0.4	UG/L
SVOA	Isophorone	AIR		UG/M3
SVOA	Isophorone	CRQL-SOIL	0.33	MG/KG
SVOA	Isophorone	CRQL-WATER	10	UG/L
SVOA	Isophorone	SOIL	7400	MG/KG
SVOA	Isophorone	WATER	370	UG/L
SVOA	Lindane (gamma BHC)	AIR		UG/M3
SVOA	Lindane (gamma BHC)	CRQL-SOIL		MG/KG
SVOA	Lindane (gamma BHC)	CRQL-WATER		UG/L
SVOA	Lindane (gamma BHC)	SOIL	0.54	MG/KG
SVOA	Lindane (gamma BHC)	WATER	0.2	UG/L
SVOA	Mecoprop(MCPP)	AIR		UG/M3
SVOA	Mecoprop(MCPP)	CRQL-SOIL		MG/KG
SVOA	Mecoprop(MCPP)	CRQL-WATER		UG/L
SVOA	Mecoprop(MCPP)	SOIL	80	MG/KG
SVOA	Mecoprop(MCPP)	WATER	35	UG/L
SVOA	Methoxychlor	AIR		UG/M3
SVOA	Methoxychlor	CRQL-SOIL		MG/KG
SVOA	Methoxychlor	CRQL-WATER		UG/L
SVOA	Methoxychlor	SOIL	400	MG/KG
SVOA	Methoxychlor	WATER	40	UG/L
SVOA	N-Nitrosodimethylamine	AIR	0.00007	UG/M3
SVOA	N-Nitrosodimethylamine	CRQL-SOIL		MG/KG
SVOA	N-Nitrosodimethylamine	CRQL-WATER		UG/L
SVOA	N-Nitrosodimethylamine	SOIL	0.014	MG/KG

SVOA	N Nitrosodimethylamine	WATER	0.0007	UG/L
SVOA	N Nitrosodi-N-propylamine	AIR		UG/M3
SVOA	N Nitrosodi-N-propylamine	CRQL-SOIL	0.33	MG/KG
SVOA	N-Nitrosodi-N-propylamine	CRQL-WATER	10	UG/L
SVOA	N-Nitrosodi-N-propylamine	SOIL	0.1	MG/KG
SVOA	N-Nitrosodi-N-propylamine	WATER	0.005	UG/L
SVOA	N-Nitrosodiphenylamine	AIR		UG/M3
SVOA	N-Nitrosodiphenylamine	CRQL-SOIL	0.33	MG/KG
SVOA	N-Nitrosodiphenylamine	CRQL-WATER	10	UG/L
SVOA	N-Nitrosodiphenylamine	SOIL	140	MG/KG
SVOA	N-Nitrosodiphenylamine	WATER	7.1	UG/L
SVOA	Naphthalene	AIR		UG/M3
SVOA	Naphthalene	CRQL-SOIL	0.33	MG/KG
SVOA	Naphthalene	CRQL-WATER	10	UG/L
SVOA	Naphthalene	SOIL	3200	MG/KG
SVOA	Naphthalene	WATER	1400	UG/L
SVOA	Nitrobenzene	AIR	2	UG/M3
SVOA	Nitrobenzene	CRQL-SOIL	0.33	MG/KG
SVOA	Nitrobenzene	CRQL-WATER	10	UG/L
SVOA	Nitrobenzene	SOIL	5.3	MG/KG
SVOA	Nitrobenzene	WATER	18	UG/L
SVOA	Octacosane	AIR		UG/M3
SVOA	Octacosane	CRQL-SOIL		MG/KG
SVOA	Octacosane	CRQL-WATER		UG/L
SVOA	Octacosane	SOIL		MG/KG
SVOA	Octacosane	WATER		UG/L
SVOA	Octadecanoic acid	AIR		UG/M3
SVOA	Octadecanoic acid	CRQL-SOIL		MG/KG
SVOA	Octadecanoic acid	CRQL-WATER		UG/L
SVOA	Octadecanoic acid	SOIL		MG/KG
SVOA	Octadecanoic acid	WATER		UG/L
SVOA	Octamethyl cyclotetrasiloxane	AIR		UG/M3
SVOA	Octamethyl cyclotetrasiloxane	CRQL-SOIL		MG/KG

SVOA	Octamethyl cyclotetrasiloxane	CRQL-WATER		UG/L
SVOA	Octamethyl cyclotetrasiloxane	SOIL		MG/KG
SVOA	Octamethyl cyclotetrasiloxane	WATER		UG/L
SVOA	PCB (Aroclors)	AIR		UG/M3
SVOA	PCB (Aroclors)	CRQL-SOIL	0.033	MG/KG
SVOA	PCB (Aroclors)	CRQL-WATER	1	UG/L
SVOA	PCB (Aroclors)	SOIL	0.09	MG/KG
SVOA	PCB (Aroclors)	WATER	0.5	UG/L
SVOA	Pentachlorophenol	AIR		UG/M3
SVOA	Pentachlorophenol	CRQL-SOIL	0.8	MG/KG
SVOA	Pentachlorophenol	CRQL-WATER	25	UG/L
SVOA	Pentachlorophenol	SOIL	5.8	MG/KG
SVOA	Pentachlorophenol	WATER	1	UG/L
SVOA	Phenanthrene	AIR		UG/M3
SVOA	Phenanthrene	CRQL-SOIL	0.33	MG/KG
SVOA	Phenanthrene	CRQL-WATER	10	UG/L
SVOA	Phenanthrene	SOIL		MG/KG
SVOA	Phenanthrene	WATER		UG/L
SVOA	Phenol	AIR		UG/M3
SVOA	Phenol	CRQL-SOIL	0.33	MG/KG
SVOA	Phenol	CRQL-WATER	10	UG/L
SVOA	Phenol	SOIL	48000	MG/KG
SVOA	Phenol	WATER	21000	UG/L
SVOA	Pyrene	AIR		UG/M3
SVOA	Pyrene	CRQL-SOIL	0.33	MG/KG
SVOA	Pyrene	CRQL-WATER	10	UG/L
SVOA	Pyrene	SOIL	2400	MG/KG
SVOA	Pyrene	WATER	1000	UG/L
SVOA	Tetradecanoic acid	AIR		UG/M3
SVOA	Tetradecanoic acid	CRQL-SOIL		MG/KG
SVOA	Tetradecanoic acid	CRQL-WATER		UG/L
SVOA	Tetradecanoic acid	SOIL		MG/KG
SVOA	Tetradecanoic acid	WATER		UG/L

SVOA	Toxaphene	AIR	0.0032	UG/M3
SVOA	Toxaphene	CRQL-SOIL		MG/KG
SVOA	Toxaphene	CRQL-WATER		UG/L
SVOA	Toxaphene	SOIL	0.64	MG/KG
SVOA	Toxaphene	WATER	3	UG/L
SVOA	Vinyl Acetate	AIR	200	UG/M3
SVOA	Vinyl Acetate	CRQL-SOIL		MG/KG
SVOA	Vinyl Acetate	CRQL-WATER		UG/L
SVOA	Vinyl Acetate	SOIL	80000	MG/KG
SVOA	Vinyl Acetate	WATER	35000	UG/L
VOA	1,1-Dichloroethane	AIR	500	UG/M3
VOA	1,1-Dichloroethane	CRQL-SOIL	0.01	MG/KG
VOA	1,1-Dichloroethane	CRQL-WATER	10	UG/L
VOA	1,1-Dichloroethane	SOIL	410	MG/KG
VOA	1,1-Dichloroethane	WATER	3500	UG/L
VOA	1,1-Dichloroethene	AIR	0.19	UG/M3
VOA	1,1-Dichloroethene	CRQL-SOIL	0.01	MG/KG
VOA	1,1-Dichloroethene	CRQL-WATER	10	UG/L
VOA	1,1-Dichloroethene	SOIL	0.4	MG/KG
VOA	1,1-Dichloroethene	WATER	7	UG/L
VOA	1,1,1-Trichloroethane	AIR	1000	UG/M3
VOA	1,1,1-Trichloroethane	CRQL-SOIL	0.01	MG/KG
VOA	1,1,1-Trichloroethane	CRQL-WATER	10	UG/L
VOA	1,1,1-Trichloroethane	SOIL	1000	MG/KG
VOA	1,1,1-Trichloroethane	WATER	200	UG/L
VOA	1,1,1,2-Tetrachloroethane	AIR	1.4	UG/M3
VOA	1,1,1,2-Tetrachloroethane	CRQL-SOIL		MG/KG
VOA	1,1,1,2-Tetrachloroethane	CRQL-WATER		UG/L
VOA	1,1,1,2-Tetrachloroethane	SOIL	270	MG/KG
VOA	1,1,1,2-Tetrachloroethane	WATER	13	UG/L
VOA	1,1,2-Trichloro-1,2,2-trifluoroethane	AIR		UG/M3
VOA	1,1,2-Trichloro-1,2,2-trifluoroethane	CRQL-SOIL		MG/KG
VOA	1,1,2-Trichloro-1,2,2-trifluoroethane	CRQL-WATER		UG/L

VOA	1,1,2 Trichloro-1,2,2-trifluoroethane	SOIL		MG/KG
VOA	1,1,2-Trichloro-1,2,2-trifluoroethane	WATER		UG/L
VOA	1,1,2-Trichloroethane	AIR	0.63	UG/M3
VOA	1,1,2-Trichloroethane	CRQL-SOIL	0.01	MG/KG
VOA	1,1,2-Trichloroethane	CRQL-WATER	10	UG/L
VOA	1,1,2-Trichloroethane	SOIL	6.3	MG/KG
VOA	1,1,2-Trichloroethane	WATER	5	UG/L
VOA	1,1,2,2-Tetrachloroethane	AIR	0.18	UG/M3
VOA	1,1,2,2-Tetrachloroethane	CRQL-SOIL	0.01	MG/KG
VOA	1,1,2,2-Tetrachloroethane	CRQL-WATER	10	UG/L
VOA	1,1,2,2-Tetrachloroethane	SOIL	3.9	MG/KG
VOA	1,1,2,2-Tetrachloroethane	WATER	1.8	UG/L
VOA	1,2-Dibromo-3-chloropropane	AIR	0.2	UG/M3
VOA	1,2-Dibromo-3-chloropropane	CRQL-SOIL		MG/KG
VOA	1,2-Dibromo-3-chloropropane	CRQL-WATER		UG/L
VOA	1,2-Dibromo-3-chloropropane	SOIL	0.5	MG/KG
VOA	1,2-Dibromo-3-chloropropane	WATER	0.2	UG/L
VOA	1,2-Dichloroethane	AIR	0.038	UG/M3
VOA	1,2-Dichloroethane	CRQL-SOIL	0.01	MG/KG
VOA	1,2-Dichloroethane	CRQL-WATER	10	UG/L
VOA	1,2-Dichloroethane	SOIL	0.2	MG/KG
VOA	1,2-Dichloroethane	WATER	5	UG/L
VOA	1,2-Dichloropropane	AIR	4	UG/M3
VOA	1,2-Dichloropropane	CRQL-SOIL	0.01	MG/KG
VOA	1,2-Dichloropropane	CRQL-WATER	10	UG/L
VOA	1,2-Dichloropropane	SOIL	6.5	MG/KG
VOA	1,2-Dichloropropane	WATER	5	UG/L
VOA	1,2,3-Trimethylbenzene	AIR		UG/M3
VOA	1,2,3-Trimethylbenzene	CRQL-SOIL		MG/KG
VOA	1,2,3-Trimethylbenzene	CRQL-WATER		UG/L
VOA	1,2,3-Trimethylbenzene	SOIL		MG/KG
VOA	1,2,3-Trimethylbenzene	WATER		UG/L
VOA	1,2,4-Trimethylbenzene	AIR		UG/M3

VOA	1,2,4-Trimethylbenzene	CRQL-SOIL		MG/KG
VOA	1,2,4-Trimethylbenzene	CRQL-WATER		UG/L
VOA	1,2,4-Trimethylbenzene	SOIL	40	MG/KG
VOA	1,2,4-Trimethylbenzene	WATER	18	UG/L
VOA	1,3,5-Trimethylbenzene	AIR		UG/M3
VOA	1,3,5-Trimethylbenzene	CRQL-SOIL		MG/KG
VOA	1,3,5-Trimethylbenzene	CRQL-WATER		UG/L
VOA	1,3,5-Trimethylbenzene	SOIL	32	MG/KG
VOA	1,3,5-Trimethylbenzene	WATER	14	UG/L
VOA	2-Butanone (Methyl ethyl ketone)	AIR	1000	UG/M3
VOA	2-Butanone (Methyl ethyl ketone)	CRQL-SOIL	0.01	MG/KG
VOA	2-Butanone (Methyl ethyl ketone)	CRQL-WATER	10	UG/L
VOA	2-Butanone (Methyl ethyl ketone)	SOIL	4000	MG/KG
VOA	2-Butanone (Methyl ethyl ketone)	WATER	1700	UG/L
VOA	2-Hexanone	AIR		UG/M3
VOA	2-Hexanone	CRQL-SOIL	0.01	MG/KG
VOA	2-Hexanone	CRQL-WATER	10	UG/L
VOA	2-Hexanone	SOIL		MG/KG
VOA	2-Hexanone	WATER		UG/L
VOA	3-Carene	AIR		UG/M3
VOA	3-Carene	CRQL-SOIL		MG/KG
VOA	3-Carene	CRQL-WATER		UG/L
VOA	3-Carene	SOIL		MG/KG
VOA	3-Carene	WATER		UG/L
VOA	4-Hydroxy-4-methyl-2-pentanone	AIR		UG/M3
VOA	4-Hydroxy-4-methyl-2-pentanone	CRQL-SOIL		MG/KG
VOA	4-Hydroxy-4-methyl-2-pentanone	CRQL-WATER		UG/L
VOA	4-Hydroxy-4-methyl-2-pentanone	SOIL		MG/KG
VOA	4-Hydroxy-4-methyl-2-pentanone	WATER		UG/L
VOA	4-Isopropyltoluene	AIR		UG/M3
VOA	4-Isopropyltoluene	CRQL-SOIL		MG/KG
VOA	4-Isopropyltoluene	CRQL-WATER		UG/L
VOA	4-Isopropyltoluene	SOIL		MG/KG

VOA	4-Isopropyltoluene	WATER		UG/L
VOA	4-Methyl-2-pentanone (MIBK)	AIR	80	UG/M3
VOA	4-Methyl-2-pentanone (MIBK)	CRQL-SOIL	0.01	MG/KG
VOA	4-Methyl-2-pentanone (MIBK)	CRQL-WATER	10	UG/L
VOA	4-Methyl-2-pentanone (MIBK)	SOIL	510	MG/KG
VOA	4-Methyl-2-pentanone (MIBK)	WATER	1700	UG/L
VOA	Acetone	AIR		UG/M3
VOA	Acetone	CRQL-SOIL	0.01	MG/KG
VOA	Acetone	CRQL-WATER	10	UG/L
VOA	Acetone	SOIL	8000	MG/KG
VOA	Acetone	WATER	3500	UG/L
VOA	Benzene	AIR	0.12	UG/M3
VOA	Benzene	CRQL-SOIL	0.01	MG/KG
VOA	Benzene	CRQL-WATER	10	UG/L
VOA	Benzene	SOIL	0.67	MG/KG
VOA	Benzene	WATER	5	UG/L
VOA	Bromobenzene	AIR		UG/M3
VOA	Bromobenzene	CRQL-SOIL		MG/KG
VOA	Bromobenzene	CRQL-WATER		UG/L
VOA	Bromobenzene	SOIL		MG/KG
VOA	Bromobenzene	WATER		UG/L
VOA	Bromochloromethane	AIR		UG/M3
VOA	Bromochloromethane	CRQL-SOIL		MG/KG
VOA	Bromochloromethane	CRQL-WATER		UG/L
VOA	Bromochloromethane	SOIL		MG/KG
VOA	Bromochloromethane	WATER		UG/L
VOA	Bromodichloromethane	AIR		UG/M3
VOA	Bromodichloromethane	CRQL-SOIL	0.01	MG/KG
VOA	Bromodichloromethane	CRQL-WATER	10	UG/L
VOA	Bromodichloromethane	SOIL	11	MG/KG
VOA	Bromodichloromethane	WATER	0.56	UG/L
VOA	Bromoform	AIR	0.9	UG/M3
VOA	Bromoform	CRQL-SOIL	0.01	MG/KG

VOA	Bromoform	CRQL-WATER	10	UG/L
VOA	Bromoform	SOIL	89	MG/KG
VOA	Bromoform	WATER	4.4	UG/L
VOA	Bromomethane	AIR	4.9	UG/M3
VOA	Bromomethane	CRQL-SOIL	0.01	MG/KG
VOA	Bromomethane	CRQL-WATER	10	UG/L
VOA	Bromomethane	SOIL	0.43	MG/KG
VOA	Bromomethane	WATER	49	UG/L
VOA	Carbon disulfide	AIR	10	UG/M3
VOA	Carbon disulfide	CRQL-SOIL	0.01	MG/KG
VOA	Carbon disulfide	CRQL-WATER	10	UG/L
VOA	Carbon disulfide	SOIL	7.4	MG/KG
VOA	Carbon disulfide	WATER	3500	UG/L
VOA	Carbon tetrachloride	AIR	0.066	UG/M3
VOA	Carbon tetrachloride	CRQL-SOIL	0.01	MG/KG
VOA	Carbon tetrachloride	CRQL-WATER	10	UG/L
VOA	Carbon tetrachloride	SOIL	0.21	MG/KG
VOA	Carbon tetrachloride	WATER	5	UG/L
VOA	Chlorobenzene	AIR	20	UG/M3
VOA	Chlorobenzene	CRQL-SOIL	0.01	MG/KG
VOA	Chlorobenzene	CRQL-WATER	10	UG/L
VOA	Chlorobenzene	SOIL	67	MG/KG
VOA	Chlorobenzene	WATER	100	UG/L
VOA	Chloroethane	AIR	10000	UG/M3
VOA	Chloroethane	CRQL-SOIL	0.01	MG/KG
VOA	Chloroethane	CRQL-WATER	10	UG/L
VOA	Chloroethane	SOIL	2900	MG/KG
VOA	Chloroethane	WATER	14000	UG/L
VOA	Chloroform	AIR	0.043	UG/M3
VOA	Chloroform	CRQL-SOIL	0.01	MG/KG
VOA	Chloroform	CRQL-WATER	10	UG/L
VOA	Chloroform	SOIL	0.21	MG/KG
VOA	Chloroform	WATER	100	UG/L

VOA	Chloromethane	AIR	5.6	UG/M3
VOA	Chloromethane	CRQL-SOIL	0.01	MG/KG
VOA	Chloromethane	CRQL-WATER	10	UG/L
VOA	Chloromethane	SOIL	6.4	MG/KG
VOA	Chloromethane	WATER	27	UG/L
VOA	Cis-1,2-Dichloroethene	AIR		UG/M3
VOA	Cis-1,2-Dichloroethene	CRQL-SOIL	0.01	MG/KG
VOA	Cis-1,2-Dichloroethene	CRQL-WATER	10	UG/L
VOA	Cis-1,2-Dichloroethene	SOIL	800	MG/KG
VOA	Cis-1,2-Dichloroethene	WATER	70	UG/L
VOA	Cis-1,3-Dichloropropene	AIR	0.027	UG/M3
VOA	Cis-1,3-Dichloropropene	CRQL-SOIL	0.01	MG/KG
VOA	Cis-1,3-Dichloropropene	CRQL-WATER	10	UG/L
VOA	Cis-1,3-Dichloropropene	SOIL	0.17	MG/KG
VOA	Cis-1,3-Dichloropropene	WATER	0.19	UG/L
VOA	Dibromochloromethane	AIR		UG/M3
VOA	Dibromochloromethane	CRQL-SOIL	0.01	MG/KG
VOA	Dibromochloromethane	CRQL-WATER	10	UG/L
VOA	Dibromochloromethane	SOIL	83	MG/KG
VOA	Dibromochloromethane	WATER	4.2	UG/L
VOA	Dibromoethane	AIR	0.005	UG/M3
VOA	Dibromoethane	CRQL-SOIL		MG/KG
VOA	Dibromoethane	CRQL-WATER		UG/L
VOA	Dibromoethane	SOIL	0.0082	MG/KG
VOA	Dibromoethane	WATER	0.0004	UG/L
VOA	Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	AIR	200	UG/M3
VOA	Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	CRQL-SOIL		MG/KG
VOA	Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	CRQL-WATER		UG/L
VOA	Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	SOIL	16000	MG/KG
VOA	Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	WATER	7000	UG/L
VOA	Ethyl benzene	AIR	1000	UG/M3
VOA	Ethyl benzene	CRQL-SOIL	0.01	MG/KG
VOA	Ethyl benzene	CRQL-WATER	10	UG/L

VOA	Ethyl benzene	SOIL	3100	MG/KG
VOA	Ethyl benzene	WATER	700	UG/L
VOA	Isopropylbenzene	AIR	9	UG/M3
VOA	Isopropylbenzene	CRQL-SOIL		MG/KG
VOA	Isopropylbenzene	CRQL-WATER		UG/L
VOA	Isopropylbenzene	SOIL	3200	MG/KG
VOA	Isopropylbenzene	WATER	1400	UG/L
VOA	Limonene	AIR		UG/M3
VOA	Limonene	CRQL-SOIL		MG/KG
VOA	Limonene	CRQL-WATER		UG/L
VOA	Limonene	SOIL		MG/KG
VOA	Limonene	WATER		UG/L
VOA	Methanol	AIR		UG/M3
VOA	Methanol	CRQL-SOIL		MG/KG
VOA	Methanol	CRQL-WATER		UG/L
VOA	Methanol	SOIL	40000	MG/KG
VOA	Methanol	WATER	18000	UG/L
VOA	Methyl iodide	AIR		UG/M3
VOA	Methyl iodide	CRQL-SOIL		MG/KG
VOA	Methyl iodide	CRQL-WATER		UG/L
VOA	Methyl iodide	SOIL		MG/KG
VOA	Methyl iodide	WATER		UG/L
VOA	Methylene Chloride	AIR	2.2	UG/M3
VOA	Methylene Chloride	CRQL-SOIL	0.01	MG/KG
VOA	Methylene Chloride	CRQL-WATER	10	UG/L
VOA	Methylene Chloride	SOIL	5.6	MG/KG
VOA	Methylene Chloride	WATER	5	UG/L
VOA	N-Butylbenzene	AIR		UG/M3
VOA	N-Butylbenzene	CRQL-SOIL		MG/KG
VOA	N-Butylbenzene	CRQL-WATER		UG/L
VOA	N-Butylbenzene	SOIL		MG/KG
VOA	N-Butylbenzene	WATER		UG/L
VOA	N-Hexane	AIR	200	UG/M3

VOA	N-Hexane	CRQL-SOIL		MG/KG
VOA	N-Hexane	CRQL-WATER		UG/L
VOA	N-Hexane	SOIL	4800	MG/KG
VOA	N-Hexane	WATER	2100	UG/L
VOA	o-Chlorotoluene	AIR		UG/M3
VOA	o-Chlorotoluene	CRQL-SOIL		MG/KG
VOA	o-Chlorotoluene	CRQL-WATER		UG/L
VOA	o-Chlorotoluene	SOIL	1600	MG/KG
VOA	o-Chlorotoluene	WATER	700	UG/L
VOA	P-Chlorotoluene	AIR		UG/M3
VOA	P-Chlorotoluene	CRQL-SOIL		MG/KG
VOA	P-Chlorotoluene	CRQL-WATER		UG/L
VOA	P-Chlorotoluene	SOIL		MG/KG
VOA	P-Chlorotoluene	WATER		UG/L
VOA	Propyl benzene	AIR		UG/M3
VOA	Propyl benzene	CRQL-SOIL		MG/KG
VOA	Propyl benzene	CRQL-WATER		UG/L
VOA	Propyl benzene	SOIL		MG/KG
VOA	Propyl benzene	WATER		UG/L
VOA	Styrene	AIR	1000	UG/M3
VOA	Styrene	CRQL-SOIL	0.01	MG/KG
VOA	Styrene	CRQL-WATER	10	UG/L
VOA	Styrene	SOIL	3300	MG/KG
VOA	Styrene	WATER	100	UG/L
VOA	Tetrachloroethene	AIR	1.8	UG/M3
VOA	Tetrachloroethene	CRQL-SOIL	0.01	MG/KG
VOA	Tetrachloroethene	CRQL-WATER	10	UG/L
VOA	Tetrachloroethene	SOIL	5.9	MG/KG
VOA	Tetrachloroethene	WATER	5	UG/L
VOA	Toluene	AIR	380	UG/M3
VOA	Toluene	CRQL-SOIL	0.01	MG/KG
VOA	Toluene	CRQL-WATER	10	UG/L
VOA	Toluene	SOIL	910	MG/KG

VOA	Toluene	WATER	1000	UG/L
VOA	Trans-1,2-Dichloroethene	AIR		UG/M3
VOA	Trans-1,2-Dichloroethene	CRQL-SOIL	0.01	MG/KG
VOA	Trans-1,2-Dichloroethene	CRQL-WATER	10	UG/L
VOA	Trans-1,2-Dichloroethene	SOIL	1600	MG/KG
VOA	Trans-1,2-Dichloroethene	WATER	100	UG/L
VOA	Trans-1,3-Dichloropropene	AIR	0.027	UG/M3
VOA	Trans-1,3-Dichloropropene	CRQL-SOIL	0.01	MG/KG
VOA	Trans-1,3-Dichloropropene	CRQL-WATER	10	UG/L
VOA	Trans-1,3-Dichloropropene	SOIL	0.17	MG/KG
VOA	Trans-1,3-Dichloropropene	WATER	0.19	UG/L
VOA	Trichloroethene	AIR	0.58	UG/M3
VOA	Trichloroethene	CRQL-SOIL	0.01	MG/KG
VOA	Trichloroethene	CRQL-WATER	10	UG/L
VOA	Trichloroethene	SOIL	3.2	MG/KG
VOA	Trichloroethene	WATER	5	UG/L
VOA	Trichlorofluoromethane	AIR	700	UG/M3
VOA	Trichlorofluoromethane	CRQL-SOIL		MG/KG
VOA	Trichlorofluoromethane	CRQL-WATER		UG/L
VOA	Trichlorofluoromethane	SOIL	24000	MG/KG
VOA	Trichlorofluoromethane	WATER	11000	UG/L
VOA	Trichloropropane (1,2,3)	AIR		UG/M3
VOA	Trichloropropane (1,2,3)	CRQL-SOIL		MG/KG
VOA	Trichloropropane (1,2,3)	CRQL-WATER		UG/L
VOA	Trichloropropane (1,2,3)	SOIL	480	MG/KG
VOA	Trichloropropane (1,2,3)	WATER	210	UG/L
VOA	Vinyl Chloride	AIR	0.012	UG/M3
VOA	Vinyl Chloride	CRQL-SOIL	0.01	MG/KG
VOA	Vinyl Chloride	CRQL-WATER	10	UG/L
VOA	Vinyl Chloride	SOIL	0.013	MG/KG
VOA	Vinyl Chloride	WATER	2	UG/L
VOA	Xylene (Total)	AIR		UG/M3
VOA	Xylene (Total)	CRQL-SOIL	0.01	MG/KG

VOA	Xylene (Total)	CRQL-WATER	10	UG/L
VOA	Xylene (Total)	SOIL	160000	MG/KG
VOA	Xylene (Total)	WATER	10000	UG/L
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APPENDIX B

DATA EVALUATION AND METHODOLOGIES FOR DEVELOPING SITE-SPECIFIC PRELIMINARY REMEDIAL GOALS TO DEMONSTRATE CLEAN CLOSURE

APPENDIX B

DATA EVALUATION AND METHODOLOGIES FOR DEVELOPING SITE-SPECIFIC PRELIMINARY REMEDIAL GOALS TO DEMONSTRATE CLEAN CLOSURE

B.1 Data Evaluation

The process for evaluating data from the proposed sampling plan is summarized in Figure B-1. All data will first be qualified per quality assurance/quality control (QA/QC) requirements. The QA/QC evaluation will be based on the Material Disposal Area (MDA)-P Quality Assurance Plan. The level of uncertainty associated with estimated (e.g., J-flagged data) values and the potential effect this may have on the decision-making process will be discussed. Those data that do not meet the QA/QC criteria will be rejected. If the rejection of the data results in less than the minimum number of three samples within the selected exposure unit(s), additional sample(s) will be analyzed. If a risk assessment is required, a minimum of three samples are needed to develop an upper confidence limit (UCL) of the mean (95% UCL of the mean), which is used in estimating exposure and potential risk. Although a risk assessment could be conducted using one or two samples per exposure unit, the uncertainty associated with that analysis is greatly reduced by using at least three samples.

B.2 DESCRIPTION AND USES OF SITE-SPECIFIC PRELIMINARY REMEDIAL GOALS

Site-specific human health preliminary remedial goals (PRGs) are site-specific risk-based concentrations that can be used to screen constituents in environmental media, trigger further investigation, and provide initial cleanup goals. Similar to screening action levels (SAL), PRGs focus on dominant exposure pathways, can be used as a screening tool, and do not address ecological concerns. However, specific PRGs may be developed to reflect site-specific direct-exposure conditions (inhalation, ingestion, dermal exposure) under specific land-use conditions (e.g., continued industrial land use) and may be used as initial cleanup goals. In addition, PRGs for soils include all pathways (including dermal absorption) for direct exposures; SALs for soils do not include the dermal pathway. As with constituent concentrations that exceed SALs, those

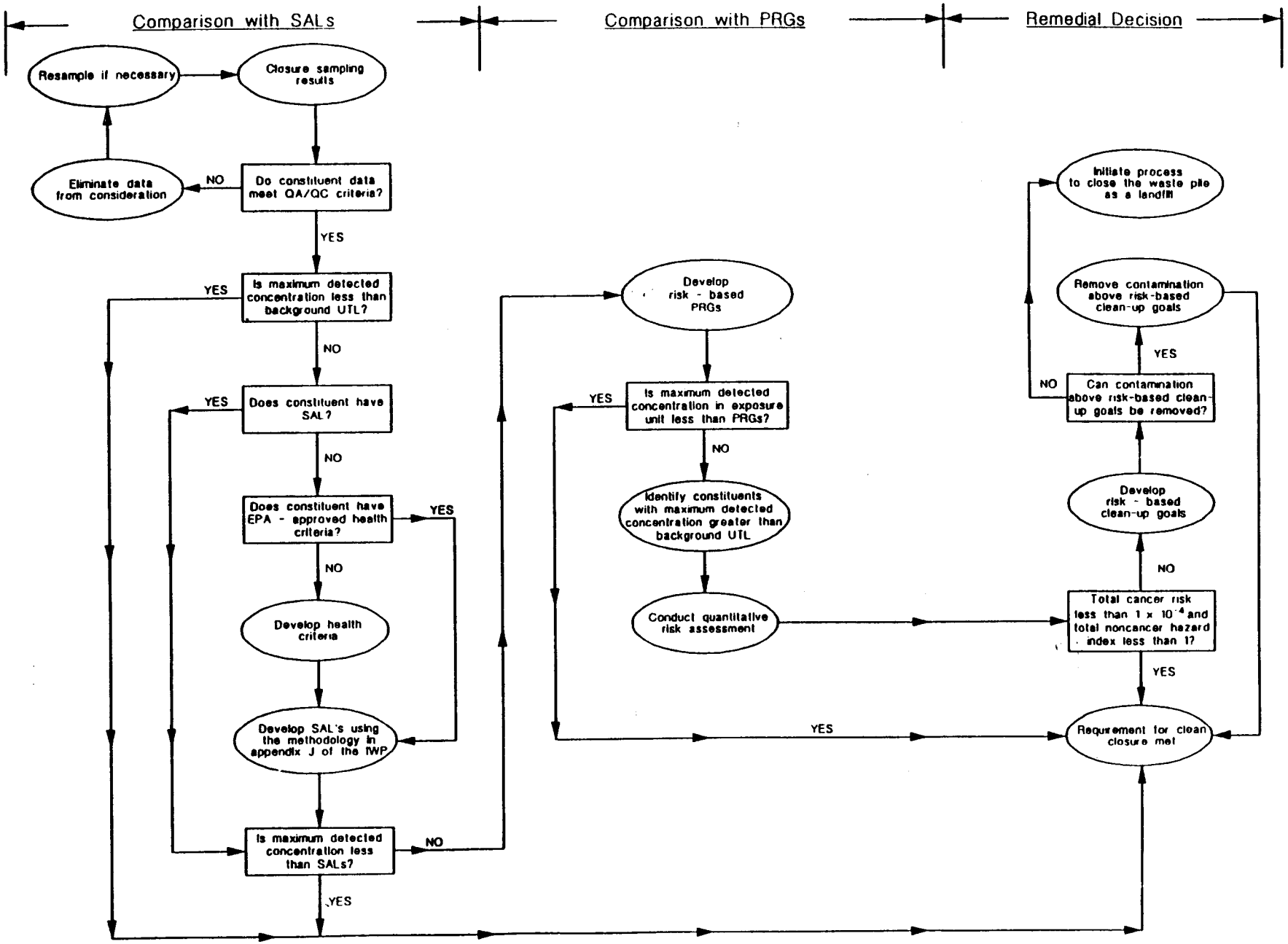


Figure B-1. Process for Determining If Closure Performance Standard Is Met (See discussion in section 6.1.1.2)

constituent concentrations that exceed PRGs do not, in themselves, mean that there is an unacceptable health threat, only that these constituents should be evaluated further.

B.3 APPROACH

PRGs for the MDA-P site will be developed for any constituent in the Phase 2 shallow grid samples that exceeds SALs (i.e., the SAL comparison ratio [maximum concentration/SAL] exceeds 1) and for those constituents whose summed SAL comparison ratios exceeds 1 for a specific target organ or effect (e.g., cancer risk) (see Section 6.1.1.2 for discussion).

The PRGs will be developed for a reasonable maximum exposed (RME) individual (i.e., a healthy working adult) based on EPA equations (EPA 1991 and EPA 1994) and default input parameters (EPA 1991a) modified using site-specific information under a continued industrial land use scenario.

This approach is considered to be conservative for the following reasons. Currently and following excavation, the land is expected to remain at a 30-degree incline. Continued slumping and mass wasting is occurring at the site. Thus, the potential for building on the site without substantial stabilization, including the importation of several thousand cubic feet of clean fill, is highly improbable.

The PRGs will use the most current sources of EPA-approved toxicity criteria such as the Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Table (HEAST), and the Environmental Criteria and Assessment Office (ECAO). Should no toxicity criteria be available from the primary source of information (i.e., IRIS) for a specific route of exposure (i.e., inhalation or oral), the other two sources (HEAST and ECAO) will be consulted. Should toxicity criteria be available for only one route of exposure (i.e., either inhalation or oral), the missing toxicity criteria will be derived from the available route-specific toxicity criteria for that constituent.

The PRGs will be compared with maximum constituent concentrations within each exposure unit, which is approximately 2000 square meters (m^2) in area. The Laboratory has identified a total

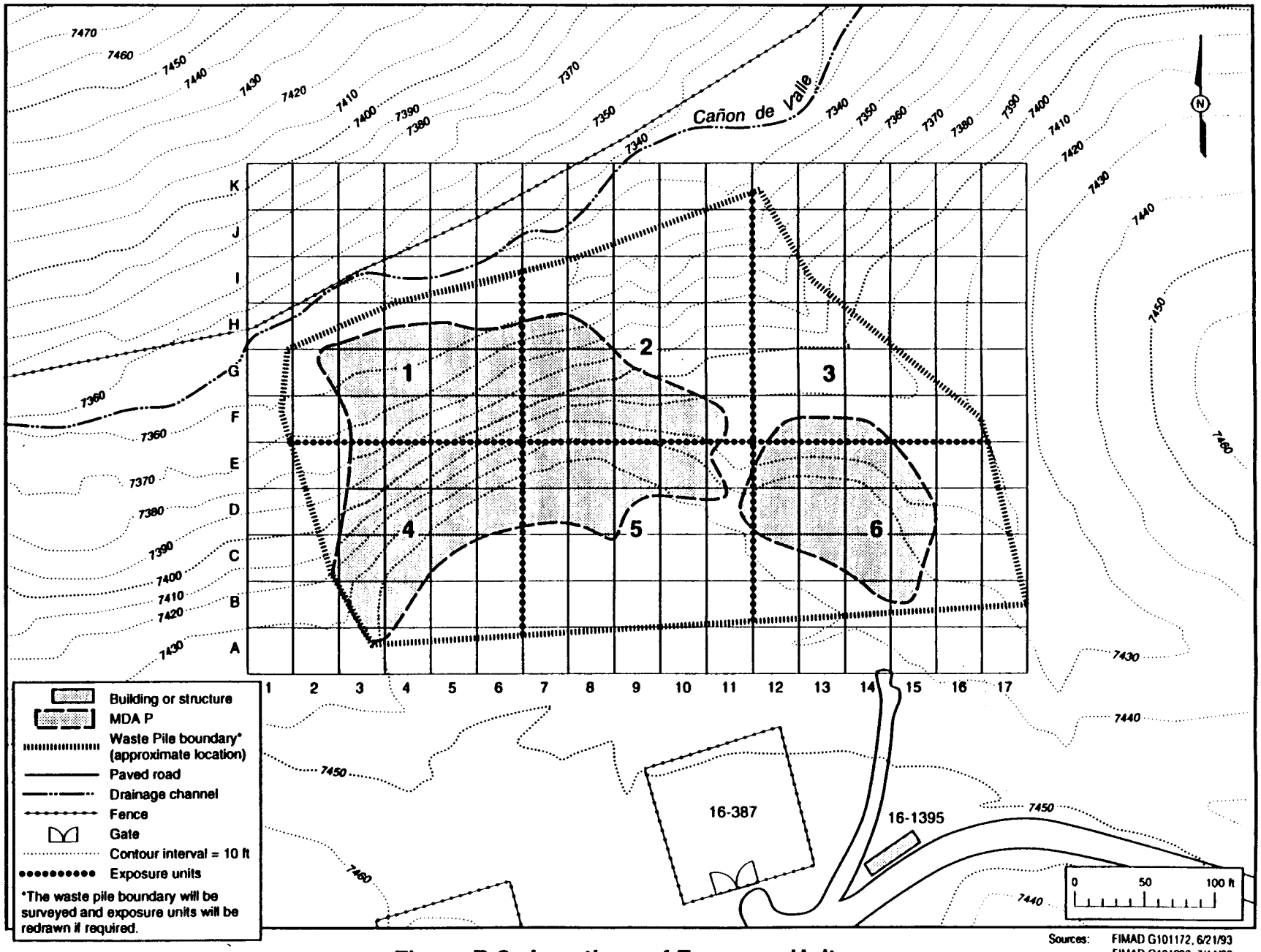
of 6 possible exposure units within the exposure area (Figure B-2). The dimensions of each exposure unit are based on the size a small industrial building, (approximately 800 m^2) within the exposure unit, which reflect a 40% coverage of the exposure unit. This coverage is similar to requirements for other structures in the Los Alamos County Building Code 17.42.010 [LAC 1991]).

If the maximum concentration of each constituent within an exposure unit exceeds its PRG (i.e., the PRG comparison ratio [maximum concentration/PRG] for the individual constituent exceeds 1) or the sum or the PRG comparison ratios for a specific target organ or effect (e.g., cancer risk) exceeds a target value of 1, then a baseline risk assessment will be conducted in accordance with EPA guidance (EPA 1989, EPA 1991a, and EPA 1992).

B.4 PRG EQUATIONS

The equations used to calculate the PRGs for carcinogenic and noncarcinogenic contaminants is presented in Equations 1 and 2. Calculations of PRGs are consistent with Risk Assessment Guidance for Superfund (RAGS) Part B (EPA 1991) but also consider updates to the RAGS Part B equations (EPA 1994). The methodology backcalculates a soil and air concentration from a target cancer risk value of 10^{-4} (i.e., 1 in 10,000) for industrial exposure conditions or a target hazard quotient of 1 for noncarcinogens. The equations for soil combine across pathways for direct exposure (i.e., ingestion, skin contact, and inhalation).

To calculate soil PRGs, the cancer slope factor and reference dose (RfD) for dermal exposure is calculated in Equations 3 and 4, respectively. For volatile chemicals in soil, a chemical-specific volatilization factor is calculated in Equation 5.



Sources: FIMAD G101172, 6/21/93
FIMAD G101223, 7/14/93
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Figure B-2. Locations of Exposure Units

Equation 1: Direct Exposures to Carcinogenic Constituents in Industrial Soil

$$C(mg/kg) = \frac{TR \times BW_a \times AT_c \times 365 d/y}{EF_o \times ED_o \left[\frac{IRS_o \times CSF_o}{10^6\ mg/kg} + \frac{SA_a \times CSF_d \times ABS}{10^6\ mg/kg} + \frac{IRA_a \times CSF_i}{VF_s} \right]}$$

Where:

C(mg/kg)	=	Preliminary remedial goal for soil based on exposure to carcinogenic constituents (mg/kg)
TR	=	Target cancer risk (unitless) Considered to be 1×10^{-4}
BW_a	=	Body weight, adult (kg) Considered to be 70 kg (EPA 1991a)
AT_c	=	Averaging Time - cancer (years) Considered to be 70 years (EPA 1991a)
EF_o	=	Exposure Frequency - occupational (d/y) Considered to be 200 d/y Based on 250 d/y (EPA 1991a) minus 50 workdays when soil is wet or covered with snow
ED_o	=	Exposure duration - occupational (years) Considered to be 25 years (EPA 1991a)
IRS_o	=	Soil ingestion - occupational (mg/day) Considered to be 50 mg/day (EPA 1991a)
CSF_o	=	Cancer slope factor-oral $(mg/kg\text{-}d)^{-1}$ (IRIS, HEAST, or ECAO)
SA_a	=	25% Surface area, adult (cm^2) Considered to be 5000 cm^2 (EPA 1992)
CSF_d	=	Cancer slope factor-dermal $(mg/kg\text{-}d)^{-1}$ (See Equation 3)
ABS	=	Skin absorption Considered to be 0.1 for organics (EPA 1994) Considered to be 0.01 for inorganics (EPA 1994)
IRA_a	=	Inhalation rate - adult (m^3/day) Considered to be 20 m^3/day (EPA 1991a)
CSF_i	=	Cancer slope factor-inhalation $(mg/kg\text{-}d)^{-1}$ (IRIS, HEAST, or ECAO)
VF_s	=	Volatilization factor for soil (m^3/kg) (See Equation 5)

Equation 2: Direct Exposures to Noncarcinogenic Constituents in Industrial Soil

$$C(mg/kg) = \frac{THQ \times BW_a \times ED_o \times 365\ d/y}{EF_o \times ED_o \left[\left(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_d} \times \frac{SA_a \times ABS}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_i} \times \frac{IRA_a}{VF_s} \right) \right]}$$

Where:

C(mg/kg)	=	Preliminary remedial goal for soil based on exposure to noncarcinogenic constituents (mg/kg)
THQ	=	Target hazard quotient (unitless) Considered to be 1
BW_a	=	Body weight, adult (kg) Considered to be 70 kg (EPA 1991a)
ED_o	=	Exposure duration - occupational (years) Considered to be 25 years (EPA 1991a)
EF_o	=	Exposure Frequency - occupational (d/y) Considered to be 200 d/y Based on 250 d/y (EPA 1991a) minus 50 workdays when soil is wet or covered with snow
RfD_o	=	Reference dose-oral (mg/kg-d) (IRIS, HEAST, or ECAO)
IRS_o	=	Soil ingestion - occupational (mg/day) Considered to be 50 mg/day (EPA 1991a)
RfD_d	=	Reference dose-dermal (mg/kg-d) (IRIS, HEAST, or ECAO) (See Equation 4)
SA_a	=	25% Surface area, adult (cm^2) Considered to be 5000 cm^2 (EPA 1992)
ABS	=	Skin absorption Considered to be 0.1 for organics (EPA 1994) Considered to be 0.01 for inorganics (EPA 1994)
RfD_i	=	Reference dose inhalation (mg/kg-d) (IRIS, HEAST, or ECAO)
IRA_a	=	Inhalation rate - adult (m^3/day) Considered to be 20 m^3/day (EPA 1991a)
VF_s	=	Volatilization factor for soil (m^3/kg) (See Equation 5)

Equation 3: Dermal Cancer-Slope Factor (CSFd) Based Upon Absorbed Dose

Cancer slope factors based upon administered doses will be adjusted for absorption to obtain estimates of potential dermal cancer-slope factors (1992). Where absorption factors and oral cancer slope factors are available, dermal cancer-slope factors will be calculated using the following equation:

$$CSF_{absorbed} = \frac{CSF_{administered}}{A_{bs}}$$

Where:

$CSF_{absorbed}$	=	cancer-slope factor based on absorbed dose
$CSF_{administered}$	=	oral cancer-slope factor
A_{bs}	=	oral absorption factor

Equation 4: Dermal Reference Dose (RfDd) Based Upon Absorbed Dose

Reference doses based upon administered doses will be adjusted for absorption to obtain estimates of potential dermal reference doses (1992). Where absorption factors and oral reference doses are available, dermal reference doses will be calculated using the following equation:

$$RfD_{absorbed} = RfD_{administered} \times A_{bs}$$

Where:

$RfD_{absorbed}$	=	reference dose based on absorbed dose
$RfD_{administered}$	=	oral reference dose
A_{bs}	=	oral absorption factor

Equation 5: Derivation of the Volatilization Factor

$$VF(m^3/kg) = \frac{LS \times V \times DH}{A} \times \frac{(\pi \times \alpha \times T)^{1/2}}{2 \times D_{ei} \times P_a \times K_{as} \times 10^{-3}\ kg/g}$$

Where:

$$\alpha = \frac{D_{ei} \times P_a}{P_a + \frac{(\rho_s)\ (1-P_a)}{K_{as}}}$$

VF = Volatization factor (m^3/kg)

LS = Length of side of contaminated area (m) Considered to be 45 m

V = Windspeed in mixing zone (m/s) Considered to be default of 2.25 m/s

DH = Diffusion height (m) Considered to be default of 2 m

A = Area of contamination (cm^2) Considered to be 20,000,000 cm^2

D_{ei} = Effective diffusivity (cm^2/s) Considered to equal to $D_i(P_a^{3.33}/P_i^2)$

P_a = Air-filled soil porosity (unitless) Considered to be equal to P_i-θß

P_i = Total soil porosity (unitless) Considered to be equal to 1-(ß/P_s)

θ = Soil moisture content (cm^3-water/g-soil) Considered to be default of 0.1 cm^3-water/g-soil

ß = Soil bulk density (g/cm^3) Considered to be default of 1.5 g/cm^3

ρ_s = True soil density or particle density (g/cm^3) Considered to be default of 2.65 g/cm^3

K_{as} = Soil-air partition coefficient (g-soil/cm^3-air) Considered to be equivalent to (H/K_s) x 41 (41 is a conversion factor)

T = Exposure interval (s) Considered to be 28,800 s (8 hr)

D_i = Diffusivity in air (cm^2/s) Chemical-specific

H = Henry's Law constant (atm-m^3/mol) Chemical-specific

K_s = Soil-water partition coefficient (cm^3/g) K_{OC}xOC

OC Organic carbon content of soil (fraction) Considered to be default of 0.02

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APPENDIX C

PHOTOGRAPHS OF THE MDA-P WASTE PILE AND SURFACE RUN-ON CONTROL TRENCH

Material Disposal Area P Surface Run-on Trench

Material Disposal Area P Surface Run-on Trench

Material Disposal Area P Exposed Debris

Material Disposal Area P Exposed Debris

Material Disposal Area P Exposed Debris

APPENDIX D

VADOSE ZONE MONITORING OBSERVATIONS AT TA-16 AREA P LANDFILL (EXCERPTED FROM McLIN 1989)

VADOSE ZONE MONITORING OBSERVATIONS AT THE TA-16 AREA P LANDFILL

by

Stephen G. McLin

with the

Solid Waste and Remedial Action Section

Environmental Surveillance Group (HSE-8)

Los Alamos National Laboratory

Los Alamos National Laboratory

Los Alamos, New Mexico

August 18, 1989

THIS PRELIMINARY REPORT IS SUBJECT TO FINAL REVIEW

TABLE OF CONTENTS

		page
	ABSTRACT	3
I.	INTRODUCTION	4
II.	GEOLOGY AT AREA P	7
III.	SHALLOW VADOSE ZONE MONITORING SYSTEM	11
IV.	MOISTURE AND WATER QUALITY DATA DURING 1988-89	12
V.	CONCLUSIONS AND RECOMMENDATIONS	15
VI.	REFERENCES	18
VII.	APPENDICES	20
	A. Borehole Logs at Landfill	21
	B. Chemical Data from Soil Samples	50
	C. Pressure-Vacuum Lysimeter Water Samples	54
	D. Canon de Valle Stream Samples	55
	E. Calibration Curves for the Neutron Moisture Probe	57
	F. Neutron Moisture Readings	60

VADOSE ZONE MONITORING OBSERVATIONS AT THE TECHNICAL AREA 16 AREA P LANDFILL

by

Stephen G. McLin

ABSTRACT

A vadose monitoring system consisting of eight separate wells clustered together into four well nests was installed into and below the landfill at Technical Area 16 (TA-16) Area P during the fall of 1988. Each well nest consists of either a single or duel completion pressure-vacuum lysimeter borehole, and an adjacent neutron moisture access well. The four lysimeter boreholes contain a total of seven independent lysimeters located at varying depths in and below the landfill, while the neutron access wells penetrate into the underlying native Bandelier tuff down to a maximum depth of 30 feet.

Soil and tuff core samples collected during these installations indicate that barium in excess of 18,000 mg/l is present in the eastern half of the landfill, while the western portion has barium below detection limits. This barium occurs as barium oxide in whi crystalline stringers of wastes located several feet below t surface. These wastes originated from barium nitrate contaminated sands associated with HE waste processing and disposal operations dating from the 1950s. At least some of this barium has been mobilized by infiltrating precipitation, and has penetrated to a depth of approximately 19 feet, or at least six feet below the landfill bottom. Four of the seven lysimeters have yielded small volumes of water at routine sampling intervals over a one year period; all of these lysimeters are adjacent to landfill materials. Barium concentrations in these water samples ranged from 1.1 to 37.8 mg/l, and averaged 9.23 mg/l. The three remaining lysimeters that did not yield water are all located below the landfill-tuff contact.

Monthly neutron moisture access well measurements from March to September 1989 have shown a consistently stable moisture distribution in four landfill access wells, and five perimeter access wells. The volumetric moisture contents over depth from individual landfill access wells are considerably higher than for the perimeter wells. Background volumetric moisture contents typically exceed 15% in the top one foot, but quickly drop below 5% at 4 feet, and remain relatively constant down to 170 feet. However the eastern landfill wells show moisture contents between 15 to 25% above the landfill-tuff contact, and between 15 to 20% in the tuff. Western landfill wells show similar moisture contents compared to those in the east, but higher moistures extend to greater depths Western portions of the landfill have waste and fill deposits tha are thicker than in the east, and contain more clayey materials.

I. INTRODUCTION

An industrial landfill, located in Technical Area 16 Area P (TA-16 Area P) at the Los Alamos National Laboratory (LANL), was actively used from the early 1950s until about 1985. At that time several landfill soil samples revealed the presence of barium in excess of Extraction Procedure (EP) toxicity limits defined in 40 CFR 261.24, and the landfill was subject to regulation under the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. The vadose zone monitoring activities described herein were conducted in support of the main aquifer ground-water monitoring waiver demonstration (McLin and Purtymun, 1988) and the interim status closure and post-closure care plans (Delta H Engineering, 1985; HSE-8, 1988); these latter two documents have been submitted to the New Mexico Environmental Improvement Division (NMEID).

There is very little documentation of the types or quantities of wastes placed into the Area P landfill. The site was used in the early 1950s to dispose of burned equipment that had been contaminated with high explosives (HE), and building demolition rubble. The procedure for handling HE-contaminated equipment and wastes has been relatively constant over the years; the notable exception is that sand-covered burn pads have recently been supplemented by fire-brick lined metal trays that are elevated above the ground surface. Initially any equipment or waste debris that is potentially HE-contaminated is partially disassembled and all surfaces are cleaned. This equipment is then taken to a sand-covered burn pad (i.e., Pad No. 387) and flashed, along with other combustible material needed to support the fire. Currently any waste HE residues are flashed in a fire-brick lined metal tray (i.e. Pad No. 388) or in pressure sand filters (i.e., Structure Nos. TA-16-401 and 406). After the thermal treatment, waste equipment and debris are inspected for any unburned HE residue. Before 1985 all flashed HE-free wastes, including the burn pad sands, were removed from the flash or burn pads and placed in the landfill. Since 1985 all ash wastes have be drummed after thermal treatment and transported to TA-54 for subsequent disposal. The source of elevated barium in the waste residue is barium nitrate that was used in the formulation of some HE materials. Barium concentrations in the sand wastes vary with barium nitrate concentrations in the HE, and with HE concentrations in the wastes. At elevated temperatures associated with the thermal treatment process, nitrates would be reduced to volatile oxides of nitrogen, and would tend to be absent in the ash.

The Area P landfill (Figs. 1 and 2) is located in a topographic saddle on a short, east-trending narrow mesa. This saddle is near the southern rim of Canon de Valle immediately north of the TA-16 thermal treatment pad number 387. The elliptically shaped landfill is about 170 wide in the north-south direction, and 400 feet long in the east-west direction; it contains an estimated 13,000 cubic yards of waste construction debris, crushed tuff and sandy clay fill material, and barium contaminated sands. Landfilling activities progressed from west to east. The western portion was closed by

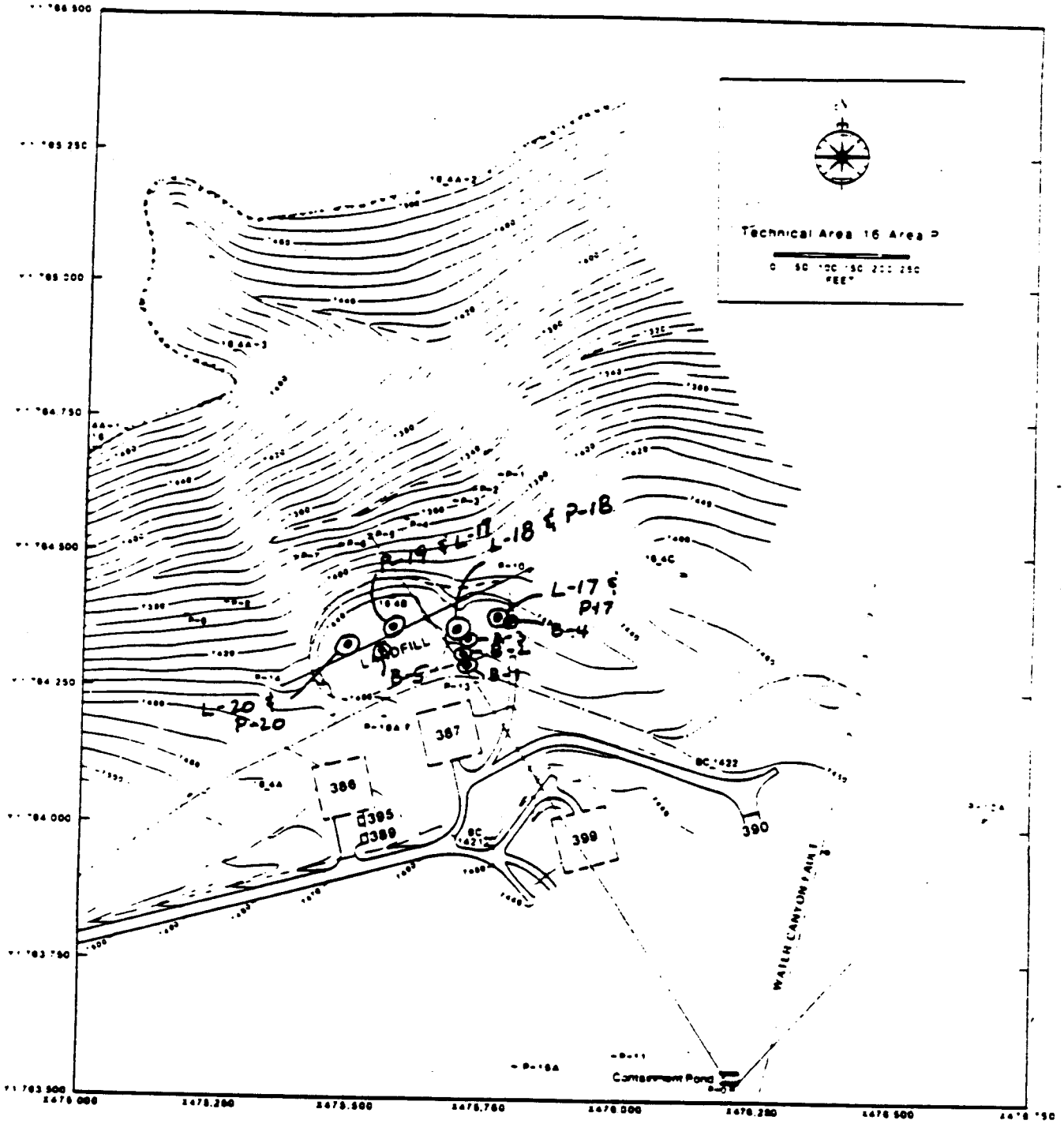

Figure 1. Site map of TA-16 Area P. Boreholes are marked with crosses, numbered P-0 through P-20, and L-17 through L-20. Additional crosses are survey marks (after Brown, et al., 1988).

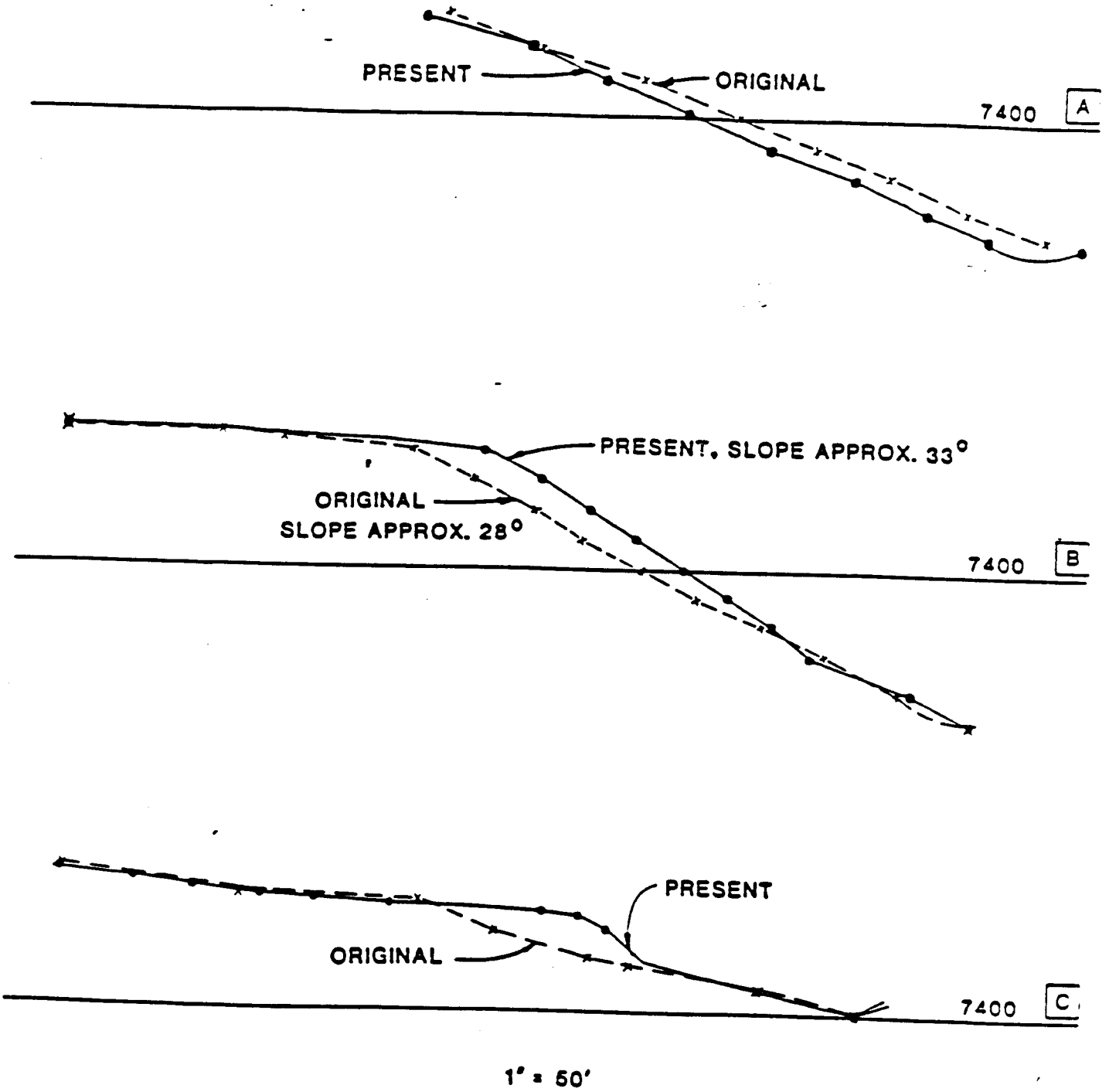

Figure 2. Map of three cross sections of waste disposal Area P showing locations of original and present land surfaces relative to elevation of 7400 feet. Cross sections A, B, and C are roughly north-south transects located immediately west of the landfill, through the middle of the landfill, and through the middle of the east portion of the landfill, respectively (after Nyhan, 1989).

leveling and covering wastes with crushed tuff and sandy clay soil. These leveling operations resulted in some landfill debris overflowing the canyon rim along the northwest quadrant. Earlier investigations, including a site geological characterization (Brown, et al. 1988) and a water balance study (Nyhan, 1989), have reported that waste deposition reaches only 30 to 40 feet back from the canyon rim, and extends down the slope to the canyon floor. However, results from this study indicate that waste deposition extends at least 100 feet back from the existing canyon rim; furthermore, barium wastes may or may not be present in the entire landfill area. Elevations across the landfill vary from about 7,350 feet above mean sea level in the canyon bottom, to about 7,450 feet at the landfill top.

The western portion of the landfill has been naturally revegetated with grasses, wild rose, wormwood, oak brush, and juniper. There are occasional protrusions of concrete rubble, steel pipe, and metal that aids in binding the mass together. In the recently active eastern portion, fill has progressed from south to north with cover soil being added as the fill advanced. Wastes on the northern face of the landfill are exposed, and no appreciable natural revegetation has occurred in the eastern portion.

II. GEOLOGY AT AREA P

The regional and site geology of the Area P landfill has been previously reported in detail (Brown, et al., 1988). However a brief geological summary is presented here to assist the reader in understanding site drilling logs presented in this report.

There are about 1,230 feet of unsaturated Bandelier Tuff and Puye fanglomerates with interbedded volcanics underlying the mesa at TA-16 (Purtymun, 1984; Purtymun and Stoker, 1987; and McLin and Purtymun, 1988). The thickness of the tuff is at its maximum along the western edge of Pajarito Plateau, roughly delineated by New Mexico Highway 4 west of LANL and the TA-16 entrance gate. This tuff gradually thins to about 600 feet in thickness near the Rio Grande located approximately 10 miles to the east. The thickness of the unsaturated tuff and sediments below the TA-16 area is indicated below in Table 1.

The 950 feet of unsaturated tuff beneath the mesa at TA-16 consists of quartz and sanadine crystals and crystal fragments, and small rock fragments of latite, rhyolite, and pumice in a glassy gray ash matrix. The degree of welding in the tuff increases westward across the plateau toward the source area at Valles Caldera. This increase in welding reduces the porosity and capillary size of the pores. It is also likely that the hydraulic transmitting characteristics of the unsaturated tuff are also reduced with increased degrees of tuff welding (Abeele, 1984; and Stephens, 1988).

Table 1. Geologic Section at TA-16.

Geologic Section	Thickness (ft)	Depth (ft)
BANDELIER TUFF		
Tshierege Member		
Unit 3		
Unit 2	190	190
Unit 1	150	340
Otowi Member	360	700
Guaje Member	210	910
	40	950
PUYE CONGLOMERATE		
Fanglomerate with interbedded volcanics	500	1,450
TESUQUE FORMATION		
Siltstones and sandstones, occasional conglomerates interbedded with volcanics, earlier volcanics, and sediments	2,000	3,450
PRECAMBRIAN		
Basement rocks	unknown	+3,450

In order to establish the shallow subsurface geology at Area P, 17 boreholes (numbered P-0 through P-16) were drilled in the fall of 1987. In addition, 13 auxiliary boreholes were drilled in the fall of 1988 (numbered P-17 through P-20, L-17 through L-20, and B-1 through B-5). All of these drill logs are contained in Appendix A of this report and in HSE-8 (1988); all borehole locations are shown in Fig. 1. A rotary drilling technique utilizing air and either 4 or 6 inch continuous flight auger were employed. Continuous drill cuttings were recovered with the 4-inch solid-stem auger, while the 6-inch hollow-stem auger allowed continuous core recovery when a split-spoon sampler was employed. Lithologic logging was done for each borehole; however, logs from continuously cored holes are more accurate. Each log description was based on the following characteristics: (1) color; (2) degree of welding; (3) shape and abundance of pumice lapilli; and (4) distribution of lithic fragments. Four distinct types of welding were recognized during drilling operations, and included:

1. Nonwelded: High porosity, low cohesion of glassy fragments, and crumbly texture. In core samples, this can be recognized by disaggregation and little or no flattening of pumice lapilli.

2. Moderately Welded: Less porosity, moderate cohesion, brittle texture, and slight deformation of glassy fragments. In core samples, this texture crumbles easily in the hand and contains some noticeably flattened pumice lapilli.

3. Welded: Low porosity, good cohesion, brittle texture, noticeable deformation of glassy fragments. This texture normally requires a hammer to break, and the majority of pumice fragments are noticeably flattened.

4. Densely Welded: Texture noticeably impedes or halts drilling, with little or no drill-bit penetration and poor core recovery.

Two major lithologic units of the Bandelier Tuff were identified at Area P during drilling operations (Fig. 3 and Table 1). The uppermost Unit 3 consists of four individual ash flows that appear to have cooled contemporaneously, forming a single compound unit. These ash flows were designated by Brown, et al. (1988) as Subunits 3a, 3b, 3c, and 3d (bottom to top). Unit 3 rests conformably above Unit 2, the lowermost unit encountered. In general, the Bandelier Tuff dips 2 to 5 degrees toward the east; however, at the landfill no dip was apparent and the units are essentially horizontal and of uniform thickness.

Subunit 3a consists of a welded dark yellowish brown tuff, with rare pumice lapilli that are slightly flattened. This subunit also contains abundant pebble-sized red porphyritic quartz latite and gray rhyolite lithic fragments. The ratio of quartz to rhyolite increases towards the base of the subunit. The contact between Subunit 3a and the underlying Unit 2 tends to be densely welded in the vicinity of the landfill, but is nonwelded farther east near P-12.

Subunit 3b consists of a welded pale yellowish brown tuff, with common gray and red pumice lapilli that are noticeably flattened. This subunit also contains rare pebble-sized rhyolite lithic fragments. This subunit weathers to a dark brown, and may also contain abundant clayey pumice lapilli.

Subunit 3c consists of a moderately welded brownish gray to yellowish brown tuff, with common gray pumice lapilli that are noticeably flattened, and rare pebble-sized rhyolite lithic fragments. Clay-filled vertical fractures are common throughout this subunit. The contact between 3c and 3d tends to be densely welded.

Subunit 3d outcrops along the higher rim of the topographic saddle at the landfill, and consists of a moderately welded yellowish brown tuff, with rare pebble-sized rhyolite lithic fragments ans common gray pumice lapilli. Subunit 3d is overlain by scattered deposits of El Cajete Pumice.

Locally, Unit 2 consists of a welded to densely welded tuff, light gray to pinkish gray in color, with common pumice lapilli an pebble-sized rhyolite fragments. Because of this dense welding, the

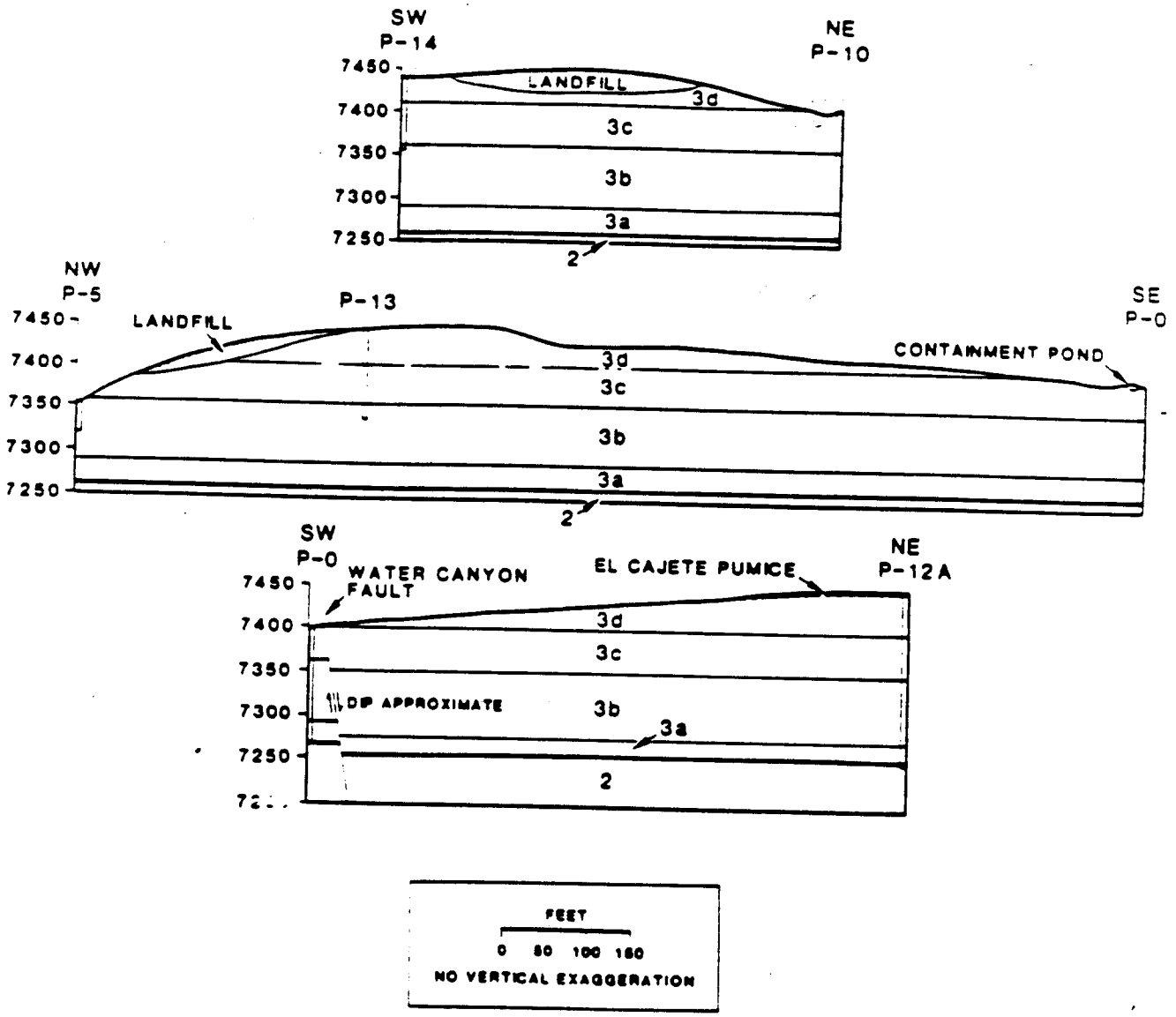

Figure 3. Geologic cross sections through Area P. Section lines are shown in Figure 1 (after Brown, et al., 1988).

drill bit was only able to penetrate the upper 5 to 10 feet of t unit.

Additional hydrogeological information from the Area P landfill is contained in the Delta H Engineering (1985) closure plan, the HSE-8 closure plan modifications (HSE-8, 1988), McLin and Purtymun (1988), and Stephens (1988).

III. SHALLOW VADOSE ZONE MONITORING SYSTEM

The geological profile extending from the ground surface downward to the upper surface of the principal water-bearing formation has been defined as the vadose zone (Everett, et al., 1984). These authors present an extensive discussion on field methods for monitoring pollution movement in the vadose zone at active or abandoned sites. According to this source, ceramic-type suction samplers are the best available technology for in-situ sampling of unsaturated media. In fact, it is not physically possible for saturated monitoring systems to extract water from the vadose zone because water held here is below atmospheric pressure. Hence a coupled network of pressure-vacuum lysimeters and neutron moisture access wells was installed at the Area P landfill to supplement the existing ground-water monitoring system and neutron moisture access wells. This vadose zone monitoring system is described below.

Of the 17 boreholes drilled in the fall of 1987 (HSE-8, 1988), eight were completed as saturated monitoring wells (i.e, boreholes P-1, and P-3 through P-9 in Appendix A), 5 were completed as neutron moisture access wells (i.e., boreholes P-0, P-12 through P-14, and P-16), and 4 were sealed closed (i.e., boreholes P-2, P-10, P-11, and P-15) after logging. In the fall of 1988, 13 additional boreholes were installed to complete a vadose monitoring system. Each of these boreholes penetrated through the landfill and into the underlying native Bandelier tuff. These boreholes were completed as a coupled network of seven pressure-vacuum lysimeters utilizing multiple completions in four boreholes (i.e., boreholes L-17 through L-20), four neutron moisture access wells (i.e., boreholes P-17 through P-20), and five exploration boreholes (i.e., B-1 through B-5) that were plugged and abandoned after logging. Completion summaries are provided for each of these in Appendix A.

The pressure-vacuum lysimeter and neutron moisture access boreholes were completed as two-well nests, with approximately six to eight feet of horizontal separation between nest boreholes to avoid interference effects. Hence lysimeter L-17 is within eight feet of neutron moisture access well P-17, and so on for the other three nests (i.e., numbered 18 to 20). The 4.0 inch diameter neutron moisture access boreholes were cased with 12 foot lengths of 2.50 inch O.D. seamless aluminum tubing having a 0.049 inch wall thickness. Two 12 foot sections of tubing were welded together int a single 24 foot section, and these 24 foot sections were joined together using a two-inch stainless steel coupling with internal

neoprene liner; the bottom section of tubing contained an end-cap plug. The remaining 0.75 inch borehole annulus was filled with a fine to medium grained silica sand to provide uniform density and compaction. A concrete surface seal and protective top-cap were installed to prevent any borehole infiltration.

Each lysimeter borehole was cored with 6-inch hollow-stem auger and split-spoon sampler. Multiple pressure-vacuum lysimeter depth locations were identified from core samples in the field; individual completion details are listed with the drilling logs in Appendix A. All lysimeters were manufactured by Soilmoisture Equipment Corporation, model number 1940. A lysimeter schematic is shown in Fig. 4. For wells P-17, P-18, and P-20, one lysimeter was placed at a depth slightly above the landfill-tuff contact, and a deeper lysimeter was placed below this contact. For well P-19, only a single lysimeter was installed above the landfill-tuff contact. The borehole annulus surrounding each lysimeter was filled with a fine to medium pure silica sand. A one to two foot concrete seal was installed between each lysimeter to prevent borehole infiltration, and a concrete surface seal and locking steel cap was also installed.

During borehole coring and drilling operations, landfill soil and undisturbed tuff samples were collected for barium, nitrate, and residual explosives analyses. Barium was analyzed using the EP toxicity test procedure specified in 40 CFR 261 Appendix II, and represents barium solubility in a mixture agitated for 24 hours at 20 to 40 degrees Celsius. This mixture has a constant pH of 5.0, and consists of soil, deionized water, and 0.5 N acetic acid. Since precipitation in Los Alamos County typically has a pH of about 5.5 to 6.5, this procedure provides a crude indication of barium leaching potential in the landfill. All of these chemical data are summarized in Appendix B.

IV. MOISTURE AND WATER QUALITY DATA

At periodic intervals, each lysimeter was evacuated to approximately 50 centibars (cb) vacuum pressure (equivalent to 15 inches of mercury or 7.4 psig). This vacuum pressure was maintained for approximately one week before a water sample was collected. Four of the seven lysimeters have yielded water using this procedure, although at sporadic intervals coinciding with heavy precipitation or snow melt periods. All of the lysimeters located in the undisturbed tuff have consistently failed to yield any water, while the landfill lysimeters have yielded small volumes (i.e., less than 25 ml) on occasion. When sufficient water volumes could be collected, they were analyzed for barium and nitrate. Results of these chemical analyses are shown in Appendix C.

During the fall of 1988, a stream sampling survey was conducted along Canon de Valle upstream of Area P to New Mexico Highway 4. Stream water and sediment samples were collected at periodic

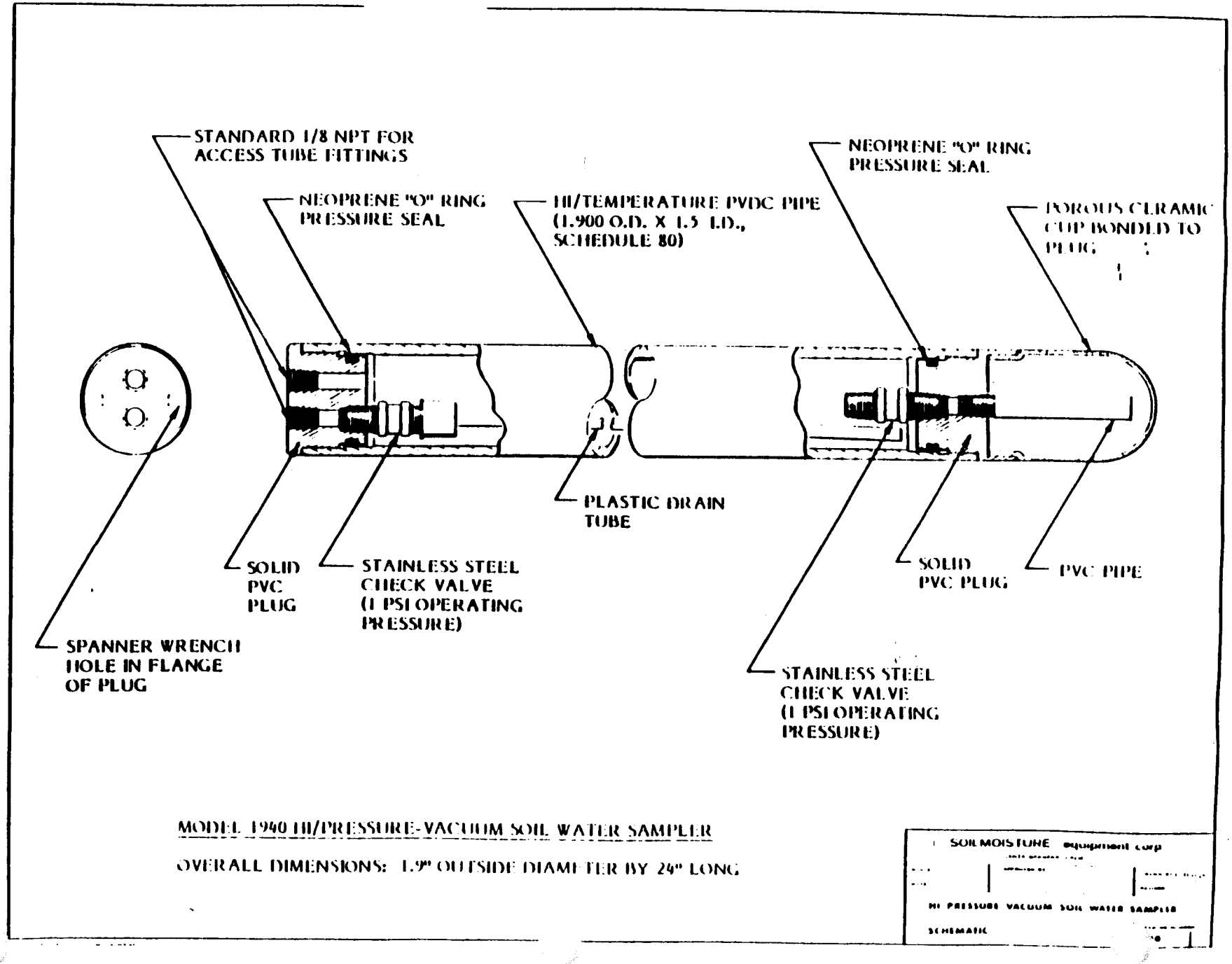

Figure 4. Schematic of pressure vacuum lysimeter.

distances for barium and nitrate analyses; results are summarized in Appendix D. These data suggest that the NPDES outfall at TA-16 Building 260 is a primary source of observed barium contamination in both surface waters and sediments in Canon de Valle at the landfill boundary.

Since March 1988, all of the neutron moisture access wells were tested monthly for moisture contents using a model 503-DR hydroprobe manufactured by Campbell Pacific Nuclear Corporation. This moisture gauge contains a Cesium-137 and Americium-241 sealed high energy neutron source, and a slow thermal neutron detector. Its design is based on the principal that any hydrogen present in the vadose zone opposite the cased wellbore will attenuate the fast moving neutrons from the probe source and be detected. This probe is capable of producing raw data in the form of neutron counts, or a variety of calibrated moisture content readings corresponding to these counts. The probe was factory calibrated to pure silica sand at a density of 2.65 grams per cubic centimeter (gm/cc) over the moisture range from dry to fully saturated. It was also calibrated to crushed Bandelier tuff by HSE-8 personnel at a density of 1.45 gm/cc over the same moisture range following the procedure of Nyhan, et al. (1983). Neutron moisture data were recorded in neutron counts, and later converted to volumetric moisture contents for this report using the factory calibration curve. Since all of the calibration curves were nearly identical (see Appendix E), the factory curve was used for these data conversions. In addition, it should be noted that the landfill materials have a density midway between that for Bandelier tuff and silica sand.

Monthly volumetric moisture contents recorded in individual neutron moisture access wells did not vary significantly during the period from March to September 1989. The six month average volumetric moisture content versus depth for each well is shown in Figs. F-1 to F-14 in Appendix F; each figure also shows the maximum and minimum moisture values recorded at each depth over the six-month period. The tabulated volumetric moisture data is also shown in Appendix F for future reference.

For background well P-12 in Figs. F-3 and F-4, one should interpret the maximum-minimum moistures as an approximate instrument error band, and not as actual moisture fluctuations. However, for the remaining wells, small temporal moisture fluctuation are apparent. These observations suggest that the landfill-tuff contact is exposed to a small but dynamic system of moisture infiltration, and that the dynamic equilibrium between moisture contents, unsaturated hydraulic conductivities, and infiltration rates increases toward the surface and decreases with depth. This equilibrium is obviously controlled at the surface by evapotranspiration and precipitation. Still, individual moisture profiles depicted in Figs. F-1 to F-14 are approximately at steady state conditions, and transient moisture fluctuations at depth can not be adequately measured at the monthly time interval utilized here. Hence these observations also suggest that average moisture profiles for individual neutron wells have not significantly changed below about 5 to 10 feet (i.e., in the lower

portions of the landfill and in the undisturbed tuff below landfill) during the past six months at this site.

V. CONCLUSION AND RECOMMENDATIONS

After a detailed review of the information presented in the Appendices section of this report, the following conclusions have been reached.

1. Barium concentrations as high as 18,000 mg/l were detected in landfill core samples using the EP toxicity method. All of these elevated barium concentration levels were from samples collected in the eastern half of the landfill. Samples from the western portion of the landfill exhibited barium concentration levels below the detection limit at 5 mg/l. A clear delineation of barium concentration levels in the eastern and western portions of the landfill has not been made. These same core samples also indicate that nitrate concentrations in the landfill are at or below 2.6 mg/l.

2. There is evidence that at least some barium contamination has occurred below the landfill near boreholes B-4 and L-17. Elevated barium levels were recorded in core samples from the undisturbed tuff in these boreholes to a depth of 19 feet, and represent at least 6 feet of barium penetration into the tuff

3. Barium concentration levels in sediment and water samples collected in Canon de Valle immediately upstream and downstream of the landfill indicate that extensive soil erosion from the landfill may not be a significant problem. Results from a single stream sampling survey indicated that the majority of barium present in Canon de Valle has probably originated from the NPDES outfall at Building 260, located approximately 1,700 feet upstream of Area P. Additional stream sampling is required to verify temporal landfill erosion potential.

4. Four of seven pressure-vacuum lysimeters installed within and below the landfill have yielded at least some water. Three of these water yielding lysimeters are within the eastern portion of the landfill, and the forth is in the western portion. Recovered water volumes range from 1 to 25 milliliters (ml) after one week of 50 centibar (cb) vacuum pressure, indicating that at least some precipitation infiltration has penetrated into the landfill. Lysimeter locations that have yielded water correspond to volumetric moisture readings above 20%, while lysimeter locations not yielding water have volumetric moistures below 20%. Several imaginary horizontal planes throughout the landfill consistently have moisture contents above 20%, but do not have any lysimeters installed nearby. Barium concentrations in recovered lysimeter waters are generally less than about 3 mg/l, suggesting that extensive barium mobilization has not occurred. However, one of the

first lysimeter water samples showed barium as high as 37.8 mg/l. This elevated barium level was probably created in response to lysimeter water additions during well completion; these municipal water supply additions are required for proper installation. All of the lysimeters that have yielded water samples are located within the landfill, while those that have not yielded any water are completed into the underlying tuff.

5. All of the soil and core samples listed in Table B-1 (Appendix B) were field screened for residual explosives contamination. Twelve of these samples that showed a slightly positive indication were submitted to the M-1 Analytical Laboratory for detailed analyses using a high pressure liquid chromatography procedure (Baytos, 1989); results of these tests are summarized in Tables B-3 and B-4 (Appendix B). The residual explosives content from replicate samples for all cases was below the 1.68% level. These results suggest that landfill materials do not contain a dangerously high level of residual explosives contamination. However, landfill waste deposition activities were never fully documented. Hence there remains an unknown element of risk at this site with regard to landfill excavation.

6. Unsaturated core samples recovered from the shallow tuff immediately south of the landfill were tested for saturated and unsaturated hydraulic transmitting characteristics in 1987 (Stephens, 1987). These data indicate that the shallow tuff has a saturated hydraulic conductivity approaching that of the main aquifer located some 1,230 feet below ground surface. However, because this tuff is unsaturated, its relative (i.e., unsaturated) hydraulic conductivity is three to six orders of magnitude below its saturated value. Hence the downward movement of water in the vadose zone is greatly restricted. In addition, there are several densely welded tuff units at depths under the landfill that have lower unsaturated hydraulic conductivity versus moisture content relationships than these shallow cores. However, if this shallow tuff material ever becomes fully saturated, it will readily convey water vertically downward to deeper flow restricting units at a rapid rate. It should also be recognized that the Area P landfill has no engineered under-liner; however, a thin natural clay layer may be present immediately above the unsaturated tuff and below the landfill.

7. Neutron moisture access wells that penetrate the landfill (i.e., P-17 through P-20) consistently have shown a higher volumetric moisture inventory over depth than those neutron wells completed elsewhere. In addition, these landfill wells have consistently shown a higher moisture inventory in landfill materials than in the underlying native tuff. Well P-12, the background neutron moisture access well, has shown the lowest moisture inventory of all wells over its entire depth. Well P-0 is immediately south of the TA-16 surface impoundment, and its moisture inventory over depth may have been influenced by

impoundment precipitation seepage because the hypolon liner all wastes were removed in 1988. Wells P-13, P-14, and P are located to the immediate south and west of the Area P landfill. These landfill perimeter wells have respective moisture inventories that are higher than at P-12, but are consistently lower than landfill well moisture inventories. This observation tends to support the conclusion that landfill moisture inventories are the result of direct precipitation infiltration through the existing landfill cover, and that landfill infiltration rates are higher than those for surrounding undisturbed areas. Nyhan (1988), however, suspects that the unlined diversion ditch located south of the landfill is primarily responsible for the elevated moisture inventory in the landfill. His water balance study was conducted prior to the installation of wells P-17 through P-20, so he has not benefited from these recent data.

8. While no detailed evaluation of maximum landfill infiltration rates has been made, one can reasonably argue that they are probably on the order of 25 milliliters per week per square foot of surface area (i.e., equivalent to 0.0384 cm/sec). This upper limit infiltration rate estimate is equal to the maximum water volume that was ever collected from an individual landfill lysimeter. It is 243 times larger than the maximum saturated hydraulic conductivity value (Stephens, 1988, Table 4) measured in a Bandelier tuff core sample recovered in well P-16 at 7.5 feet below the surface (i.e. sample no. 7-8 Stephens); furthermore, it is about 243,000 times larger than the unsaturated hydraulic conductivity of this same core sample when the moisture content is at 20% (Stephens, 1988, unnumbered figure entitled, "Relative Hydraulic Conductivity vs. Moisture Content, Sample No. 7-8"). One can also argue that landfill infiltration rates are considerably lower in the western portions of the landfill as compared to the eastern portions because eastern landfill lysimeters have consistently yielded more water than western landfill lysimeters. Finally, one can conclude that infiltration rates vary throughout the year, and are probably highest during the spring snow-melt season.

9. A similar procedure to estimate infiltration rates in the underlying tuff can not be made because these lysimeters never yielded any water. However, if one uses the relative hydraulic conductivity vs. moisture content data of Stephens (1988), the neutron moisture data presented herein, and assumes a unit unsaturated hydraulic gradient for these tuff units, then an infiltration rate can be estimated. One concludes from this procedure that the tuff underlying the landfill is completely restricting all deep infiltration below the landfill.

The following recommendations are made with regard to the Area landfill.

1. Additional lysimeters should only be installed after an adjacent neutron moisture access well has been completed and moisture readings have been recorded. Preliminary results in this study indicate that lysimeters can extract water from a target horizon only when the moisture content in an adjacent neutron moisture access well exceeds about 20%. Hence neutron moisture access wells can be used as indicators to target optimal depth locations for subsequent lysimeter placement.

2. Unsaturated laboratory column leaching studies at infiltration rates typical of those in the landfill would be helpful in characterizing any future barium mobility from the landfill. This recommendation implies that an average infiltration rate into the landfill should be computed to support these soil column studies. These soil column leaching studies would support the contention that no deep aquifer monitoring below the 1,230 foot interval is necessary. A sufficient volume of these waste barium sands is currently held in drum storage for off-site disposal, and could be used to perform such studies.

3. Two and three dimensional vadose zone flow modeling studies should be used as a supplement the above recommendations, and would assist in the evaluation of alternative landfill cover designs that might eventually be proposed.

4. Additional vadose zone monitoring wells should be installed through the landfill and into the shallow tuff to supplement the existing monitoring network by giving more spatial coverage over the 1.5 acre site. During these drilling operations, additional soil samples should be collected so that the areal and vertical extent of barium contamination is completely defined. Furthermore, vadose zone monitoring wells should also be installed on the floor of Canon de Valle immediately north of the landfill. Locations should be similar to the saturated monitoring system that is presently in place, unless the vadose zone modeling efforts indicate more optimal locations are desirable.

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VII. APPENDICES

Appendix A. Borehole Logs from TA-16 Area P Landfill

See Figure 1 for borehole locations

DRILLING LOG

BOREHOLE	: B-1	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Purtymun & McLin	**TOTAL DEPTH**	: 5 feet
DATE DRILLED	: August 26, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Cuttings Fill

DEPTH	**DESCRIPTION**
0- 2	Dark brown clay soil, moist
2- 5	Dark brown sandy clay soil - looks like cover-fill material

WELL COMPLETION SUMMARY

Borehole B-1 was used as an exploration hole; it was then filled with bentonite and drill cuttings before being abandoned. No samples were collected.

DRILLING LOG

BOREHOLE	: B-2	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Purtymun & McLin	**TOTAL DEPTH**	: 4 feet
DATE DRILLED	: August 26, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Cuttings Fill

DEPTH	**DESCRIPTION**
0- 2	Dark brown clay soil, moist
2- 4	Dark brown sandy clay soil - looks like cover-fill material

WELL COMPLETION SUMMARY

Borehole B-2 was used as an exploration hole; it was then filled with bentonite and drill cuttings before being abandoned. No samples were collected.

DRILLING LOG

BOREHOLE	: B-3	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Purtymun & McLin	**TOTAL DEPTH**	: 14 feet
DATE DRILLED	: August 26, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Cuttings Fill

DEPTH	**DESCRIPTION**
0- 1	Dark brown sandy clay cover, moist
1- 4	Mixture of brown clay and sand waste - white BaO crystals 95% Core recovery; moderate moisture
4- 8	Dark brown sticky clay with some gray sand - waste material Fragments of tuff and charcoal throughout 80% Core recovery; moderate moisture
8-13	Dark brown to black sticky clay with tuff & BaO fragments 85% Core recovery; optimal moisture; solid tuff in bit
13-14	Tuff; Unit 3d; low moisture

WELL COMPLETION SUMMARY

Borehole B-3 was used as an exploration hole ; it was then filled with bentonite and drill cuttings before being abandoned. No samples were collected.

DRILLING LOG

BOREHOLE	: B-4	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 19 feet
DATE DRILLED	: August 30, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Cuttings Fill

DEPTH	**DESCRIPTION**
0- 3	Brown clay with black burn debris inclusions 50% Core recovery, little moisture Tests positive for explosive compounds using field test kit
4- 9	Brown clay and sand with black burn debris inclusions 10% Core recovery, very little moisture
9-14	Brown clay and sand mixture with burn debris inclusions 5% Core recovery, very dry
14-19	Tuff, Unit 3d, non-welded, very low moisture 85% Core recovery; coarse to medium grain size tuff

WX-12 field representative confirms presence of explosives and drilling operation terminated until M-1 Analytical Lab verified. On 9-1-88 M-1 Lab reported < 1% TNT, HMX, and RDX was present in sample.

WELL COMPLETION SUMMARY

Borehole B-4 was used as an exploration hole and for sample recovery; it was then filled with bentonite and drill cuttings before being abandoned.

DRILLING LOG

BOREHOLE	: B-5	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Purtymun & McLin	**TOTAL DEPTH**	: 12 feet
DATE DRILLED	: September 15, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Western Landfill	**CASING MATERIAL**	: Cuttings Fill

DEPTH	DESCRIPTION
0- 1	Topsoil of crushed tuff, sand, and clay mixture
1- 4	Brown crushed tuff cover-fill material 50% Core recovery; dry
4- 8	Brown crushed tuff cover-fill material; moderately dry 60% Core recovery; saturated clay lense 6-7 ft
8-12	Brown dense clay; moderately dry 90% Core recovery; waste not apparent

WELL COMPLETION SUMMARY

Borehole B-5 was used as an exploration hole and for sample recovery; it was then filled with bentonite and drill cuttings before being abandoned.

DRILLING LOG

BOREHOLE	: L-17	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 19 feet
DATE DRILLED	: September 6, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Lysimeters

DEPTH	**DESCRIPTION**
0- 1	Light brown sandy clay soil
1- 2	Dark brown clay with black sandy waste
2- 4	Black sandy waste with white BaO crystalline stringers 60% Core recovery 0-4 ft; all moderately dry
4-11	Light brown clayey sand; wood chips at 9 ft Less than 10% core recovery
11-19	Tuff; Unit 3d, non-welded, lt. brown color 50% recovery 9-14 ft; 100% recovery 14-19 ft.

LYSIMETER COMPLETION SUMMARY - DUEL COMPLETION

```
LOCKING STEEL CAP IN CEMENT ->KC| |<---- TOPSOIL COVER
                              C| |<---- TOP OF LANDFILL AT 1 FT
                              T| |
                              T| |
                              T| |
                              S| |
SHALLOW LYSIMETER AT 7 FT --->SL| |
ONE FT CEMENT SEAL 7-8 FT ---->C| |
                              T| |
                              T| |<----- BASE OF LANDFILL AT 11 FT
                              T| |<----- TUFF CONTACT AT 11 FT
                              T| |
                              S| |
                              S| |
                              S| |
                              S| |
DEEP LYSIMETER AT 17 FT ----->SL| |
                              S| |
                              T| |<----- TOTAL DEPTH AT 19 FT
```

DIAGRAM NOT TO SCALE

```
----------------------------
STEEL LOCKING CAP............K
CEMENT SLURRY SEAL...........C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PRESSURE-VACUUM LYSIMETER...L
CAVED IN....................X
----------------------------
```

DRILLING LOG

BOREHOLE	: P-17	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 30 feet
DATE DRILLED	: September 21, 1988	**DIAMETER**	: 4.00 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION**
0-19	Off-set from L-17 6 ft; see drilling log for L-17 & B-4
19-30	Tuff; Unit 3d; low moisture; not cored Light brown tuff with rhyolite fragments Appears to be non-welded to moderately welded

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH SAND ---->SA|  |<---- TOP OF LANDFILL AT 1 FT
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |<---- BASE OF LANDFILL AT 11 FT
                              SA|  |<---- TUFF CONTACT AT 11 FT
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|P |<---- TOTAL DEPTH AT 30 FT
```

DIAGRAM NOT TO SCALE

```
-----------------------------
CEMENT SLURRY SEAL..........C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
END-CAP PLUG................P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: L-1B	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 19 feet
DATE DRILLED	: September 8, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Lysimeters

DEPTH	**DESCRIPTION**
0- 1	Light brown sandy soil cover
1- 4	Light to bark brown clay with sand stringers; some moisture Some white BaO crystals; 95% Core recovery
4-13	Dark brown sticky black clay with some gray sand at 4 ft Fragments of charcoal and tuff 5-8 ft; BaO crystals 8-12 ft 80% Core recovery; optimal moisture; hard tuff in bit 13 ft
13-19	Tuff; Unit 3d; non-welded, low moisture Light grey to light brown color; 100% Core recovery

LYSIMETER COMPLETION SUMMARY - DUEL COMPLETION

```
LOCKING STEEL CAP IN CEMENT ->KC|  |<---- TOPSOIL COVER
                               C|  |<---- TOP OF LANDFILL AT 1 FT
                               T|  |
                               T|  |
                               T|  |
                               S|  |
SHALLOW LYSIMETER AT 7 FT --->SL|  |
                               T|  |
                               T|  |
                               T|  |
                               C|  |
THREE FT CEMENT SEAL 10-13 FT->C|  |<----- BASE OF LANDFILL AT 13 FT
                               T|  |<----- TUFF CONTACT AT 13 FT
                               T|  |
                               T|  |
                               S|  |
                               S|  |
DEEP LYSIMETER AT 18 FT ----->SL|  |
                               T|X|<----- TOTAL DEPTH AT 19 FT
```

DIAGRAM NOT TO SCALE

STEEL LOCKING CAP.....K
CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PRESSURE-VACUUM LYSIMETER...L
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-18	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 30 feet
DATE DRILLED	: September 21, 1988	**DIAMETER**	: 4.00 in
LOCATION	: Eastern Landfill	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION**
0-19	Off-set from L-18 6 ft; see drilling log for L-18 & B-3
19-30	Tuff; Unit 3d; low moisture; not cored Light brown tuff with rhyolite and sanadine fragments Appears to be non-welded to moderately welded

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH SAND ---->SA|  |<---- TOP OF LANDFILL AT 1 FT
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |<----- BASE OF LANDFILL AT 13 FT
                              SA|  |<----- TUFF CONTACT AT 13 FT
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|  |
                              SA|P |<----- TOTAL DEPTH AT 30 FT
```

DIAGRAM NOT TO SCALE

```
-----------------------------
CEMENT SLURRY SEAL...........C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
END-CAP PLUG................P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: L-19	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 14 feet
DATE DRILLED	: September 14, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Western Landfill	**CASING MATERIAL**	: Lysimeters

DEPTH	**DESCRIPTION**
0- 1	Sandy soil cover; dry
1- 4	Crushed tuff fill 60% Core recovery; moderately dry
4- 9	Crushed tuff fill; no wastes apparent 70% Core recovery; moderately dry
9-14	Crushed tuff fill; no wastes apparent 75% Core recovery; moderately dry

LYSIMETER COMPLETION SUMMARY - SINGLE COMPLETION

```
LOCKING STEEL CAP IN CEMENT ->KC|  |<---- TOPSOIL COVER
                              C|  |<---- TOP OF LANDFILL WASTE
                              T|  |                NOT APPARENT
                              T|  |
                              T|  |
                              T|  |
                              T|  |
                              T|  |
                              T|  |
                              T|  |
                              S|  |
SINGLE LYSIMETER AT 12 FT --->SL|  |<----- BASE OF LANDFILL NOT
                              T|X|                     DETECTED
                              T|X|<----- TOTAL DEPTH AT 14 FT
```

DIAGRAM NOT TO SCALE

STEEL LOCKING CAP.....K
CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PRESSURE-VACUUM LYSIMETER...L
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-19	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 30 feet
DATE DRILLED	: September 20, 1988	**DIAMETER**	: 4.00 in
LOCATION	: Western Landfill	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION**
0-14	Off-set from L-19 6 ft; see drilling log for L-19
19-30	Tuff; Unit 3d; low moisture; not cored Light brown tuff with rhyolite and sanadine fragments Appears to be non-welded to moderately welded

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH SAND ---->SA|  |<---- TOP OF LANDFILL WASTES
                               SA|  |                NOT APPARENT
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |<----- APPROXIMATE TUFF CONTACT
                               SA|  |          AT 15 FT
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|P |<----- TOTAL DEPTH AT 30 FT
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
END-CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: L-20	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 29 feet
DATE DRILLED	: September 15, 1988	**DIAMETER**	: 6.875 in
LOCATION	: Western Landfill	**CASING MATERIAL**	: Lysimeter

DEPTH	**DESCRIPTION**
0- 4	Sandy crushed tuff and soil mixture; concrete at 3 ft 50% Core Recovery; dry; does not look like waste sands
4-13	Sandy light brown crushed tuff and soil mixture 50% Core Recovery; dry
13-15	Dark brown sandy clay soil; wastes not apparent 50% Core Recovery; dry
15-21	Tuff fill and brown clay with charcoal fragments & waste 70% Core Recovery; some moisture
21-22	Brown native clay soil; moderately moist 75% Core Recovery
22-29	Tuff; Unit 3d; non-welded, low moisture 100% Core Recovery

LYSIMETER COMPLETION SUMMARY - DUEL COMPLETION

```
LOCKING STEEL CAP IN CEMENT ->KC|  |<---- TOP SOIL COVER
                               T|  |<---- TOP OF LANDFILL AT 1 FT
                               S|  |
SHALLOW LYSIMETER AT 8 FT --->SL|  |
                               S|  |
                               T|  |
                               T|  |
                               T|  |
                               T|  |<----- LANDFILL BASE AT 21 FT
                               T|  |<----- NATIVE 1 FT CLAY LAYER
                               T|  |<----- TUFF CONTACT AT 22 FT
ONE FT CEMENT PLUG 22-23 FT -->C|  |
                               T|  |
                               S|  |
DEEP LYSIMETER AT 29 FT ----->SL|  |<----- TOTAL DEPTH AT 29 FT
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP...........K
CEMENT SLURRY SEAL..........C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PRESSURE-VACUUM LYSIMETER...L
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-20	**ELEVATION**	: Not Surveyed
GEOLOGIST	: McLin & Purtymun	**TOTAL DEPTH**	: 30 feet
DATE DRILLED	: September 20, 1988	**DIAMETER**	: 4.00 in
LOCATION	: Western Landfill	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION**
0-29	Off-set from L-20 6 ft; see drilling log for L-20 & B-5
29-30	Tuff; Unit 3d; low moisture; not cored Light brown tuff with rhyolite and sanadine fragments Appears to be non-welded to moderately welded

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH SAND ---->SA|  |<---- TOP OF LANDFILL AT 1 FT
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |
                               SA|  |<----- BASE OF LANDFILL AT 21 FT
                               SA|  |<----- NATIVE 1 FT CLAY LAYER
                               SA|  |<----- TUFF CONTACT AT 22 FT
                               SA|  |
                               SA|  |
ALUMINUM CASING TO 26 FT ---->SA|P|
                                T|X|
                                T|X|
                                T|X|<----- TOTAL DEPTH AT 30 FT
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
END-CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-0	**ELEVATION**	: 7399
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 135 feet
DATE DRILLED	: July 21, 1987	**DIAMETER**	: 6.875 in
LOCATION	: S of TA-16 Pond	**CASING MATERIAL**	: Aluminum
COORDINATES	: X=476215, Y=1763523	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH TUFF ---->TA|  |<---- UNIT 3c CONTACT AT 3 FT
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |<---- UNIT 3b CONTACT AT 40 FT
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |<---- UNIT 3a CONTACT AT 110 FT
                              TA|  |
CASING PLUG AT 120 FT ------->TA|P|
                               T|X|
                               T|X|
TOTAL DEPTH AT 135 FT -------> T|X|<---- UNIT 2 CONTACT AT 135 FT
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
WELDED END CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-1	**ELEVATION**	: 7344
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 35 feet
DATE DRILLED	: July 29, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in PVC
COORDINATES	: X=475756, Y=1764645	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCV|  |<---- TOPSOIL COVER
                              CV|  |<---- UNIT 3b CONTACT AT 4 FT
                              CV|  |
                              CV|  |
                              CV|  |
                              CV|  |
BOTTOM OF CEMENT AT 13 FT --->CV|  |
                              BV|  |
BOTTOM OF BENTONITE AT 15 FT->BV|  |
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
20 FT FACTORY SLOTTED SCREEN->SF|=|
   0.010 in SLOTTED PVC       SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
TOTAL DEPTH AT 35 FT -------->SF|P|
```

DIAGRAM NOT TO SCALE

STEEL LOCKING CAP.....K
CEMENT SLURRY SEAL.....C
BENTONITE PELLETS.....B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PVC CASING 2 in ID.....V
FACTORY SLOTTED 0.010 in....F
PVC END CAP.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-2	**ELEVATION**	: 7341
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 10 feet
DATE DRILLED	: July 23, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: Abandoned
COORDINATES	: X=475708, Y=1764617	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

EXPLORATION BOREHOLE LOG SUMMARY

```
                                T|X|<---- SANDY LOAM TOP SOIL
                                T|X|
                                T|X|<---- UNIT 3b CONTACT AT 3 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
TOTAL DEPTH AT 10 FT ---------->T|X|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
BENTONITE PELLET SEAL.......B
BACKFILLED TUFF CUTTINGS....T
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-3	**ELEVATION**	: 7342
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 9 feet
DATE DRILLED	: July 23, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in Teflon
COORDINATES	: X=475676, Y=1764596	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCE|  |<---- TOPSOIL COVER
CEMENT 0-1 & PELLETS 1-2 FT ->BE|  |
                              SF|=|<---- UNIT 3b CONTACT AT 3 FT
5 FT THREADED TEFLON SCREEN ->SF|=|
   0.01 in FACTORY SLOTTED    SF|=|
                              SF|=|
TEFLON END CAP AT 7 FT ------>SF|P|
                                |X|
TOTAL DEPTH AT 9 FT ----------->|X|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP...........K
CEMENT SLURRY SEAL..........C
BENTONITE PELLETS...........B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
THREADED TEFLON CASING......E
FACTORY SLOTTED 0.010 in....F
TEFLON END CAP PLUG.........P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-4	**ELEVATION**	: 7348
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 10 feet
DATE DRILLED	: July 28, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in Teflon
COORDINATES	: X=475588, Y=1764562	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCE|  |<---- TOPSOIL COVER
CEMENT 0-1 & PELLETS 1-3 FT ->BE|  |
                              BE|  |
                              SF|=|<---- UNIT 3b CONTACT AT 4 FT
5 FT THREADED TEFLON SCREEN ->SF|=|
   0.01 in FACTORY SLOTTED    SF|=|
                              SF|=|
TEFLON END CAP AT 8 FT ------>SF|P|
                                |X|
TOTAL DEPTH AT 10 FT -------->  |X|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............K
CEMENT SLURRY SEAL...........C
BENTONITE PELLETS............B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
THREADED TEFLON CASING......E
FACTORY SLOTTED 0.010 in....F
TEFLON END CAP PLUG.........P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-5	**ELEVATION**	: 7353
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 35 feet
DATE DRILLED	: July 29, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in PVC
COORDINATES	: X=475520, Y=1764532	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCV|  |<---- TOPSOIL COVER
                              CV|  |<---- UNIT 3b CONTACT AT 3 FT
                              CV|  |
                              CV|  |
                              CV|  |
                              CV|  |
BOTTOM OF CEMENT AT 13 FT --->CV|  |
                              BV|  |
BOTTOM OF BENTONITE AT 15 FT->BV|  |
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
20 FT FACTORY SLOTTED SCREEN->SF|=|
   0.010 in SLOTTED PVC       SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
TOTAL DEPTH AT 35 FT -------->SF|P|
```

DIAGRAM NOT TO SCALE

STEEL LOCKING CAP.....K
CEMENT SLURRY SEAL.....C
BENTONITE PELLETS.....B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PVC CASING 2 in ID.....V
FACTORY SLOTTED 0.010 in....F
PVC END CAP.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-6	**ELEVATION**	: 7352
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 10 feet
DATE DRILLED	: July 28, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in Teflon
COORDINATES	: X=475467, Y=1764514	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCE|  |<---- TOPSOIL COVER
CEMENT 0-1 & PELLETS 1-2 FT ->BE|  |
                              SF|=|
5 FT THREADED TEFLON SCREEN ->SF|=|<---- UNIT 3b CONTACT AT 4 FT
   0.01 in FACTORY SLOTTED    SF|=|
                              SF|=|
TEFLON END CAP AT 7 FT ------>SF|P|
                                |X|
                                |X|
TOTAL DEPTH AT 10 FT --------->  |X|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............K
CEMENT SLURRY SEAL...........C
BENTONITE PELLETS............B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
THREADED TEFLON CASING......E
FACTORY SLOTTED 0.010 in....F
TEFLON END CAP PLUG.........P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-7	**ELEVATION**	: 7356
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 35 feet
DATE DRILLED	: July 29, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in PVC
COORDINATES	: X=475381, Y=1764491	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCV| |<---- TOPSOIL COVER
                              CV| |<---- UNIT 3b CONTACT AT 2 FT
                              CV| |
                              CV| |
                              CV| |
                              CV| |
BOTTOM OF CEMENT AT 13 FT --->CV| |
                              BV| |
BOTTOM OF BENTONITE AT 15 FT->BV| |
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
20 FT FACTORY SLOTTED SCREEN->SF|=|
   0.010 in SLOTTED PVC       SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
TOTAL DEPTH AT 35 FT -------->SF|P|
```

DIAGRAM NOT TO SCALE

STEEL LOCKING CAP.....K
CEMENT SLURRY SEAL.....C
BENTONITE PELLETS.....B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PVC CASING 2 in ID.....V
FACTORY SLOTTED 0.010 in....F
PVC END CAP.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-8	**ELEVATION**	: 7370
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 10 feet
DATE DRILLED	: July 28, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in Teflon
COORDINATES	: X=475257, Y=1764405	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCE|  |<---- TOPSOIL COVER
CEMENT 0-1 & PELLETS 1-2 FT ->BE|  |
                              SF|=|<---- UNIT 3b CONTACT AT 3 FT
5 FT THREADED TEFLON SCREEN ->SF|=|
   0.01 in FACTORY SLOTTED    SF|=|
                              SF|=|
TEFLON END CAP AT 7 FT ------>SF|P|
                                |X|
                                |X|
TOTAL DEPTH AT 10 FT -------->  |X|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP...........K
CEMENT SLURRY SEAL..........C
BENTONITE PELLETS...........B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
THREADED TEFLON CASING......E
FACTORY SLOTTED 0.010 in....F
TEFLON END CAP PLUG.........P
CAVED IN....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-9	**ELEVATION**	: 7376
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 35 feet
DATE DRILLED	: July 29, 1987	**DIAMETER**	: 6.875 in
LOCATION	: Canon de Valle	**CASING MATERIAL**	: 2 in PVC
COORDINATES	: X=475183, Y=1764381	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

GROUND-WATER MONITORING WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->KCV|  |<---- TOPSOIL COVER
                              CV|  |<---- UNIT 3c CONTACT AT 3 FT
                              CV|  |
                              CV|  |
                              CV|  |
                              CV|  |
BOTTOM OF CEMENT AT 13 FT --->CV|  |
                              BV|  |
BOTTOM OF BENTONITE AT 15 FT->BV|  |<---- UNIT 3b CONTACT AT 15 FT
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
20 FT FACTORY SLOTTED SCREEN->SF|=|
   0.010 in SLOTTED PVC       SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
                              SF|=|
TOTAL DEPTH AT 35 FT -------->SF|P|
```

DIAGRAM NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............K
CEMENT SLURRY SEAL...........C
BENTONITE PELLETS............B
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
PVC CASING 2 in ID...........V
FACTORY SLOTTED 0.010 in....F
PVC END CAP..................P
CAVED IN.....................X
-----------------------------
```

DRILLING LOG

BOREHOLE	: P-10	**ELEVATION**	: 7411
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 150 feet
DATE DRILLED	: July 30, 1987	**DIAMETER**	: 6.875 in
LOCATION	: E of Landfill	**CASING MATERIAL**	: Abandoned
COORDINATES	: X=475814, Y=1764473	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

EXPLORATION BOREHOLE LOG SUMMARY

```
                                T|X|<---- SANDY LOAM TOP SOIL
                                T|X|<---- UNIT 3c CONTACT AT 3 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|<---- UNIT 3b CONTACT AT 50 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|<---- UNIT 3a CONTACT AT 120 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
TOTAL DEPTH AT 150 FT -------->T|X|<---- UNIT 2 CONTACT AT 150 FT
```

DIAGRAM NOT TO SCALE

BENTONITE PELLET SEAL.....B
BACKFILLED TUFF CUTTINGS....T
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-11	**ELEVATION**	: 7409
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 70 feet
DATE DRILLED	: August 27, 1987	**DIAMETER**	: 6.875 in
LOCATION	: W of TA-16 Pond	**CASING MATERIAL**	: Abandoned
COORDINATES	: X=475991, Y=1763584	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

EXPLORATION BOREHOLE LOG SUMMARY

```
                                T|X|<---- SANDY LOAM TOP SOIL
                                T|X|<---- UNIT 3c CONTACT AT 2 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|<---- UNIT 3b CONTACT AT 50 FT
                                T|X|
                                T|X|
                                T|X|
TOTAL DEPTH AT 70 FT ---------->T|X|
```

DIAGRAM NOT TO SCALE

BENTONITE PELLET SEAL.....B
BACKFILLED TUFF CUTTINGS....T
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-12	**ELEVATION**	: 7448
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 200 feet
DATE DRILLED	: August 21, 1987	**DIAMETER**	: 6.875 in
LOCATION	: NW of TA-16 Pond	**CASING MATERIAL**	: Aluminum
COORDINATES	: X=476664, Y=1764036	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA| |<---- TOPSOIL COVER
ANNULUS FILLED WITH TUFF ---->TA| |<---- UNIT 3d CONTACT AT 3 FT
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |<---- UNIT 3c CONTACT AT 50 FT
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |<---- UNIT 3b CONTACT AT 102 FT
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
CASING PLUG AT 171 FT ------->TA|P|
                                T|X|<---- UNIT 3a CONTACT AT 173 FT
                                T|X|
                                T|X|
                                T|X|<---- UNIT 2 CONTACT AT 195 FT
TOTAL DEPTH AT 200 FT -------> T|X|
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
WELDED END CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-13	**ELEVATION**	: 7445
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 103 feet
DATE DRILLED	: October 3, 1987	**DIAMETER**	: 6.875 in
LOCATION	: S of Landfill	**CASING MATERIAL**	: Aluminum
COORDINATES	: X=475720, Y=1764264	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA| |<---- TOPSOIL COVER
ANNULUS FILLED WITH TUFF ---->TA| |<---- UNIT 3d CONTACT AT 0 FT
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |<---- UNIT 3c CONTACT AT 38 FT
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |
                              TA| |<---- UNIT 3b CONTACT AT 84 FT
                              TA| |
CASING PLUG AT 92 FT -------->TA|P|
                               T|X|
                               T|X|
TOTAL DEPTH AT 103 FT -------> T|X|
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
WELDED END CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-14	**ELEVATION**	: 7437
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 85 feet
DATE DRILLED	: August 28, 1987	**DIAMETER**	: 6.875 in
LOCATION	: W of Landfill	**CASING MATERIAL**	: Aluminum
COORDINATES	: X=475365, Y=1764251	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA|  |<---- TOPSOIL COVER
ANNULUS FILLED WITH TUFF ---->TA|  |<---- UNIT 3d CONTACT AT 4 FT
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |<---- UNIT 3c CONTACT AT 30 FT
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |
                              TA|  |<---- UNIT 3b CONTACT AT 75 FT
CASING PLUG AT 79 FT -------->TA|P|
                               T|X|
TOTAL DEPTH AT 85 FT --------> T|X|
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
WELDED END CAP PLUG.....P
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-15	**ELEVATION**	: 7413
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 70 feet
DATE DRILLED	: August 27, 1987	**DIAMETER**	: 6.875 in
LOCATION	: W of TA-16 Pond	**CASING MATERIAL**	: Abandoned
COORDINATES	: X=475803, Y=1763520	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

EXPLORATION BOREHOLE LOG SUMMARY

```
                                T|X|<---- SANDY LOAM TOP SOIL
                                T|X|<---- UNIT 3c CONTACT AT 4 FT
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|
                                T|X|<---- UNIT 3b CONTACT AT 55 FT
                                T|X|
                                T|X|
TOTAL DEPTH AT 70 FT --------->T|X|
```

DIAGRAM NOT TO SCALE

BENTONITE PELLET SEAL.....B
BACKFILLED TUFF CUTTINGS....T
CAVED IN.....X

DRILLING LOG

BOREHOLE	: P-16	**ELEVATION**	: 7452
GEOLOGIST	: Brown & Purtymun	**TOTAL DEPTH**	: 105 feet
DATE DRILLED	: September 4, 1987	**DIAMETER**	: 6.875 in
LOCATION	: S of Landfill	**CASING MATERIAL**	: Aluminum
COORDINATES	: X=475550, Y=1764200	**MAP SYSTEM**	: NM State

See Appendix D (in HSE-8, 1988) for detailed log.

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
ONE FT CEMENT SEAL AND CAP -->CA| |<---- TOPSOIL COVER
ANNULUS FILLED WITH TUFF ---->TA| |
                               TA| |<---- UNIT 3d CONTACT AT 7 FT
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |<---- UNIT 3c CONTACT AT 42 FT
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |
                               TA| |<---- UNIT 3b CONTACT AT 87 FT
CASING PLUG AT 88 FT -------->TA|P|
                                T|X|
                                T|X|
TOTAL DEPTH AT 105 FT -------> T|X|
```

DIAGRAM NOT TO SCALE

CEMENT SLURRY SEAL.....C
BACKFILLED TUFF CUTTINGS....T
MEDIUM GRAIN SILICA SAND....S
ALUMINUM CASING, 2 in ID....A
WELDED END CAP PLUG.....P
CAVED IN.....X

VII. APPENDICES

Appendix B. Chemical Data from Soil Core Samples

TABLE B-1. EP Toxic Barium Concentrations in mg/l.

DEPTH (ft)	BOREHOLE NUMBER ===> B-4	B-5	L-17	L-18	L-19	L-20
1	686.5		2486.4	18114.4	< 5.0	
2		< 5.0	13206.9		< 5.0	< 5.0
3	4169.7			12.3		
4			16803.3	11.0		
5					< 5.0	
6		< 5.0		7.5		
7	11300.0					
8				< 5.0		< 5.0
9			3014.8	< 5.0		
10			2048.5		< 5.0	< 5.0
11	1839.5			< 5.0		
12		< 5.0	6.5			
13				< 5.0		< 5.0
14		< 5.0	17.8	< 5.0		
15			9.0			< 5.0
16	229.3		8.8	< 5.0		
17	23.4					
18	20.7			< 5.0		< 5.0
19	14.8					
20						< 5.0
21						
22						
23						< 5.0
24						
25						< 5.0
26						< 5.0
27						
28						< 5.0
29						< 5.0
30						

Appendix B. Chemical Data from Soil Core Samples

TABLE B-2. Nitrate Concentrations in mg/l.

DEPTH (ft)	BOREHOLE NUMBER ===> B-4	B-5	L-17	L-18	L-19	L-20
1	0.3		0.7	0.5	0.7	
2		< 0.2	6.0		< 0.3	< 0.2
3	0.5			0.3		
4			2.6	0.8		
5					< 0.2	
6		< 0.2		0.8		
7	1.2					
8				< 0.2		
9			< 0.7	< 0.2		< 0.2
10			2.2		< 0.3	< 0.2
11	2.6			< 0.2		
12		0.4	1.0			
13				< 0.2		
14		0.4	0.4	< 0.2		< 0.2
15			0.3			< 0.2
16	< 0.2		0.9	1.8		
17	< 0.2					
18	0.3			< 0.2		
19	0.25					0.2
20						< 0.2
21						
22						
23						
24						< 0.2
25						< 0.3
26						
27						< 0.2
28						
29						< 0.2
30						< 0.2

Appendix B. Chemical Data from Soil Core Samples

TABLE B-3. Average residual high explosives content, expressed as soluble acetonitrile (wt %).

DEPTH (ft)	BOREHOLE NUMBER ===> B-2	B-4	B-5	L-17	L-18	L-19	L-20
1				0.27			
2	0.12			0.98			
3		1.46			0.07		
4				0.78	0.06		
5							
6					0.09		0.12
7		0.20					
8							
9				0.77			
10				0.56			
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

Appendix B. Chemical Data from Soil Core Samples

TABLE B-4. Residual high explosives content.

BOREHOLE NUMBER	DEPTH (ft)	ACETONITRILE* (soluble wt %)	HMX (ppm)	RDX (ppm)	TNT (ppm)	DNT (ppm)
B-2	2	0.11	0	0	0	0
B-2	2	0.12	0	0	0	0
B-4	3	1.68	730	343	7869	0
B-4	3	1.24	1010	292	7115	0
B-4	7	0.21	585	13	26	0
B-4	7	0.18	370	4	12	0
L-17	1	0.27	1201	32	0	0
L-17	1	0.27	1301	139	1	0
L-17	2	0.95	2551	2206	0	0
L-17	2	1.00	2582	2138	0	0
L-17	4	0.77	821	4133	594	0
L-17	4	0.78	1099	4132	557	0
L-17	9	0.70	164	1195	211	0
L-17	9	0.83	146	983	406	0
L-17	10	0.58	220	2639	1497	0
L-17	10	0.53	270	2655	1275	0
L-18	3	0.06	14	3	17	0
L-18	3	0.08	0	0	54	0
L-18	4	0.08	22	2	4	0
L-18	4	0.04	22	1	0	0
L-18	6	0.10	0	2	0	0
L-18	6	0.07	5	0	7	0
L-20	6	0.18	21	50	27	0
L-20	6	0.05	0	0	0	0

*Total high explosives extracted with acetonitrile

VII. APPENDICES

Appendix C. Pressure-Vacuum Lysimeter Water Samples[1]

Sample Number	Sample Date	Volume Recovered	Barium Concentration	Nitrate Concentration
L-18S	11-23-88	10 ml	37.8 mg/l	3.4 mg/l
L-18D[3]	11-23-88	< 1 ml	NA[2]	NA[2]
L-18S[3]	11-29-88	10 ml	18.5 mg/l	1.2 mg/l
L-17S	3-17-89	2 ml	1.1 mg/l	5.5 mg/l
L-18S	3-17-89	10 ml	1.1 mg/l	0.735 mg/l
L-19	3-17-89	25 ml	3.0 mg/l	0.44 mg/l
L-17S	3-28-89	< 1 ml	NA[2]	NA[2]
L-18S	3-28-89	2 ml	1.1 mg/l	2.37 mg/l
L-19	3-28-89	10 ml	2.0 mg/l	0.21 mg/l
L-17S	6-02-89	< 1 ml	NA[2]	NA[2]
L-18S	6-02-89	< 1 ml	NA[2]	NA[2]
L-19	6-02-89	< 1 ml	NA[2]	NA[2]
L-17S	8-11-89	trace	NA[2]	NA[2]
L-18S	8-11-89	< 1 ml	NA[2]	NA[2]
L-19	8-11-89	trace	NA[2]	NA[2]

1 = All other lysimeters failed to yield water on the sample dates indicated above. Samples were collected after one week of 50 cb vacuum pressure was applied.

2 = Not Analyzed; insufficient water volume

3 = S represents the shallow lysimeter in a duel completion borehole, while D means the deep lysimeter in the same borehole.

VII. APPENDICES

Appendix D. Canon de Valle Stream Survey Samples

TABLE D-1. Barium and Nitrate Concentrations in Water Samples. See location map for station numbers.

STATION	STATION DESCRIPTION	BARIUM (mg/l)[1]	NITRATE (mg/l)[2]
1	Channel at Hiway-4.....	dry	dry
2	Channel below old pond...	35.8	< 0.2
3	Channel above Bldg-260...	9.9	0.8
4	Bldg-260 NPDES outfall...	4.4	0.8
5	Tributary above outfall..	dry	dry
6	Tributary below outfall..	6.4	7.7
7	Tributary below outfall..	38.1	< 0.2
8	Tributary below outfall..	39.9	2.5
9	Channel below outfall....	10.0	0.8
10	Channel below outfall....	12.4	0.7
11	Channel below outfall....	9.1	0.8
12	Channel below outfall....	8.7	0.6
13	Channel above landfill...	9.5	0.6
14	Channel below landfill...	9.5	NA[3]

TABLE D-2. Barium and Nitrate Concentrations in Sediment Samples. See location map for station numbers.

STATION	STATION DESCRIPTION	BARIUM (mg/l)[1]	NITRATE (mg/l)[2]
1	Channel at Hiway-4.....	< 5.0	< 0.2
2	Channel below old pond...	< 5.0	< 0.3
3	Channel above Bldg-260...	5.6	< 0.2
4	Bldg-260 NPDES outfall...	< 5.0	< 0.2
5	Tributary above outfall..	< 5.0	< 0.2
6	Tributary below outfall..	6.4	< 0.2
7	Tributary below outfall..	33.5	< 0.2
8	Tributary below outfall..	51.2	0.3
9	Channel below outfall....	< 5.0	< 0.2
10	Channel below outfall....	< 5.0	< 0.2
11	Channel below outfall....	< 5.0	< 0.2
12	Channel below outfall....	< 5.0	< 0.2
13	Channel above landfill...	< 5.0	0.4
14	Channel below landfill...	< 5.0	NA[3]

[1] = EP toxicity test procedure.

[2] = Total inorganic nitrates.

[3] = Not Analyzed.

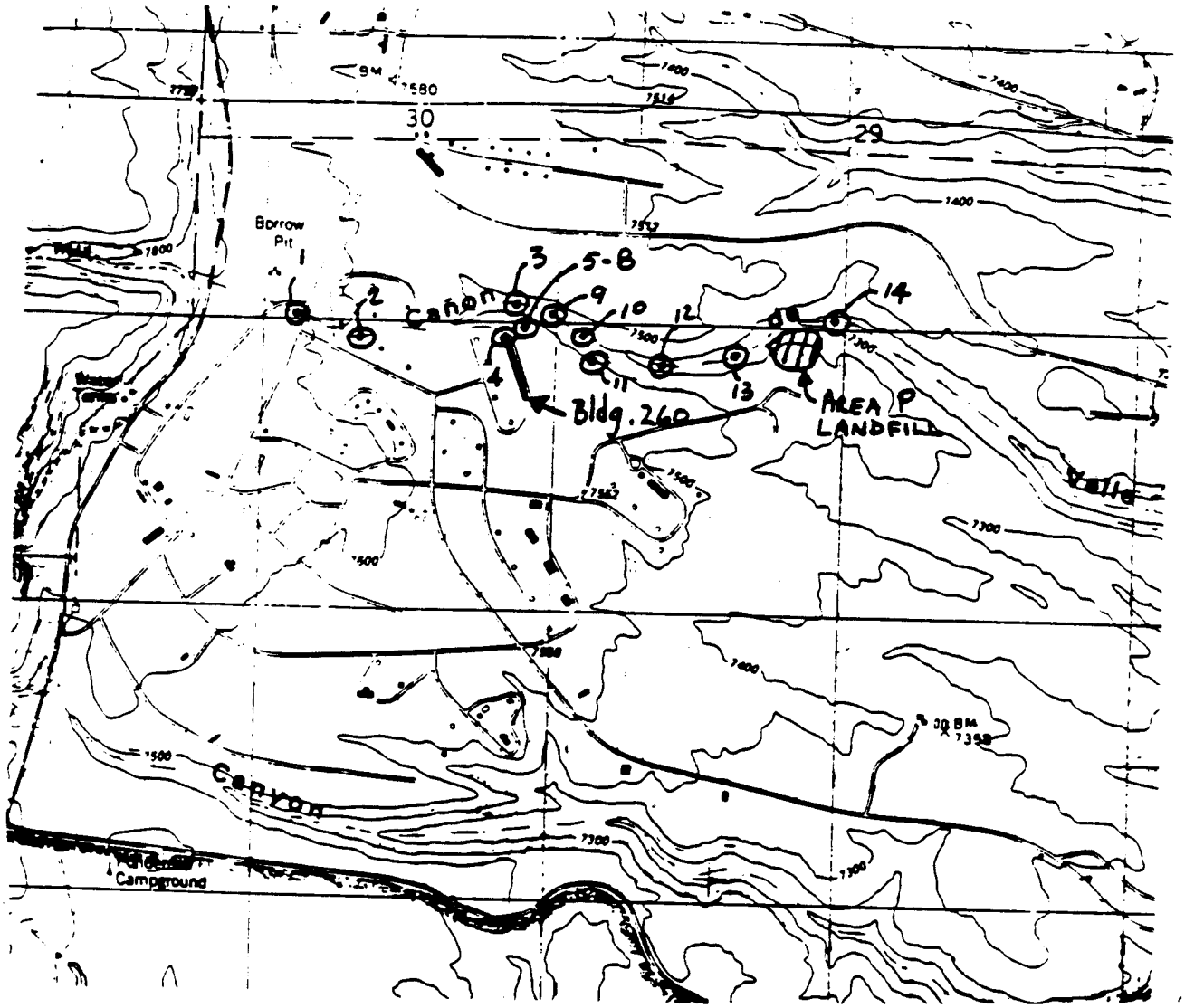


Figure D-1. Location map for Canon de Valle stream samples.

VII. APPENDICES

Appendix E. Calibration Curves for the Neutron Moisture Probe

Calibration curves for the CPN Model 503-DR Hydroprobe, serial number H36076933, are shown in the attached figure.

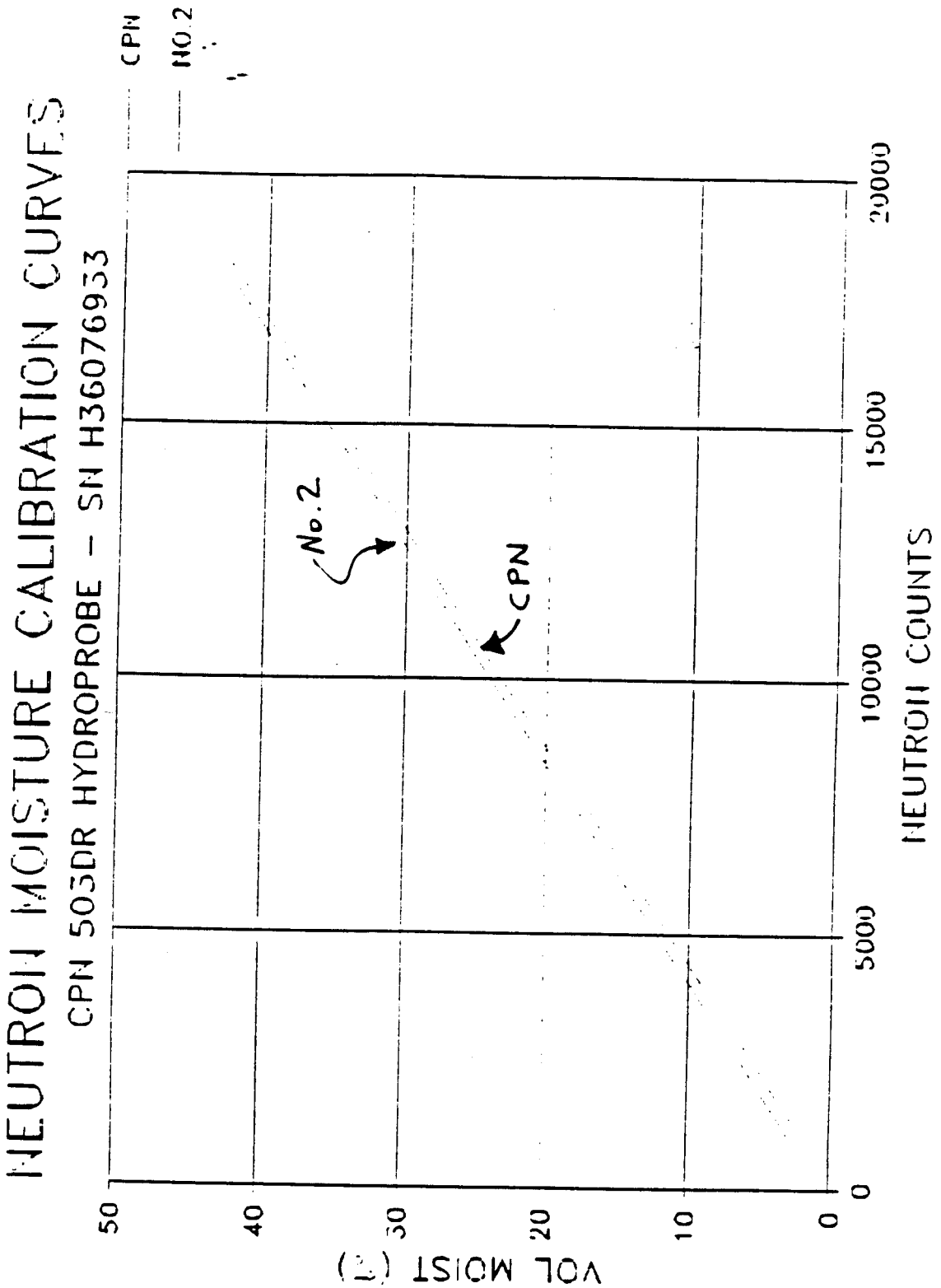


Figure E-1. Calibration curves for the neutron moisture probe. CPN represents the factory calibration curve in pure silica sand, while the curve No. 2 is an HSE-8 calibration curve for Bandelier tuff.

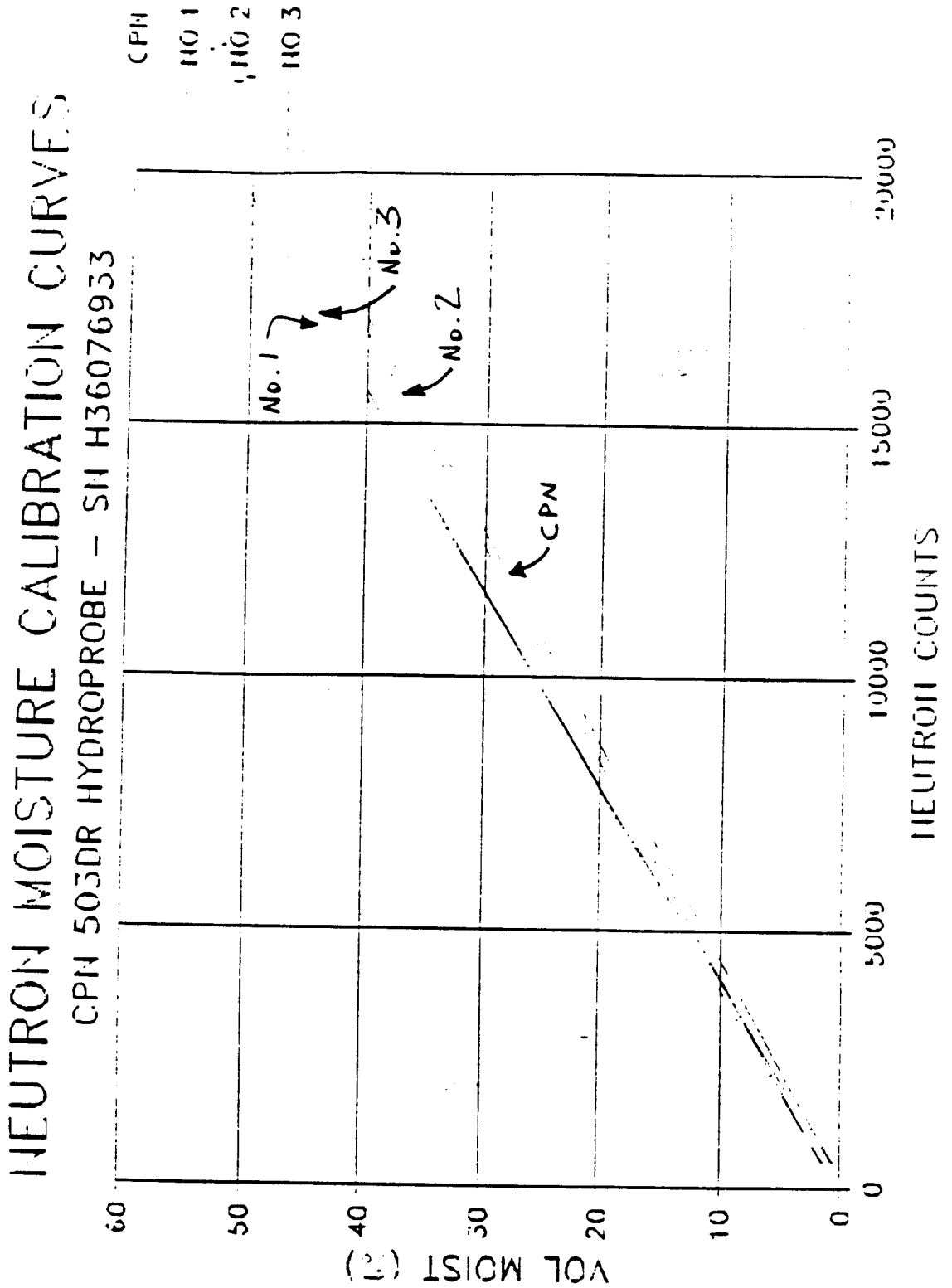


Figure E-2. Calibration curves for the neutron moisture probe. CPN represents the factory calibration curve in pure silica sand, while curves No.1, No. 2, and No. 3 are HSE-8 calibration curves for Bandelier tuff.

VII. APPENDICES

Appendix F. Neutron Moisture Readings

Plots of volumetric moisture content versus depth below ground surface are attached. These data are from neutron access wells numbered P-0, P-12, P-13, P-14, P-16, P-17, P-18, P-19 , and P-20. These curves were originally collected in neutron counts, and were converted to volumetric moisture contents using the CPN calibration curve shown in Figs. E-1 and E-2. This calibration curve equation is given by:

$$\text{Volumetric Moisture (\%)} = A * (\text{Counts/Standard Count}) + B \qquad \text{(F.1)}$$

where A = 19.2599 and B = -0.5794. Tabulated data were recorded on a monthly basis from March through September 1989, and are also attached for future reference purposes.

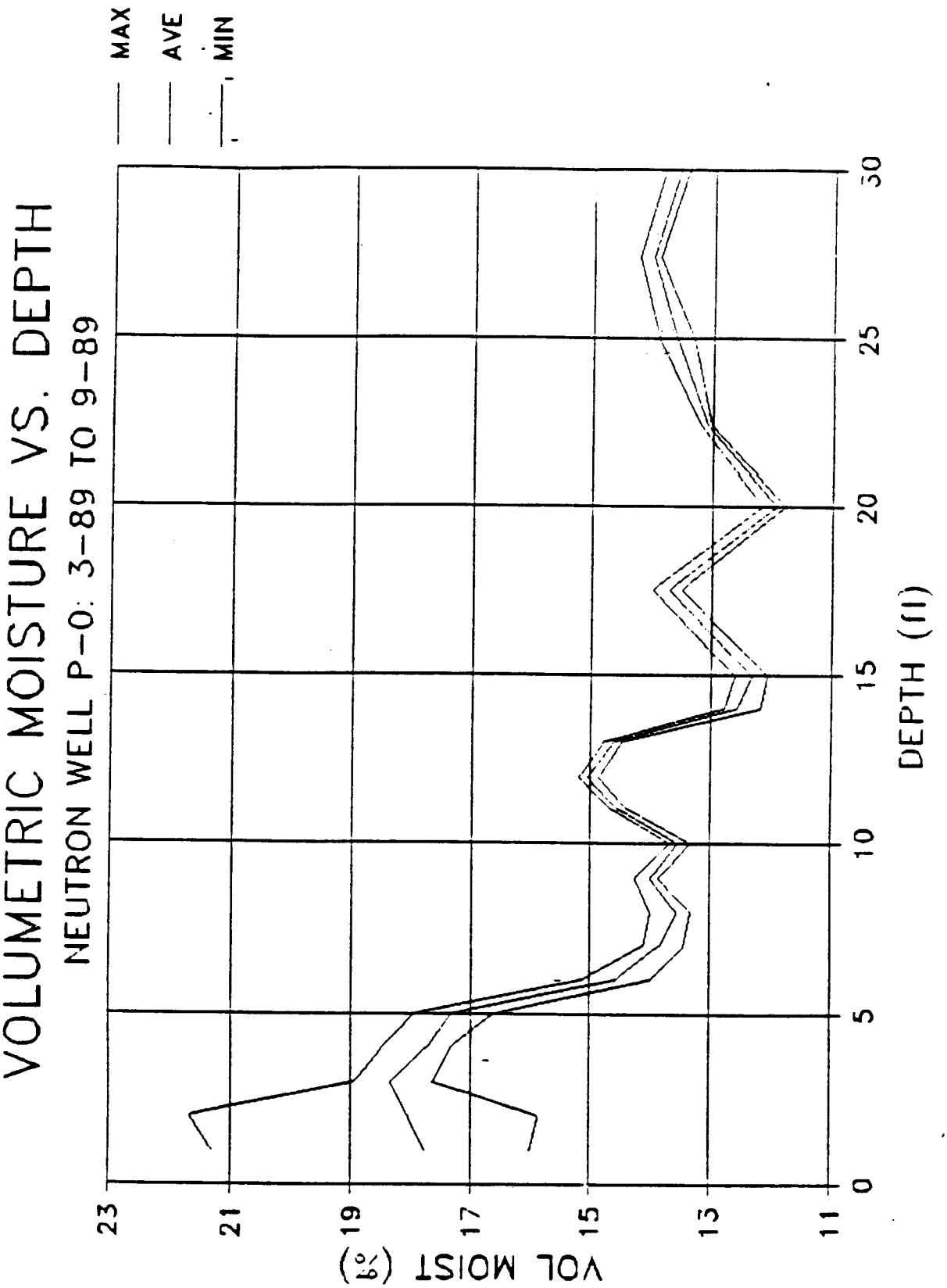


Figure F-1. Volumetric moisture (%) vs. depth for neutron access well P-0 (the TA-16 surface impoundment well); logging depths are from the surface down to 30 feet.

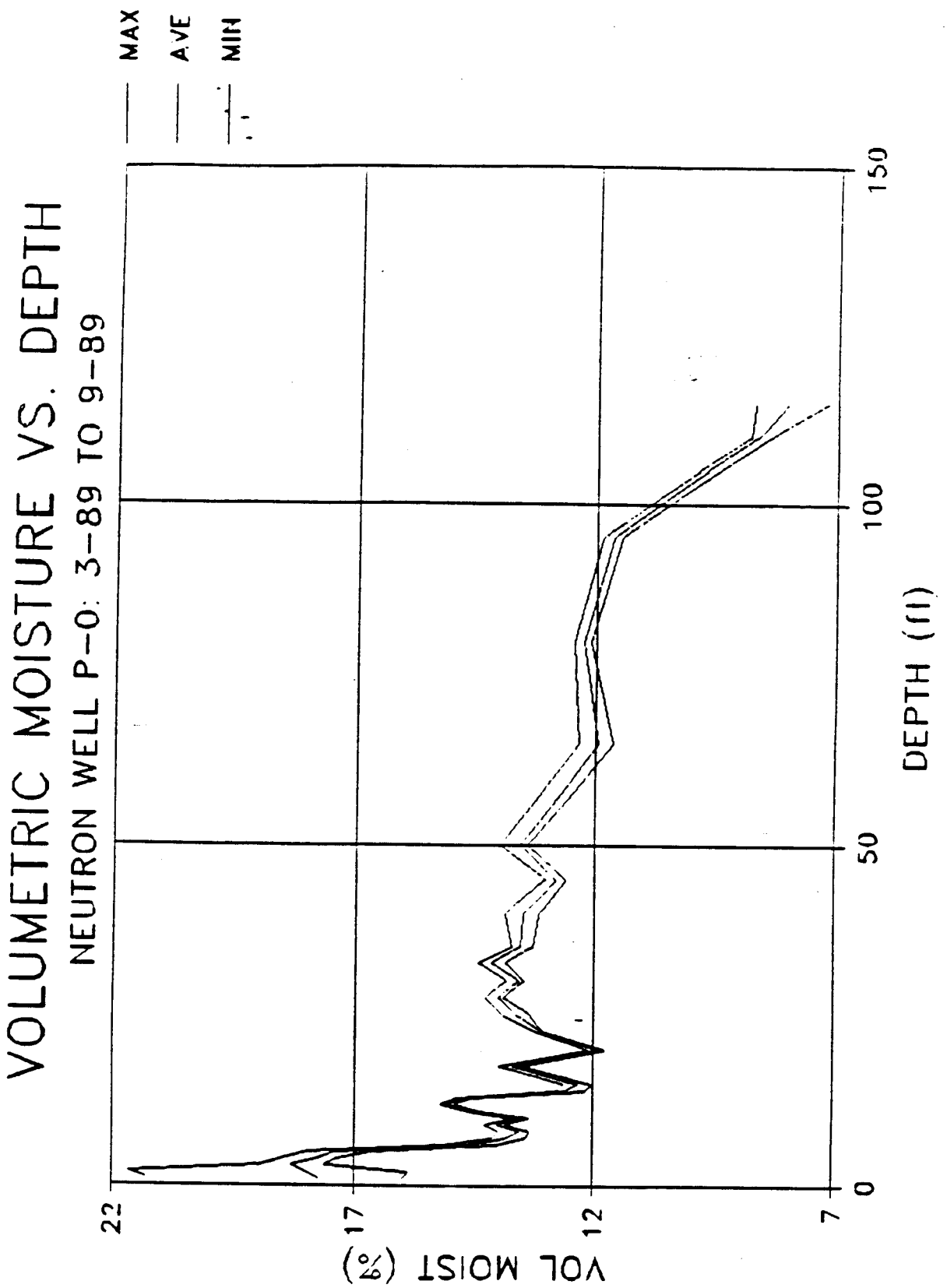


Figure F-2. Volumetric moisture (%) vs. depth for neutron access well P-0 (the TA-16 surface impoundment well); logging depths a from the surface down to 114 feet.

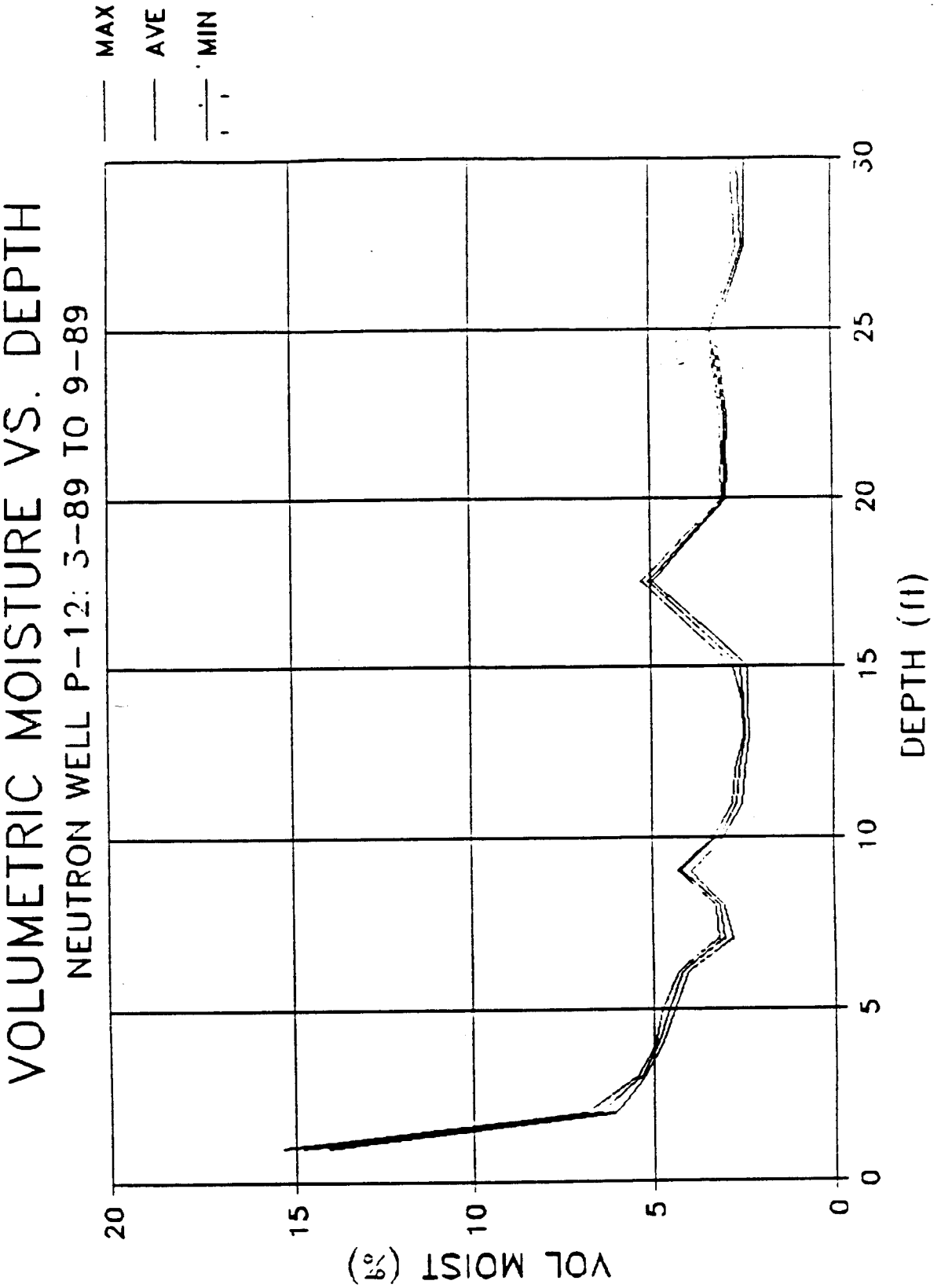


Figure F-3. Volumetric moisture (%) vs. depth for neutron access well P-12 (the background well); logging depths are from the surface down to 30 feet.

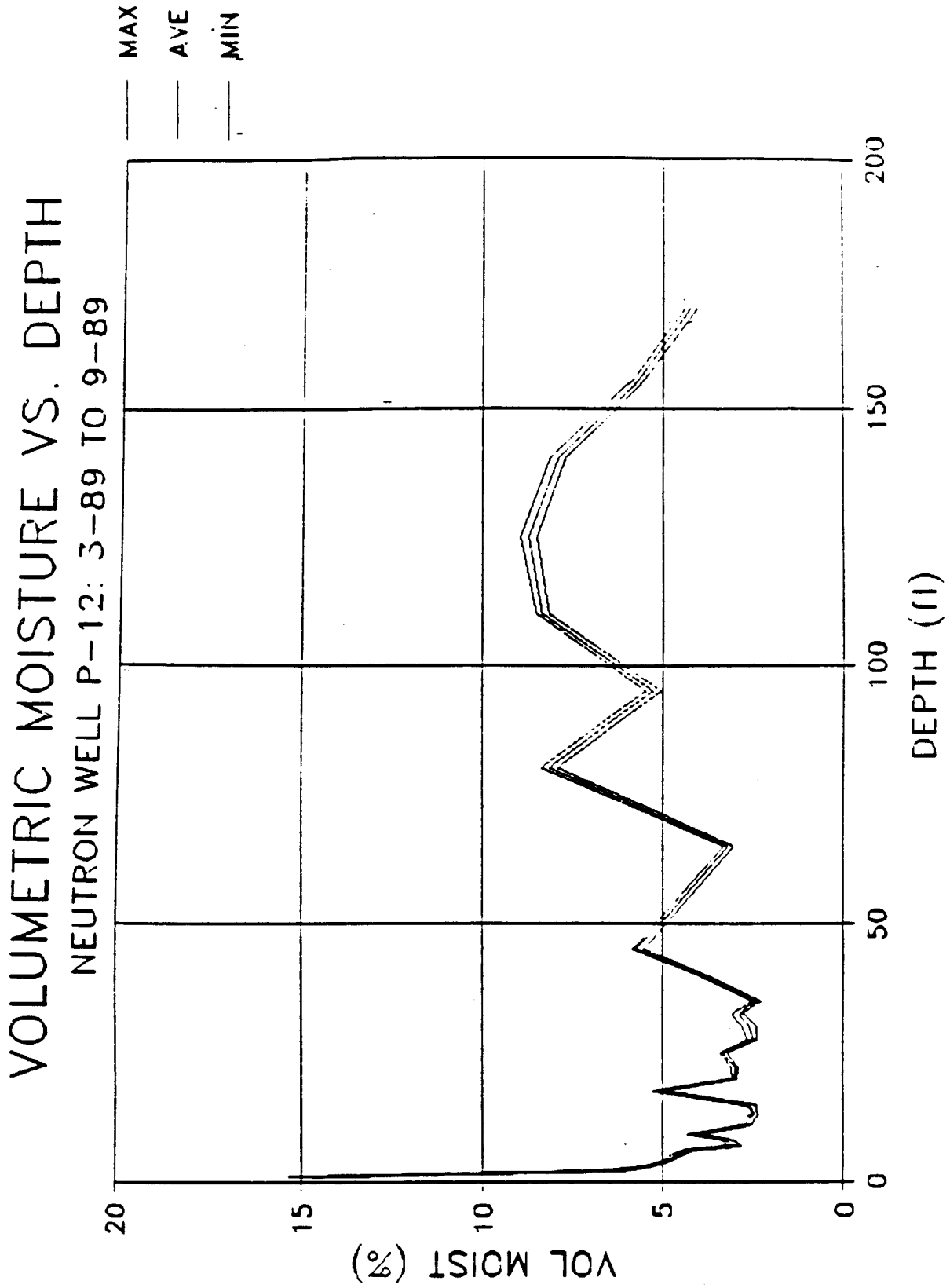


Figure F-4. Volumetric moisture (%) vs. depth for neutron access well P-12 (the background well); logging depths are from the surface down to 170 feet.

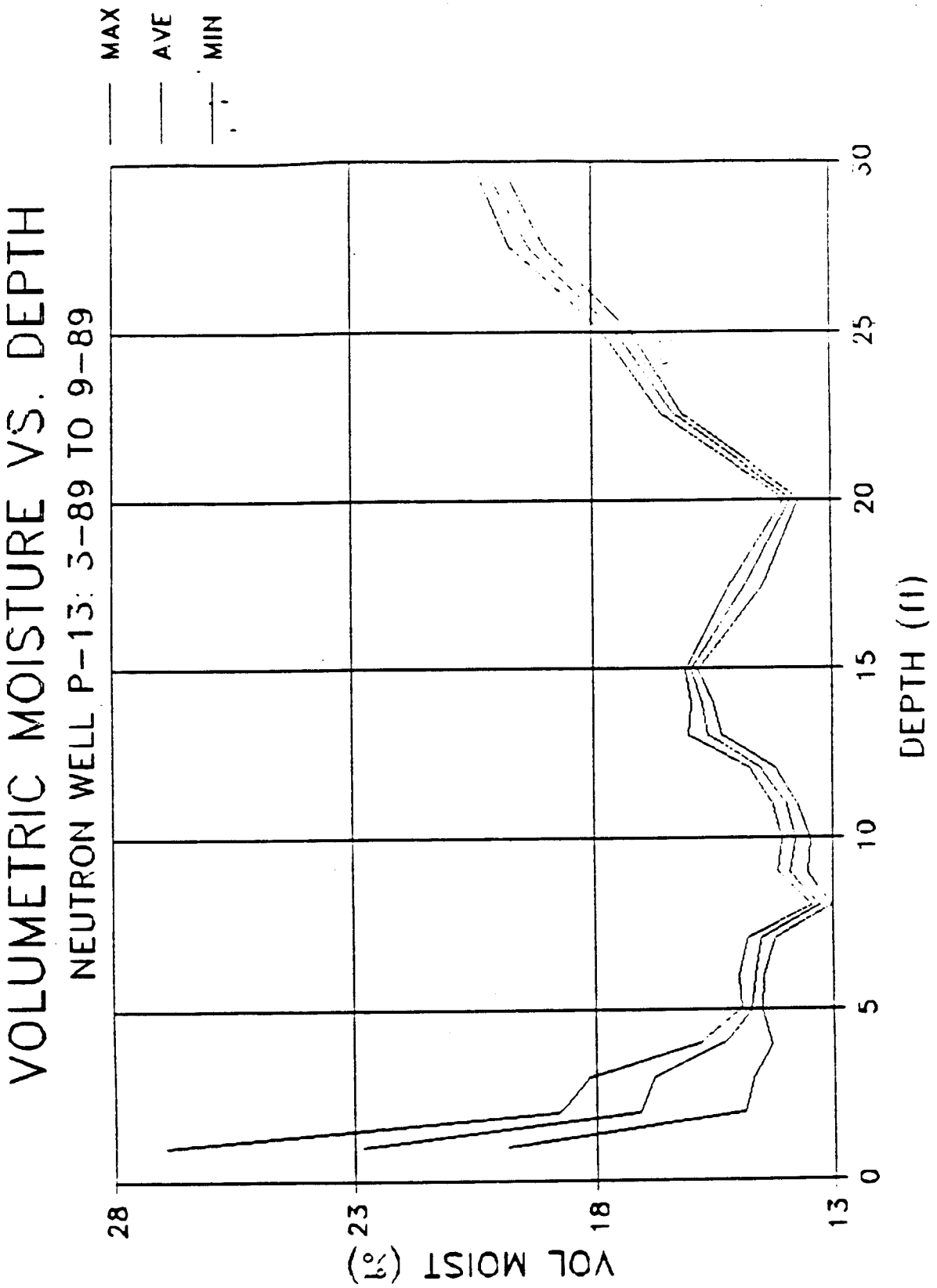


Figure F-5. Volumetric moisture (%) vs. depth for neutron access well P-13 (a landfill perimeter well); logging depths are from the surface down to 30 feet.

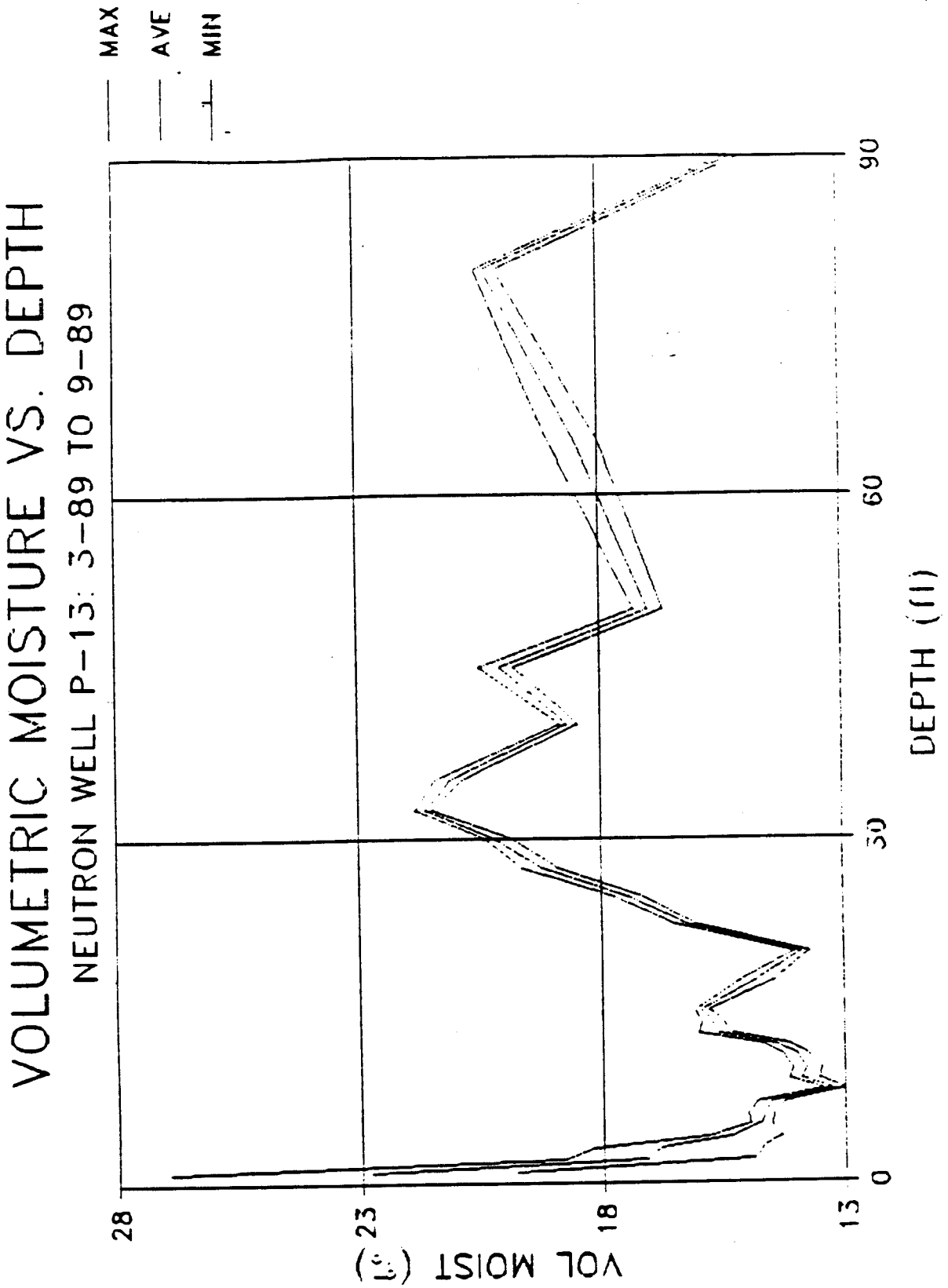


Figure F-6. Volumetric moisture (%) vs. depth for neutron access well P-13 (a landfill perimeter well); logging depths are from the surface down to 90 feet.

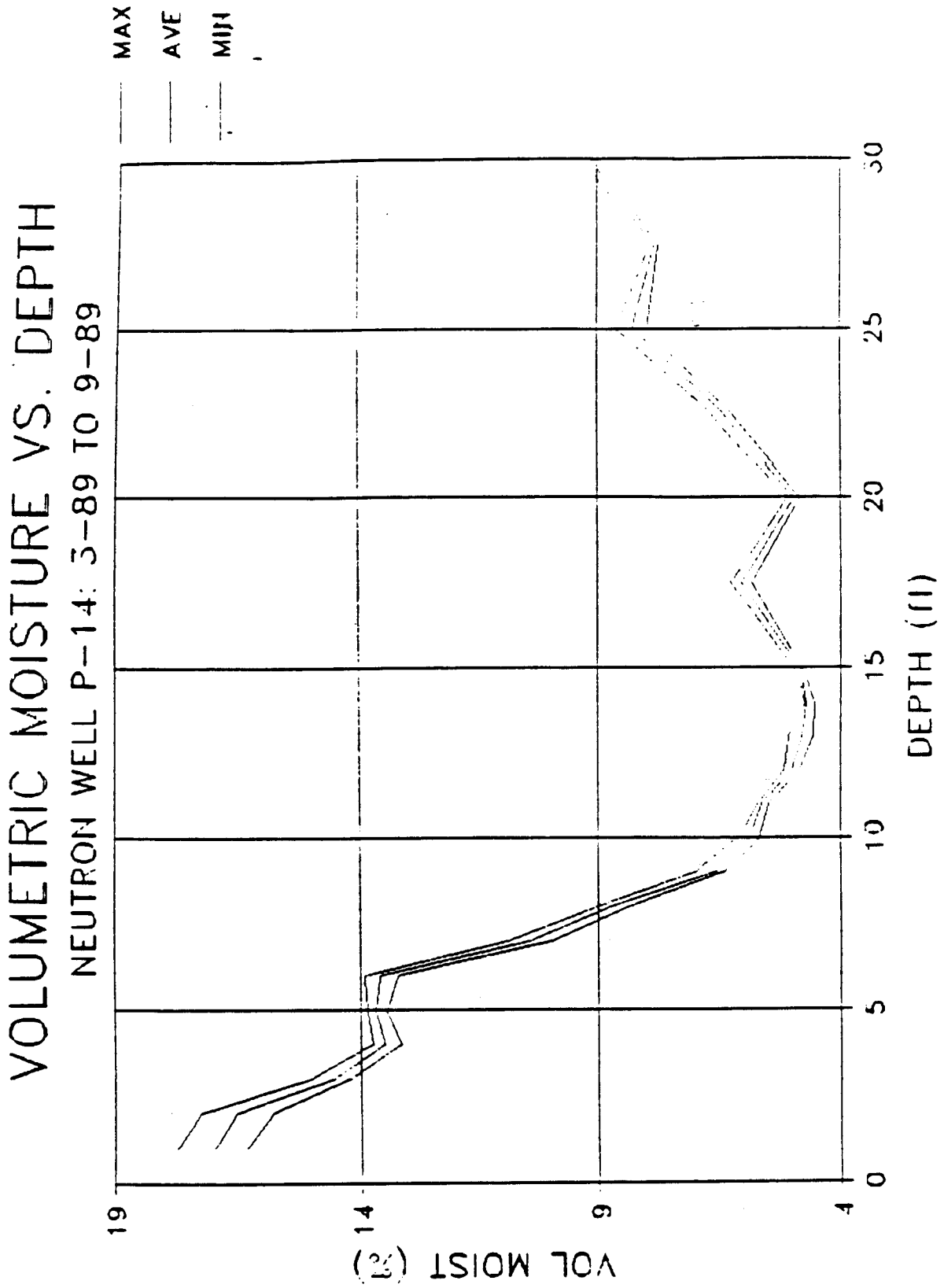


Figure F-7. Volumetric moisture (%) vs. depth for neutron access well P-14 (a landfill perimeter well); logging depths are from the surface down to 30 feet.

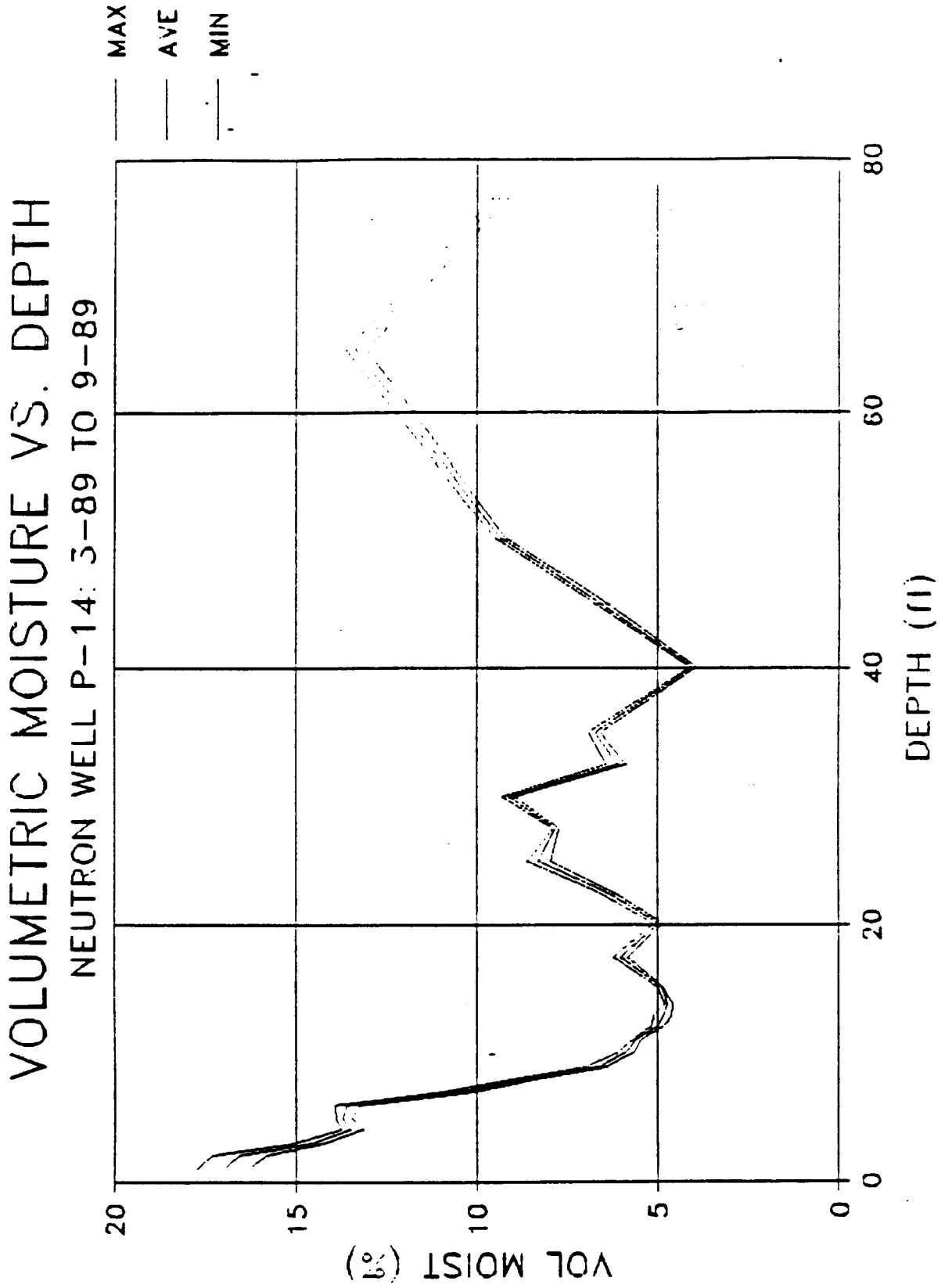


Figure F-8. Volumetric moisture (%) vs. depth for neutron acce well P-14 (a landfill perimeter well); logging depths are from the surface down to 77 feet.

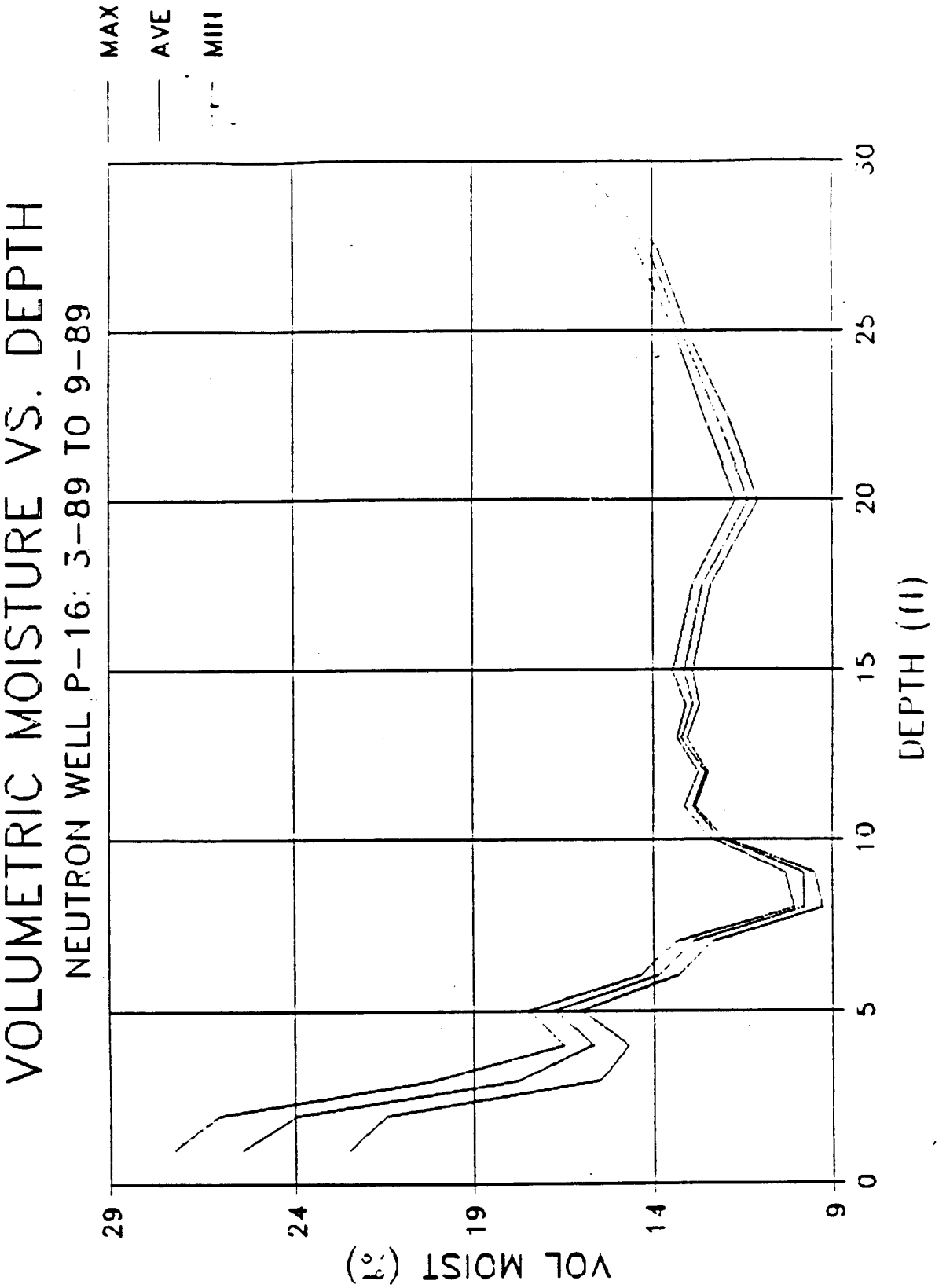


Figure F-9. Volumetric moisture (%) vs. depth for neutron access well P-16 (a landfill perimeter well); logging depths are from the surface down to 30 feet.

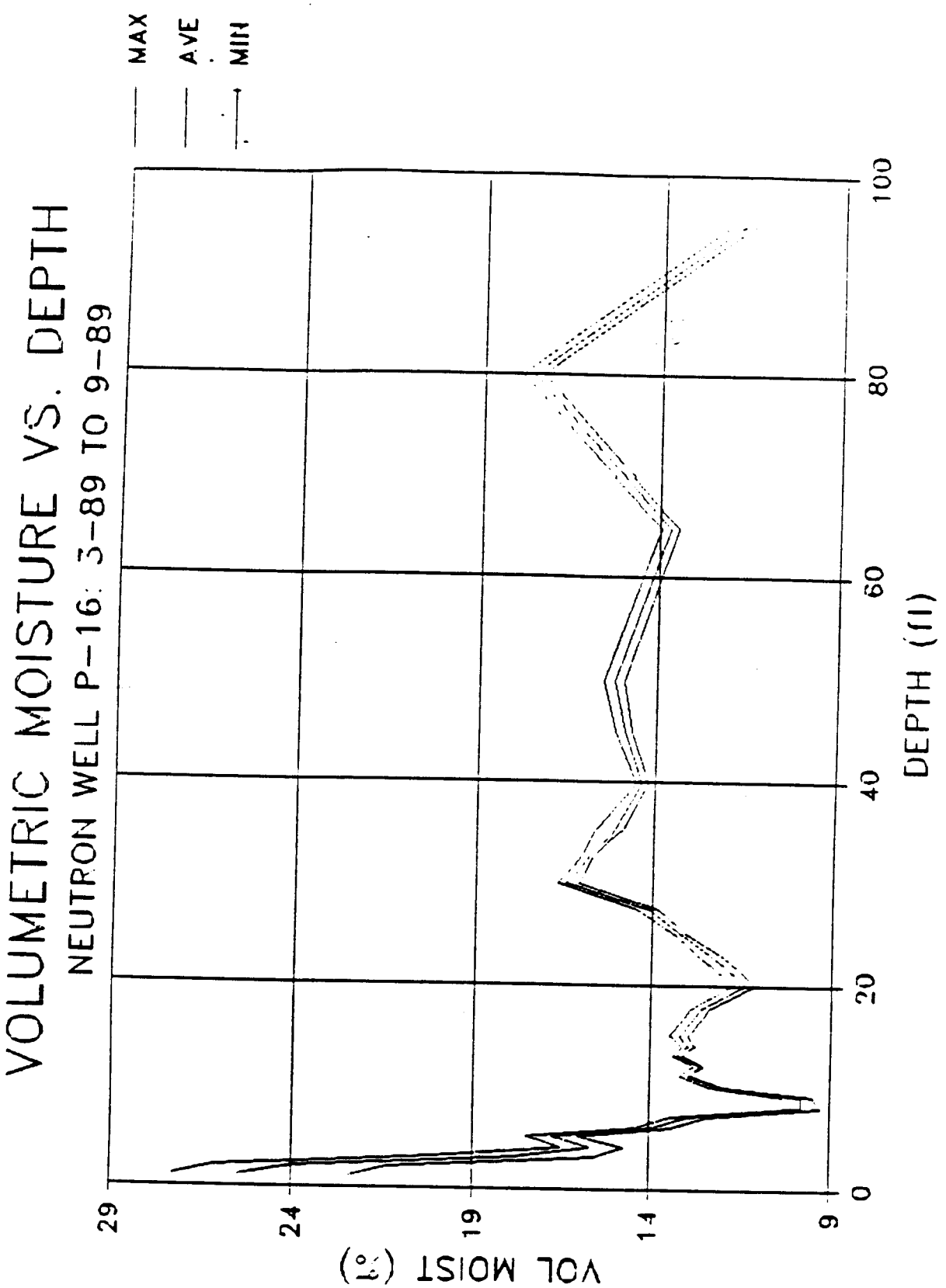


Figure F-10. Volumetric moisture (%) vs. depth for neutron access well P-16 (a landfill perimeter well); logging depths are from the surface down to 95 feet.

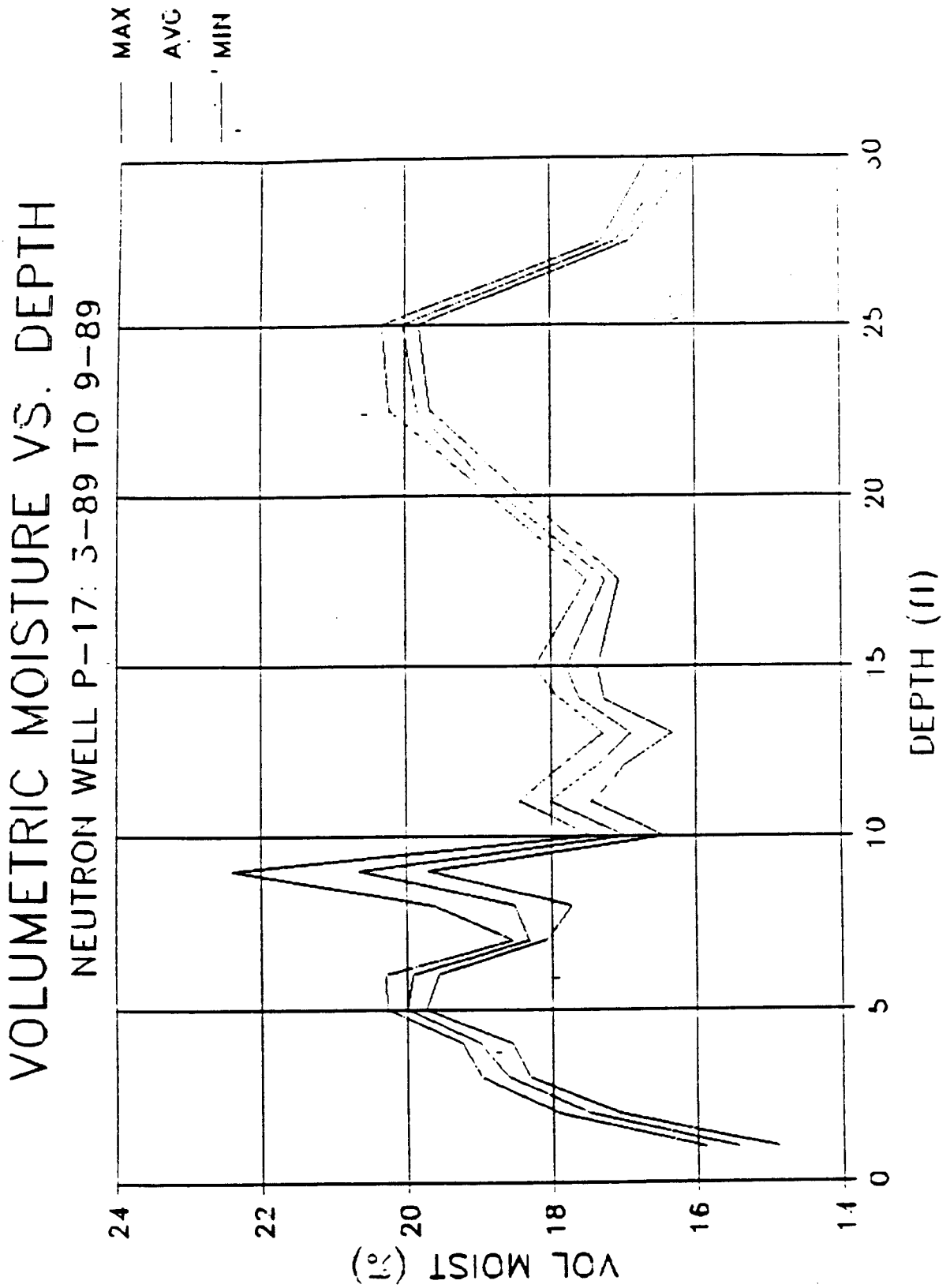


Figure F-11. Volumetric moisture (%) vs. depth for neutron access well P-17 (a landfill well); logging depths are from the surface down to 30 feet.

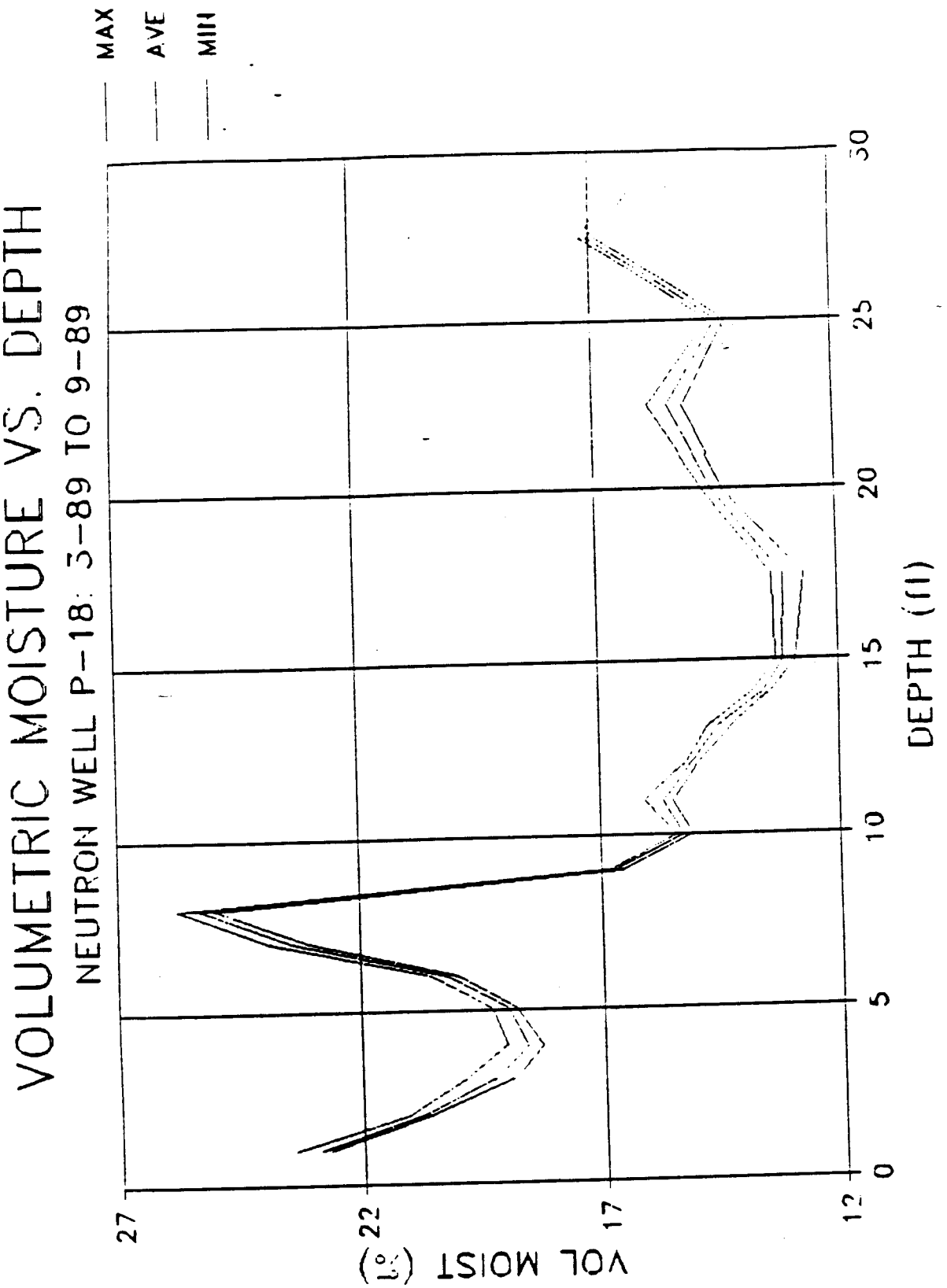


Figure F-12. Volumetric moisture (%) vs. depth for neutron acce well P-18 (a landfill well); logging depths are from the surfa down to 30 feet.

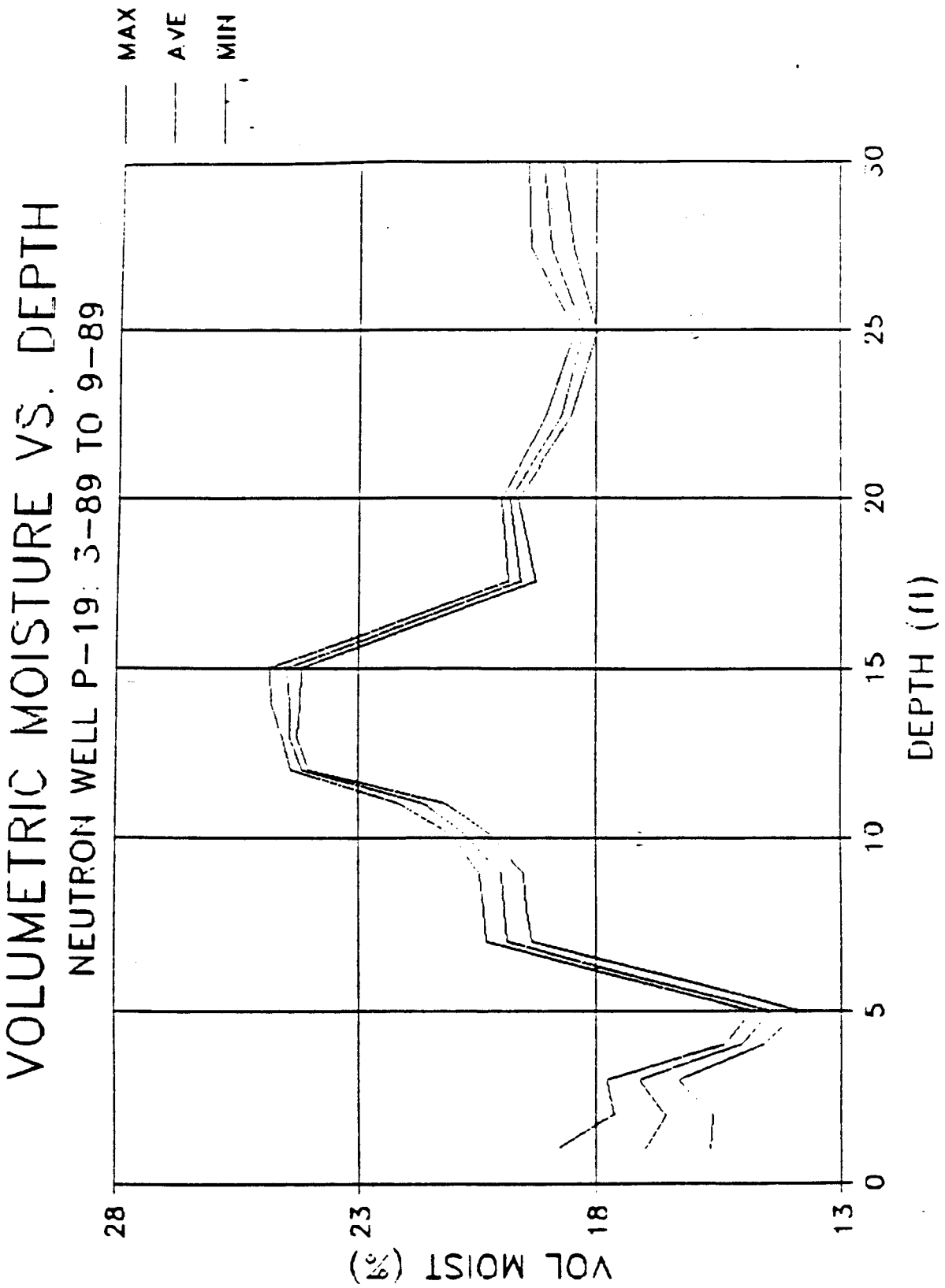


Figure F-13. Volumetric moisture (%) vs. depth for neutron access well P-19 (a landfill well); logging depths are from the surface down to 30 feet.

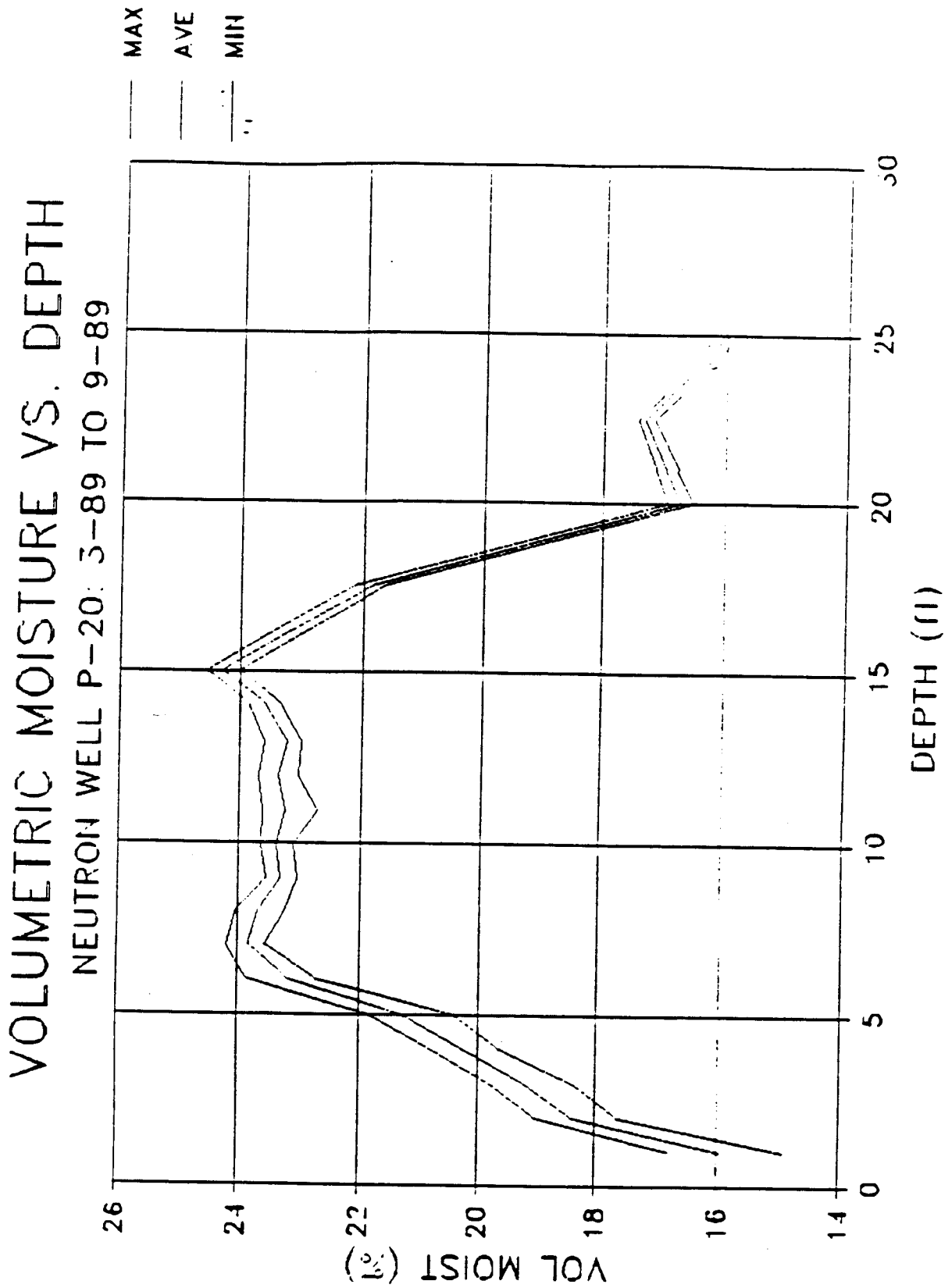


Figure F-14. Volumetric moisture (%) vs. depth for neutron access well P-20 (a landfill well); logging depths are from the surface down to 25 feet.

APPENDIX E

HISTORICAL RECORDS ASSOCIATED WITH TA-16 AND MATERIAL DISPOSAL AREA P

Archival Material Concerning Area P Landfill and the Burning Ground

The following material in our reference collection concern operations at the TA-16 Burning Ground and the Area P landfill. These are provided roughly in chronological order:

Date	Author	Subject/Relevance to Area P
11/18/53	Wilder	Discusses HE waste burning operations at Burning Ground.
4/18/54	Burch	Shows that materials other than HE were disposed at Burning Ground
9/16/56(?)	GMX Division	Describes SOP for HE burning at TA-16. Shows that residues are dumped at Area P.
12/23/59	Ballance	Shows that large items (i.e trucks involved in Burning Ground accident) were deposited in Area P.
8/29/60	Ballance	Shows that filter baskets were flashed and disposed of in Area P. Also shows that some "unburnable and uncontaminated" material were deposited. unflashed in Area P.
9/1/65	Eng-3	Shows that detonators were burned at Area P and that metallic material found at old S-site was disposed of in Area P.
9/30/65	Williams	See 9/1/65 entry.
4/13/66	Courtright	Shows that non-combustibles from old buildings were disposed of in Area P. HE contaminated material went to Mesita del Buey (TA-54).
5/2/66	Work order	See 4/13/66

9/69	Courtright	"Slide 20" states that 1325 truck loads of noncombustible material from the demolished buildings went to the 'regular controlled disposal area' (Area P). Attached photo (LASL 665553) shows material being dumped into Area P landfill.
8/19/70	MacDougall.	Estimates HE burned at 1900 lbs/week.
6/1/71	Salgado	Estimates 49,400 lbs HE and 3,284 gallons of solvents were disposed of at TA-16 during 6 month period
6/28/71	Panowski and Salgado	Confirms (roughly) waste volumes in 6/1/71 memo. Further describes Burning Ground wastes as containing 49,500 lbs HE, 3000 lbs barium nitrate, 3000 lbs HE contaminated solvents, 54 lbs depleted uranium, and 165 lbs kerosene over 6 months. Memo notes that uranium burns are monitored and the residues go to Mesita del Buey (TA-54). Memo notes that 143,000 lbs of normal trash and 7,500 lbs of contaminated trash were burned during this period.
1970's	no author	Viewgraph shows that 100,600 lbs of HE and 29,600 lbs of contaminated material were burned at LASL in 1975(??).
4/25/83	Warren	Further information on HE and HE-contaminated material burning at S-Site.
8/13/92	Barr	A site-worker provides a perspective on the history of the burning ground.

16-000214

USE ONLY

LAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS NEW MEXICO

OFFICE MEMORANDUM

TO M. L. Brooks

DATE: November 18, 1953

FROM Edward Wilder

SUBJECT: PROCEDURE FOR THE OPERATION OF THE S-SITE BURNING GROUNDS

SYMBOL: GMX-3

The pickup of scrap material starts at approximately 1300. The operation is normally under the supervision of R. L. Converse. In his absence, Adolfo Arellano or a designated alternate is in charge. The alternate is familiar with all phases of the operation. There are five laborers assigned to the scrap collecting crew.

The truck used is a high-body stake type truck. This truck is equipped with a hydraulic lift tail gate to facilitate the handling of the waste material. The material on the truck is carried in GI cans. On certain instances where this is impractical, it is covered with a tarpaulin.

The material is picked up in the old explosive area from points outside of the building. In the new area, scrap is held inside the building until the scrap crew collects it.

There are three burning pits available for use. These are rotated so that no pit is used two days in succession. The placement of the scrap in the burn pits is alternated so that no two burns in the same pit occur in the same location in succession.

In the burning grounds, the scrap material is spread out one layer thick. It is not practical to break up big pieces, therefore, all pieces are burned without any treatment at the burning grounds. Two thousand pounds is considered a normal quantity. Material picked up from GMX-2 or other non GMX-3 sources to be burned is burned independently of GMX-3 scrap, unless Converse is sure the material is such as to present no greater hazard than the GMX-3

At the time the burning takes place, the labor crew leaves the area via their big truck. Material is fired by Converse or his alternate. He is accompanied at all times by a second person. The firing is accomplished by means of an electric squib. It fires into a handful of excelsior which in turn lights some wax paper in which there is a chunk of Composition B. The excelsior is wet with a few drops of gasoline or kerosene near the squib to make it ignite easier. The squib is fired by means of a blasting machine located in the shelter.

When the labor crew leaves the area just before firing, they close the railroad gate near the west end of Building 140. Converse and his companion leave the area after burning is completed. After approximately 30 minutes, they return to the area to assure themselves that burning is completed and that no brush fires have started. We do not notify the Fire Department of the time of each burn when it takes place at the usual time (between 1400 and 1500). In the event that a burn does not come at the usual time, the Fire Department is notified.

Normally there is only one burn per day. Occasionally more material needs to be burned than can be picked up in the afternoon run. In this case, there is a pickup in the morning. It is spread out for burning at the burning grounds; the fence gate is locked and the material is burned at the scheduled time.

At certain times of the year, because of high winds or other climatic conditions, it is considered dangerous to burn the material. In this case, the scrap is stored overnight in a repository type building and burned the next day.

The sludge filter baskets are picked up at our new building at a frequency determined by the processes at the building. These are taken to the bag wash building and washed. Sludge from the old process building where filter baskets are not available is dipped from the sump and carried to the bag wash building.

The filter baskets are washed using a water hose, which washes the sludge down inclined troughs and discharges it into sand bed filters. Normally, the filter bed accommodate the sludge from one day's operation. We have three filter beds so that each bed is used every third day, with a day of drying between the time the bed is filled and burned.

It is estimated that 400 pounds of dry explosives are burned at these beds each day. The beds are ignited using a train similar to that used with the solid scrap.

During the time the burning takes place, the railroad crossing gate across the road from the sand bed filters is closed. The railroad crossing gate on the main road to the area is not closed. This means that normal operations in the bag wash building and burning grounds continue at the same time as the operations at the sand bed filters.

After each burning on the filters, the burned material is raked to one side and deposited in the GI cans. Fresh sand is added to bring the bed back to the original depth and raked smooth. The burned material in the GI cans is transported to the scrap HE burning pit and reburned at a later date.

Edward Wilder

Edward Wilder

EW/ph
cc: R. W. Drake
Roy Reider
R. L. Thrap
F. A. Hauser
[illegible]

April 19, 1954

John Haddock, SP-2

Safety Office, Z-3

DISPOSAL OF EXPLOSIVES BOXES

Z-3

This office concurs with your proposed disposal procedures of burning, in the S-site explosives burning pit, unwanted wooden boxes that have been used for shipping explosives. We believe the operation safe. Richard Converse, in charge of burning explosives, should supervise the box burning.

C. Austin Burch
C. Austin Burch
Safety Engineer

CABrvmm
cc: O. C. Cowgill, GEX-3
Dick Converse, GEX-3

16-000240

INTER-OFFICE ROUTING

LOS ALAMOS SCIENTIFIC LABORATORY

6050

previously 9/16/56 (note by C.P.)

FROM [redacted] DATE ~~9-16~~ TELEPHONE ~~7-612~~

	Initials	Date
1. Safety Office Q-Bldg.		
2. ADCS		
3. Reider		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

My secretary suggest C

____ Immediate Action

____ Comment

____ Prepare Reply

____ Necessary Action

____ See Me

(2) For Approval

____ For Your Information

____ Signature

[redacted] Note, Initial and Return

Comments: [redacted] to send a copy of this to [redacted] Laboratory (Monsanto) to help them in the new work that they are to engage in on AEC contract this work will be similar to that done by GMX-7.

(This form available in Stationery Stock)

STANDARD PROCEDURES FOR EXPLOSIVES BURNING

CMX Division, [redacted]

Los Alamos Scientific Laboratory

GENERAL:

Scrap explosives are collected by two methods, wet and dry. Dry scrap is produced by breakage, X-ray rejects, sawed sprues, machining rejects, emptied boxes, and excess H. E. from a melt and other operations. Wet scrap is produced in machining operations (separated from machining coolant), washing down floors of inspection, weighing, mixing, melting, casting, machining, pressing and other operations. [redacted] Composition B [redacted]

In addition to the above production scrap, small amounts of various explosives from laboratories are collected and burned separately.

One man is responsible for the whole operation and makes certain the standard procedure is followed.

A. DRY SCRAP

1. Collecting: Dry scrap is placed in G. I. cans (Painted red and marked "H. E." in White) and original wooden packing boxes by the operating people. These cans are outside the building and usually on wooden or concrete stands constructed to be the same height above the ground as the bed of the truck used for hauling.

   Scrap size is from small particles to castings weighing as much as 80 pounds with thicknesses as great as 14 inches.

   Such scrap is picked up either daily, weekly, or only on special call depending on the quantities accrued.

2. Transporting: A 1½ ton stake-bed truck is used to haul the scrap in cans. The truck has plywood sideboards nailed with brass nails to the inside of the regular side boards. There is also a removable plywood [redacted] floor which is taken out after each run in order to clean the [redacted] truck is equipped with two 15# CO_2 fire extinguishers, has [redacted] unting and reversing "Danger, Explosives" signs on front [redacted] both sides. Bumpers are equipped for mounting two red [redacted] and after [redacted] reasons, a tarpaulin is used to cover the scrap as the truck leaves the "old exclusion area". When not in use, the tarpaulin is rolled on a spool immediately behind the cab.

   A half-ton pick-up truck equipped with [redacted] a "dog-house" with seats, is used to haul the work crew of four to eight men.

   The pick-up truck precedes the H. E. truck to the burning pits and the convoy travels no faster than 20 m.p.h.

3. Burning: Dry scrap is burned in three "pits" surrounded by an 8' foot cyclone fence with lockable gate. The pits are approximately 100 X 100 feet, rectangular in shape and separated from each other by a minimum of 130 feet. The burning beds are covered with several inches of sand. Each pit is equipped with running water.

Scrap H. E. is spread evenly across the bed. H. E. is not stacked, in order to reduce thickness. However, no attempt is made to reduce the thickness of individual pieces. Boxes, H. E. contaminated paper and rags are all burned together. To ignite the H. E., a "fuse" of combustible material (sprinkled with kerosene) is laid and an electric squib attached to a blasting line is laid in paper at end away from H. E. The blasting line is run to a barricade about 140 feet from the nearest pit. All people in the area are behind the barricade during burning. A railroad gate 1800 feet down the only approach road and bearing the sign "Do not enter when gate is lowered" is lowered to prevent people from wandering into the area. The area is searched to make certain no unprotected people are in the area. The labor crew may or may not leave the area before burning, but there are always two men present at the time burning takes place.

The squib is ignited by use of a small hand-blasting machine. Two thousand pounds is considered a normal burn, but as much as 7000 [illegible]s of H. E. has been burned in one pit at one time without incident. The fire reaches its intensity in about six minutes and has about burned out in twenty minutes.

Each pit is used every third day and, therefore, each pit is allowed to cool a minimum of about 48 hours before being used again. The placement of scrap in a burn pit is alternated so that no two burns in succession occur in the same location on the same pit. [redacted] each year. This material is [redacted].

Normally, scrap is burned every afternoon but if the wind velocity is high and the woods fire danger great, scrap is stored overnite in the repository type building.

forest

overnight

[redacted] Machines, equipment and floors in operating buildings [redacted] down and the water and H. E. leaves the rooms by scuppers. [redacted] flows into baskets in concrete sumps located outside the [redacted] The baskets are made of aluminum alloy framework and perforated plate. A fiberglass fabric is attached inside the plate which filters out the solid H. E. in the solution. The filtered water leaves the sumps through a drain, runs into small drainage ditches [illegible] eventually into the canyon.

Some old buildings do not have baskets in the sumps. Material in these sumps is scooped out.

4. Transportation: Two low-bed cab-over-engine trucks are used for hauling the baskets. These trucks have beds about 18 inches deep

tight tank constructed of 16-gauge galvanized iron. A jib crane with a half-ton chain hoist is mounted on one side for raising the baskets into the truck. No escort is used in delivering wet scrap to the basket-washing building at the burning grounds.

3. Washing and burning: The baskets are washed by hand using warm water from a hose (automatic washing devices have never proven satisfactory). The material flows out of the building into one of three sand-covered filter beds by means of black iron "V" trough. The pits are located 350 feet from the basket washing building and 300 feet from each other. The pits are built up of brick, contain several layers of sand and gravel. Heating elements run through the bed to aid in drying and to prevent freezing in the winter. Water draining out the bottom runs into the canyon.

About 400 pounds can be burned at each pit after the H. E. has been allowed to dry overnite. Wet scrap is lighted similarly to dry scrap. However, the area is not cleared of personnel; men are allowed to work in the washing building. Railroad type gates are lowered to prevent vehicle access to the pits.

Ash is scraped from the sand, piled in the dry scrap pits and reburned. New sand is added as needed.

16-000260

LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS NEW MEXICO

OFFICE MEMORANDUM

TO: M. L. Brooks

DATE: December 23, 1959

FROM: H. E. Ballance

SUBJECT: BURNING GROUND (ACCIDENT AREA) CLEANUP PROCEDURE

SYMBOL: GMX-3

The following procedure is proposed for cleaning the accident area of the Group GMX-3 Burning Ground.

Visual Inspection and HE Scrap Pickup

1. The attached sketch, SK-4350 A-1, indicates the approximate area that will be visually inspected. All HE and suspected HE contaminated items will be picked up for burning.

2. A party of six men equipped with rubber buckets will be used. (These men are to be experienced in visual recognition of various forms of HE.)

3. Parallel rows, within the designated area, will be marked off by using cord and stakes. The men will be positioned approximately eight feet apart and walk in parallel lines within the rows and will pick up any HE scrap and suspected HE contaminated items. Each of the rows will be thoroughly inspected and all picked up material deposited in Burning Pit TA-16-387.

Truck Disposal

1. The large truck will be dragged from the pavement to a place within five feet outside the fenced area of Burning Pit 387, and burned again as described below for the panel truck.

2. The loose rubber tires will be stacked in the panel truck. Kindling wood (purchased from Cook's Lumber, Espanola) will be stacked in and around the trucks using approximately one cord for each truck. Approximately five gallons of kerosene will be poured on each pile of wood. An ignition train of paper will be placed on the ground and connected to the wood. The paper will then be soaked with kerosene; a squib will be placed in the paper and ignited from the barricade TA-16-395.

3. A minimum of 24 hours after the fire has burned, the trucks will be inspected and then dumped into the canyon behind Burning Pit 387 by using a Zia wrecker.

Burning Pit 387

1. All of the fenced area of Burning Pit 387 and five feet surrounding the fence will be covered with kindling wood. All scrap picked up will be piled on the wood. Kerosene will be poured on the wood to enhance the burning. The squib ignition will be performed as for burning of the trucks.

2. A minimum of 24 hours after the pit has been burned, the pit will be inspected and the resulting ash material will be loaded in a scoop loader and dumped over the canyon behind Burning Pit 387.

General Conditions

1. During the pouring of the kerosene on the wood and the setting of the squib for ignition, J. R. Ditto and I will be the only personnel in the burning area. Flameproof clothing will be worn. All other observers will be behind Barricade 395 (maximum 5; minimum 1).

2. The Fire Department will be notified and asked to stand by at the railroad gate entrance to the Burning Ground in case they are required to fight a brush fire after the burning of the trucks. I will determine if and when this is necessary.

3. The burning of the trucks and the pit will take place at the same time.

4. A test plot of approximately eight feet by eight feet, using kindling wood, will be set up and burned before the actual burning of the pit. This will provide information regarding the effectiveness of using kindling wood to accomplish a satisfactory cleaning job.

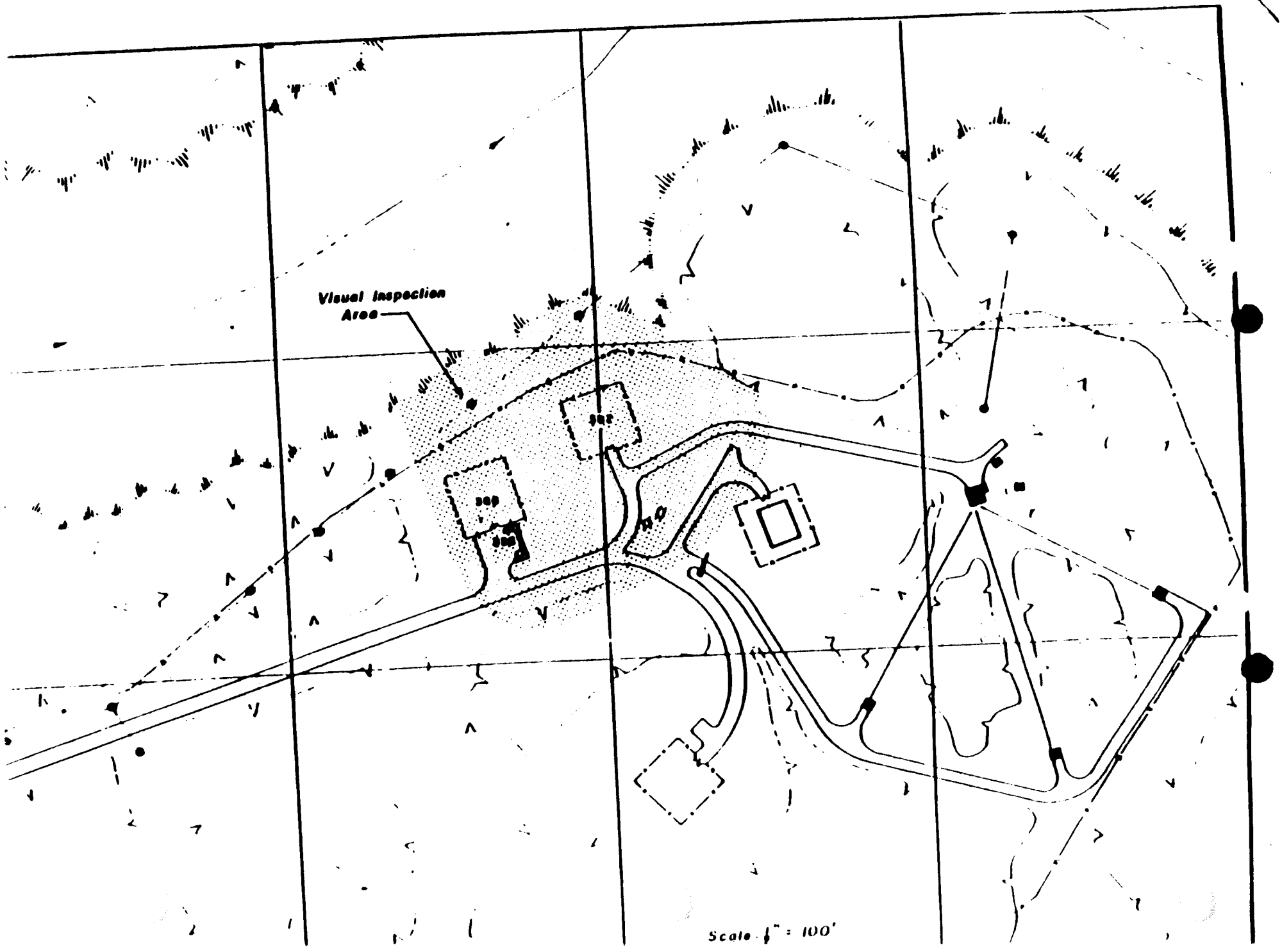
5. We plan to complete this entire operation between December 28 and 31, 1959, weather permitting.

H. E. Ballance

H. E. Ballance

HEB/pc

Attachment: SK-4350 A-1


Visual Inspection Area
Scale 1" = 100'

OFFICE MEMORANDUM

DATE: August 29, 1960

TO : M. L. Brooks

16-000123

FROM : H. E. Ballance

SUBJECT: REVIEW OF GROUP GMX-3 SOP CHAPTER 12, DISPOSAL

SYMBOL : GMX-3

Reference: Memorandum to M. L. Brooks from H. E. Ballance, E. Wilder and W. C. Courtright, dated July 13, 1960

The reference memorandum presented comments and observations the safety survey team had as a result of reviewing Chapter 12 and inspecting the disposal operations. This memorandum presents the action taken as a result of the review.

A. GMX-3 SOP Chapter 12

Revisions have been made in Chapter 12 SOP's to take care of the pertinent comments made in the reference memorandum.

An additional SOP (SOP 12.4.1) has been written to cover disposal of HE contaminated materials and HE scrap created by Laboratory Groups other than GMX-3.

B. Reference memorandum, item B.56

I have requested that this RFW be made permanent.

C. Reference memorandum, item B.58

I have requested that this RFW be made permanent.

D. Reference memorandum, inspection, item 1.b

This situation has been corrected. The Disposal Supervisor has been instructed to notify me immediately if he finds that any of the baskets are being handled other than as specified in the SOP. Also, our new filter baskets have been purchased and are being installed. The old filter baskets are being flashed and dumped into the canyon.

E. Reference memorandum, inspection, item 1.c

The leaks have been repaired by using Johns-Manville Uniseal Caulki Compound.

APPENDIX F

Completed Forms "Survey of Effluent Streams"

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Do not [illegible]

Group GMX-3 Tech Area 16 Building 193

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer ____

Sanitary Sewer X Storm Sewer ____

Trash Container Type: ____

Other: ____

Disposal Method: Atmospheric Dispersal ____ Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground ____

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other ____

Volume of Effluent: Known ____ Estimated ____

Contaminants (see list)	Estimated Discharge
Detergent (250 lbs/mo)	Awaiting analysis
Bleach - Purex (13 gal/mo)	" "
Aerosol - OT (1/2 lb/10 gal of water once a month)	" "

*See below

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks There is no detectable HE in the wash water (< 1 ppm)

R 16

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Do not [illegible] in this [illegible]

Group GMX-3 Tech Area 16 Building 202, Rm 114

Accounting Number(s) _____

Nature of Effluent Streams: Gas X Liquid ___ Solid ___ Other ___

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack _____ Industrial Sewer _____

Sanitary Sewer _____ Storm Sewer _____

Trash Container Type: _____

Other: Exhaust duct

Disposal Method: Atmospheric Dispersal X Sewage Plant _____

Waste Process Plant _____ Chemical Dump _____

Sewage Lagoon _____ Surface of Ground _____

Contaminated Burial Area _____ Septic Tank _____

Community Landfill _____ Other _____

Volume of Effluent: Known _____ Estimated 500 ft^3/yr

Contaminants (see list)	Estimated Discharge
Brazing alloy(Easy Flo)	1 lb/yr
Acetylene	500 ft^3/yr

Monitoring Equipment on Effluent Stream: No X Yes ___

Describe _____

Remarks One lb/yr of alloy is used. Only a small fraction of the alloy is volatile. The acetylene is burned and the products of combustion are emitted to the atmosphere.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Do not at... in this sta...

Group GMX-3 Tech Area 16 Building 202 Room 114

Accounting Number(s) _____

Nature of Effluent Streams: Gas X Liquid ___ Solid ___ Other ___

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack _____ Industrial Sewer _____

Sanitary Sewer _____ Storm Sewer _____

Trash Container Type: _____

Other: Charging Refrigeration Unit

Disposal Method: Atmospheric Dispersal X Sewage Plant _____

Waste Process Plant _____ Chemical Dump _____

Sewage Lagoon _____ Surface of Ground _____

Contaminated Burial Area _____ Septic Tank _____

Community Landfill _____ Other _____

Volume of Effluent: Known _____ Estimated 30 lb/yr

Contaminants (see list)	Estimated Discharge
Freon	30 lb/yr

Monitoring Equipment on Effluent Stream: No X Yes _____

Describe _____

Remarks This is the amount of Freon that must be added to the refrigeration unit to replace that which leaks and evaporates.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building 202 Room 114

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer ____

Sanitary Sewer ____ Storm Sewer ____

Trash Container Type: Wiping rags

Other: ____

Disposal Method: Atmospheric Dispersal X Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground ____

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other ____

Volume of Effluent: Known 1 gal/mo Estimated ____

Contaminants (see list)	Estimated Discharge
Chlorothene	1 gal/mo
Petroleum Distillate	0.2 gal/mo
Muriatic Acid	0.1 gal/yr

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks These materials are used to wipe and clean surfaces.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Do not [illegible]

Group GMX-3 Tech Area TA-16 Building 222

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer X

Sanitary Sewer ____ Storm Sewer ____

Trash Container Type: ____

Other: ____

Disposal Method: Atmospheric Dispersal ____ Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground X

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other ____

Volume of Effluent: Known ____ Estimated 40 gal/wk

Contaminants (see list)	Estimated Discharge Diluted (Undiluted)
Acetic acid	5 gal/wk (approx 500 lb/yr)
Hydroquinone	7 lb/wk (approx 90 lb/yr)
Sodium Sulfite and Sodium Metaborate	40 lb/wk (approx 500 lb/yr)
* Potassium Bromide	1-1/2 lb/wk (approx 20 lb/yr)

* See below

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks Effluent is fixer (20 gal/wk) and developer (20 gal/wk) film processing solutions. The discharge, about once every three months, is accompanied by voluminous quantities of water.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building 222

Accounting Number(s) _____

Nature of Effluent Streams: Gas X Liquid ___ Solid ___ Other ___

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack _____ Industrial Sewer _____

Sanitary Sewer _____ Storm Sewer _____

Trash Container Type: _____

Other: Coolant leakage

Disposal Method: Atmospheric Dispersal X Sewage Plant _____

Waste Process Plant _____ Chemical Dump _____

Sewage Lagoon _____ Surface of Ground _____

Contaminated Burial Area _____ Septic Tank _____

Community Landfill _____ Other _____

Volume of Effluent: Known _____ Estimated 150 lb/yr

Contaminants (see list) Estimated Discharge

Sulfur Hexafluoride _____

Monitoring Equipment on Effluent Stream: No X Yes _____

Describe _____

Remarks This material is used as a coolant in radiograph equipment. It is replaced as it leaks.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Do not write in this space

Group GMX-3 Tech Area 16 Building 106

Accounting Number(s)

Nature of Effluent Streams: Gas ____ Liquid (1) ____ Solid ____ Other Solvent Vapor

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: (1) Sump, (2) None.

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer ____

Sanitary Sewer ____ Storm Sewer X (1)

Trash Container Type:

Other: Hoods (2)

Disposal Method: Atmospheric Dispersal X (2) Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground X (1)

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other Sump (1)

Volume of Effluent: Known ____ Estimated 1000 gal/day

Contaminants (see list)	Estimated Discharge /6 mo (gallons)
Acetone	220
Chlorothene	55

* See below

Monitoring Equipment on Effluent Stream: No ____ Yes ____

Describe

Remarks Most of the indicated discharge is water.

* Methylene chloride

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building 340

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: Sump

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer X

Sanitary Sewer ____ Storm Sewer ____

Trash Container Type: ____

Other: ____

Disposal Method: Atmospheric Dispersal ____ Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground X

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other ____

Volume of Effluent: Known ____ Estimated X

Contaminants (see list)	Estimated Discharge/6 mo (gallons) **
H Cl	4
Acetone	700
n-Butyl acetate	120

* See below

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks These solvents will, in a short time, evaporate into the atmosphere, although, perhaps 90% of them leave as liquids.

* Ammonium sulfate	500
Methyl ethyl ketone	750

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building 370

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer ____

Sanitary Sewer ____ Storm Sewer ____

Trash Container Type: ____

Other: Metal chips to salvage

Disposal Method: Atmospheric Dispersal ____ Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground ____

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other Burn

Volume of Effluent: Known 1 gal/mo Estimated ____

Contaminants (see list)	Estimated Discharge
Kerosene	1 gal/mo

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks ____

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building 370

Accounting Number(s) _____

Nature of Effluent Streams: Gas ____ Liquid X Solid ____ Other ____

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack ____ Industrial Sewer ____

Sanitary Sewer ____ Storm Sewer X

Trash Container Type: ____

Other: ____

Disposal Method: Atmospheric Dispersal ____ Sewage Plant ____

Waste Process Plant ____ Chemical Dump ____

Sewage Lagoon ____ Surface of Ground X

Contaminated Burial Area ____ Septic Tank ____

Community Landfill ____ Other ____

Volume of Effluent: Known ____ Estimated 15 gal/mo

Contaminants (see list)	Estimated Discharge
Trichloroethylene	15 gal/mo

Monitoring Equipment on Effluent Stream: No X Yes ____

Describe ____

Remarks ____

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building [illegible]

Accounting Number(s) _____

Nature of Effluent Streams: Gas X Liquid ___ Solid ___ Other ___

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: None

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack X Industrial Sewer ___

Sanitary Sewer ___ Storm Sewer ___

Trash Container Type: ___

Other: ___

Disposal Method: Atmospheric Dispersal X Sewage Plant ___

Waste Process Plant ___ Chemical Dump ___

Sewage Lagoon ___ Surface of Ground ___

Contaminated Burial Area ___ Septic Tank ___

Community Landfill ___ Other ___

Volume of Effluent: Known ___ Estimated 3840 ft^3/yr

Contaminants (see list)	Estimated Discharge
Acetylene	3840 ft^3/yr

Monitoring Equipment on Effluent Stream: No X Yes ___

Describe ___

Remarks The acetylene is burned.

LOS ALAMOS SCIENTIFIC LABORATORY

Survey of Effluent Streams

Group GMX-3 Tech Area 16 Building Burning Ground Area (1) Do not ... in this ...

Accounting Number(s)

Nature of Effluent Streams: Gas X Liquid X Solid X Other Solvent vapor

(Fill out one sheet for each effluent stream)

Effluent Treatment: Type: Combustible material is burned.

Discharge Point: (Identify and show sketch on reverse if more than one per building)

Stack _____ Industrial Sewer _____

Sanitary Sewer _____ Storm Sewer _____

Trash Container Type: _____

Other: Burning pits and filter vessels (1)

Disposal Method: Atmospheric Dispersal X Sewage Plant _____

Waste Process Plant _____ Chemical Dump _____

Sewage Lagoon _____ Surface of Ground _____

Contaminated Burial Area _____ Septic Tank _____

Community Landfill _____ Other Restricted Landfill

Volume of Effluent: Known _____ Estimated _____

Contaminants (see list)	Estimated Discharge (lbs/6 mo)
Explosives	49,500 (2)
Barium nitrate	3,000
~~HF contaminated oil and solvents~~	~~3,000 (2)~~
Uranium alloys	54 (3)
Kerosene	165 (3)

Monitoring Equipment on Effluent Stream: No X Yes X (3)

Describe (1) TA-16-412, 387, 388, 389, 392, 399, 401, 406

(2) A detailed listing of material burns, quantities burned, and smoke densities is attached.

(3) Uranium alloy burns monitored and documented. Residues are monitored, collected, and buried at Mesita del Buey.

Remarks

(4) This material is burned and the products of combustion are evolved.

APPENDIX B

Materials of Concern Supplied to S-Site Buildings

LISTING OF MISCELLANEOUS MATERIALS VERSUS BUILDINGS
GROUP GMX-3
(November 1970 through April 1971)

	Quantity (lbs)				
Building TA-16-	193	222	340	450	460
Material					
Ammonium Phosphate	75				
Ammonium Sulfate			500		
Diethylene Triamine				1.1	1.1
Hydroquinone		45.5			
Chlorine Bleach	3				
Phosphate Dibasic	96				
Detergents	1500				

LISTING OF METALS AND METAL SALTS VERSUS BUILDINGS
GROUP GMX-3
(November 1970 through April 1971)

	Quantity (lbs)				
Building TA-16-	193	202	222	370	460
Material					
Nickel (Foil)	1.4				
E-Z-Flo Brazing Alloy		0.5		0.25	
Cupric Oxalate					1
Cupric Oxide					3
Sodium Bichromate					2
Sodium Sulfite - Sodium Metaborate			260		
Magnesium Perchlorate			10		0.25
Potassium Bromide					1
Potassium Hydroxide					6

LISTING OF GASES AND ACIDS VERSUS BUILDINGS
GROUP GMX-3
(November 1970 through April 1971)

	Quantity (lbs)					
Building TA-16-	202	222	340	370	450	460
Material						
Acetylene	17			130		16
Carbon Dioxide					100	
Freon 13	15					
Acetic Acid (Glacial)		270				10
Hydrochloric (Muriatic) Acid	0.4	36	33			24
Hydrobromic Acid						0.07

July 28, 197

LISTING OF SOLVENTS VERSUS BUILDINGS
GROUP GMX-3
(November 1970 through April 1971)

	Quantity (gal)						
Building TA-16-	7	202	260	306	340	460	Unidentified
Material							
Met-l-it	1	2					
Freon-PCA Solvent	55			2			
Dimethyl Sulfoxide			94				
Acetone				220	700	139	
Chlorothene		6		55			165
Methylene Chloride				55	72		
n-Butyl Acetate					330		
Chloroform					3	12	
1, 2-Dichloroethane					54.6	0.66	
Dimethylformamide					110	3.3	
Isopropyl Alcohol					72		
n-Octane							1.3
1, 1, 2, 2, Tetrachloroethane							0.99

LISTING OF SOLVENTS VERSUS BUILDINGS
GROUP GMX-3
(November 1970 through April 1971)

Building TA-16-	Quantity (gal)						
	7	340	370	389	410	460	Unidentified
Material							
Ethyl Acetate		10.9					
Methanol		110					
Methyl Ethyl Ketone		750					
Toluene		110					
Trichloroethylene			90				55
Kerosene				165			
Ethylene Glycol					10		
Carbon Tetrachloride						4	
Chlorobenzene						0.2	
n-Hexane						0.5	55
Methylcyclohexane						1.1	
Ethanol							55
Petroleum Distillate	1.2						

MATERIALS DISPOSED OF BY BURNING AT GROUP GMX-3 DISPOSAL AREAS (November 1970 through April 1971)

Materials	Quantity (lbs) Burning Ground	Quantity (lbs) Incinerator
Explosives	49,500	
Barium Nitrate	3,000	
Oil and Solvents (HE contaminated)	3,000	
Uranium Alloys	54	
Trash	7,500	143,000

GROUP GMX-3 WAST[illegible] D[illegible] SAL
(October 15, 1970 through April 15, 1971)

	Burning Frequency (burns/yr)	Burning Frequency Average (burns/wk)	Weight of Material Burned (lbs/yr)	Weight of Material Burned Average (lbs/wk)	Burning Time (min/burn)	Burning Time (min/wk)	Smoke Density, Ringlemann Scale	Period Smoke Density Exceeds Ringlemann No. 1 (min/wk)
	130	2.5	45,000	900	10	25	1	0
p waste	88	1.7	54,000	1,000	10	17	1	0
ncy of burns		3.2						
of burns			99,000	1,900				
inated	30	0.6	15,000	290	45	27	2 to 3	27
inated oil olvents	8	0.15	6,000	115	60	9	3 to 4	9
inated mstible e				405				
rator burns	52	1.0	286,000	5,500	120	120	2 to 3	120
waste burns				7,805		198		156

16-000033

'Many' Count

DISPOSAL OF WASTE or EXCESS HE

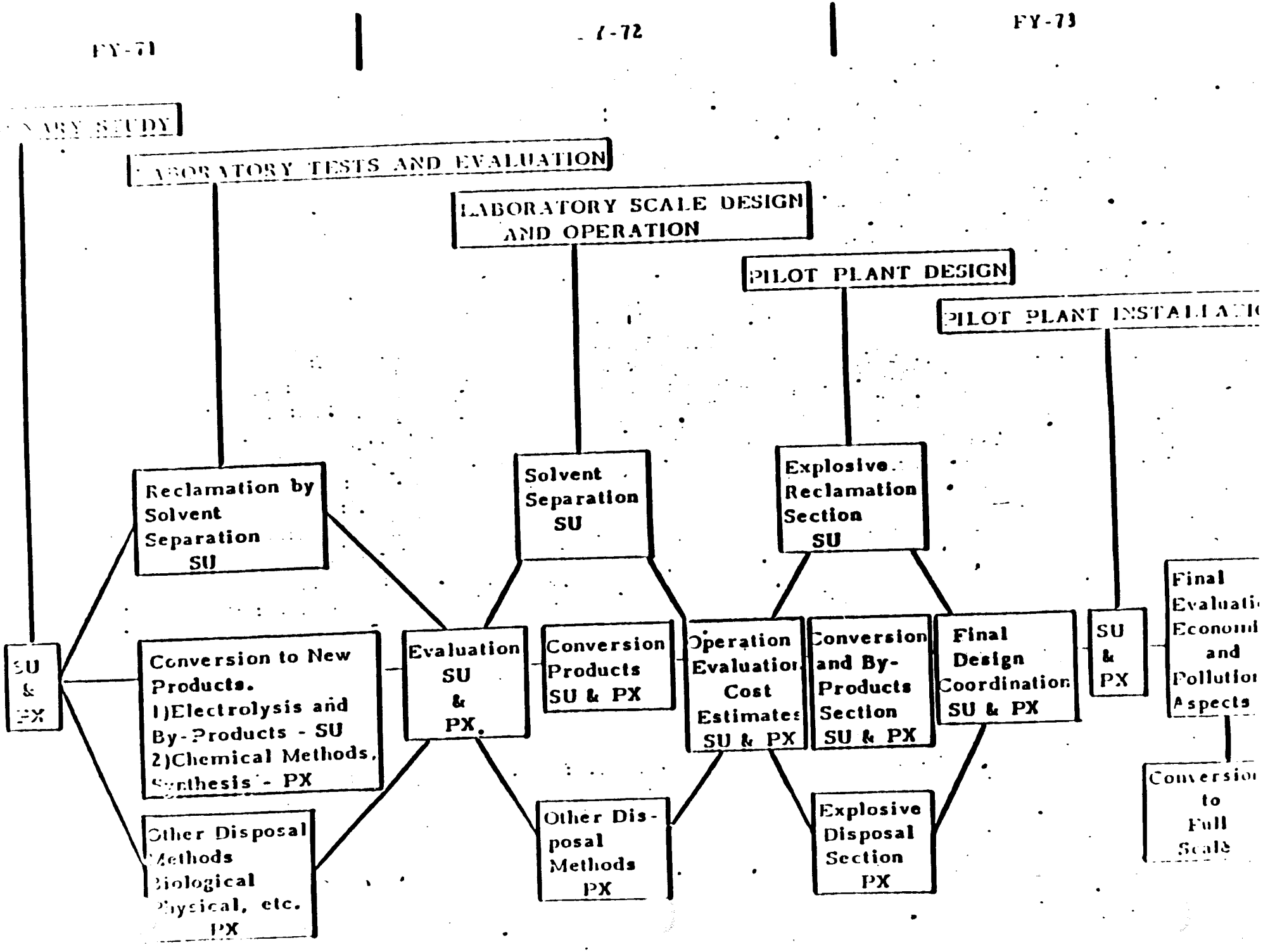
A SUMMARY OF STUDY EFFORT

by

Mason & Hanger–Silas Mason Co., Inc.

for the

U.S. Atomic Energy Commission


FY-71
FY-72
FY-73
LABORATORY TESTS AND EVALUATION
LABORATORY SCALE DESIGN AND OPERATION
PILOT PLANT DESIGN
Reclamation by Solvent Separation SU
Solvent Separation SU
Explosive Reclamation Section SU
SU & PX
Conversion to New Products. 1)Electrolysis and By-Products - SU 2)Chemical Methods, Synthesis - PX
Evaluation SU & PX.
Conversion Products SU & PX
Operation Evaluation Cost Estimates SU & PX
Conversion and By-Products Section SU & PX
Final Design Coordination SU & PX
SU & PX
Final Evaluati Economi and Pollutio Aspects
Other Disposal Methods Biological Physical, etc. PX
Other Disposal Methods PX
Explosive Disposal Section PX
Conversio to Full Scale

1. AIR & WATER POLLUTION REQUIREMENTS

1.1 AEC Requirements

1.2 Other Federal Agencies

1.3 State & Local

1.4 Projected

- State-Of-The-Art For Pollution Control
- Recent New Laws And Trends

2. SOURCES, TYPES & AMOUNTS OF WASTE MATERIALS

2.1 Pantex & Burlington

2.2 Sandia, LRL, Los Alamos

2.3 Other AEC Facilities

2.4 Other HE Plants

2.5 Projected

- New Explosives
- Changing Amounts

3. METHODS OF DISPOSAL

3.1 General

- 3.1.1 Incinerators
  - Open
  - Closed
- 3.1.2 Detonation
- 3.1.3 Decomposition
  - Reclamation
  - New Byproducts
  - Safe Waste Products
- 3.1.4 Dumping
  - Disposal At Sea
  - Deep Well Burial
- 3.1.5 New Methods
  - Electrolysis
  - Biological
  - Combined Systems
  - Photochemistry
  - Other (Atomic Energy)
- 3.1.6 Recycle
  - Inplant Reuse
  - For Sale

3.2 Specific Methods For Specific Materials

3.3 Curtailment Of Waste Products

- New Synthesis Processes
- Improved Manufacturing Techniques

4. EVALUATION OF METHODS

4.1 Performance - Air & Water Pollution

4.2 Requirements
- Heat
- Flow Rates
- Power
- Chemicals

4.3 Economic Considerations
- Original Equipment Costs
- Operating Costs
  - Normal
  - Maintenance
  - Replacement
- Potential Income
  - Shared Facilities
  - Byproducts

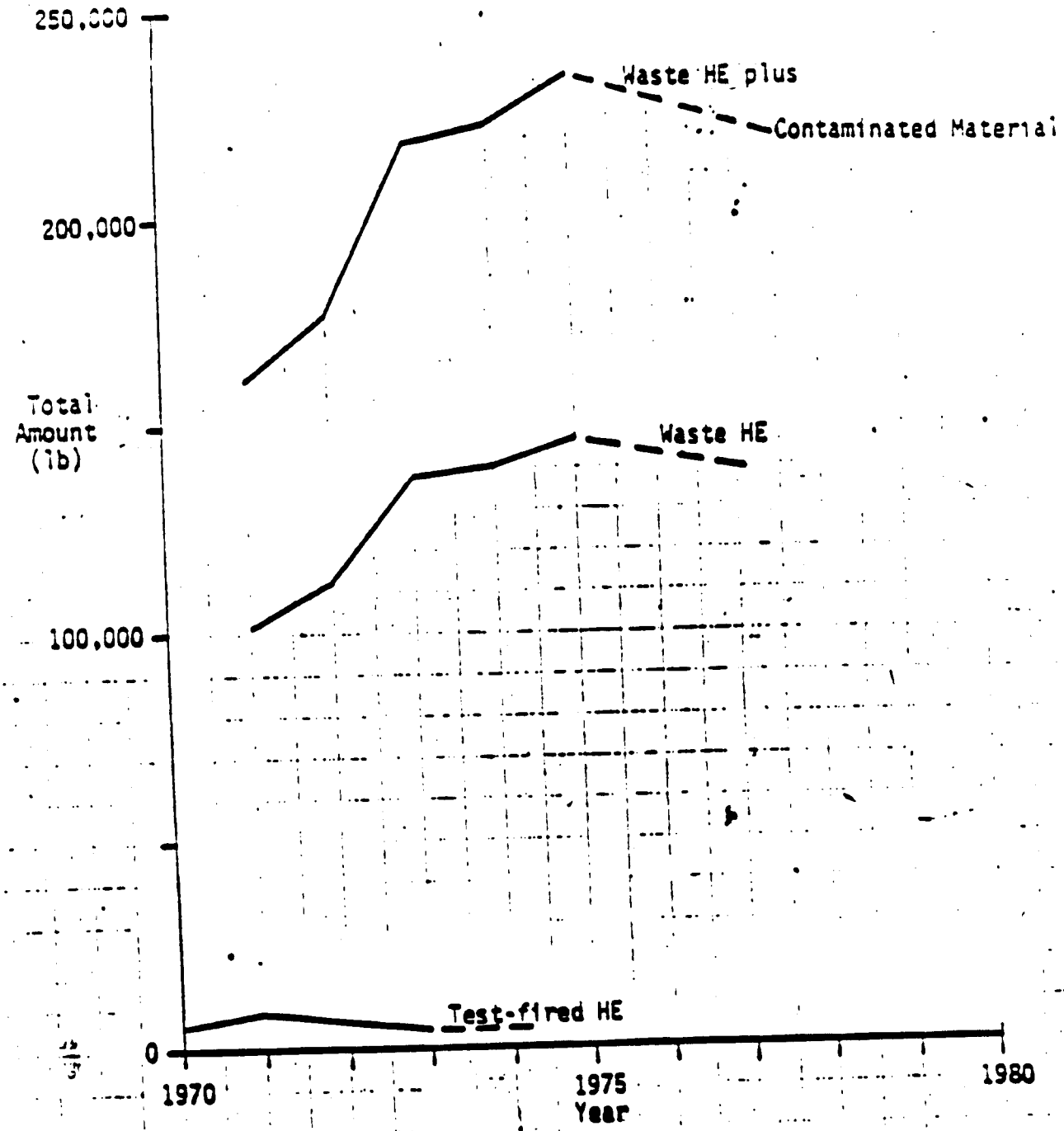
4.4 Estimate Of Development & Installation Times

4.5 Potential For Expansion & Improvement

4.6 Laboratory-Scale Tests For Uncertainties

Table I. Pantex Burned Excess HE Amounts-FY 70

Type of HE	Manufacturing	Development	Total
	Pounds		
PBX (Type) (~ 90% HMX)		18,000	18,000
PBX 9010	250		250
PBX 9011			
PBX 9404	11,380		11,380
LX-04	24,369		24,369
LX-09	12,005		12,005
XTX	7		7
Comp. B + Cyclotol	12,200		12,200
Mock HE	3,500		3,500
Miscellaneous ~90% HMX (Classified obsolete parts, etc.)	20,000		
TOTAL	83,611	18,000	~ 102,000 (2000 lb/wk)
HE-Contam. Material (~ 60%)	48,000	12,000	60,000 (~ 1200 lb/wk)
Total Material Burned	132,000	30,000	162,000 (3200 lb/wk)
Test-Fired Total	5441.9	1785	7226.9 (~ 145 lb/wk)



Pantex Trends for Waste HE

BURLINGTON AEC PLANT
BURLINGTON, IOWA

Average H. E. Destruction/Week		Contaminated Combustibles
Burning	Detonation (Open)	Open Burning/Week
6500 lbs.	25 lbs.	2000 - 3000 lbs.

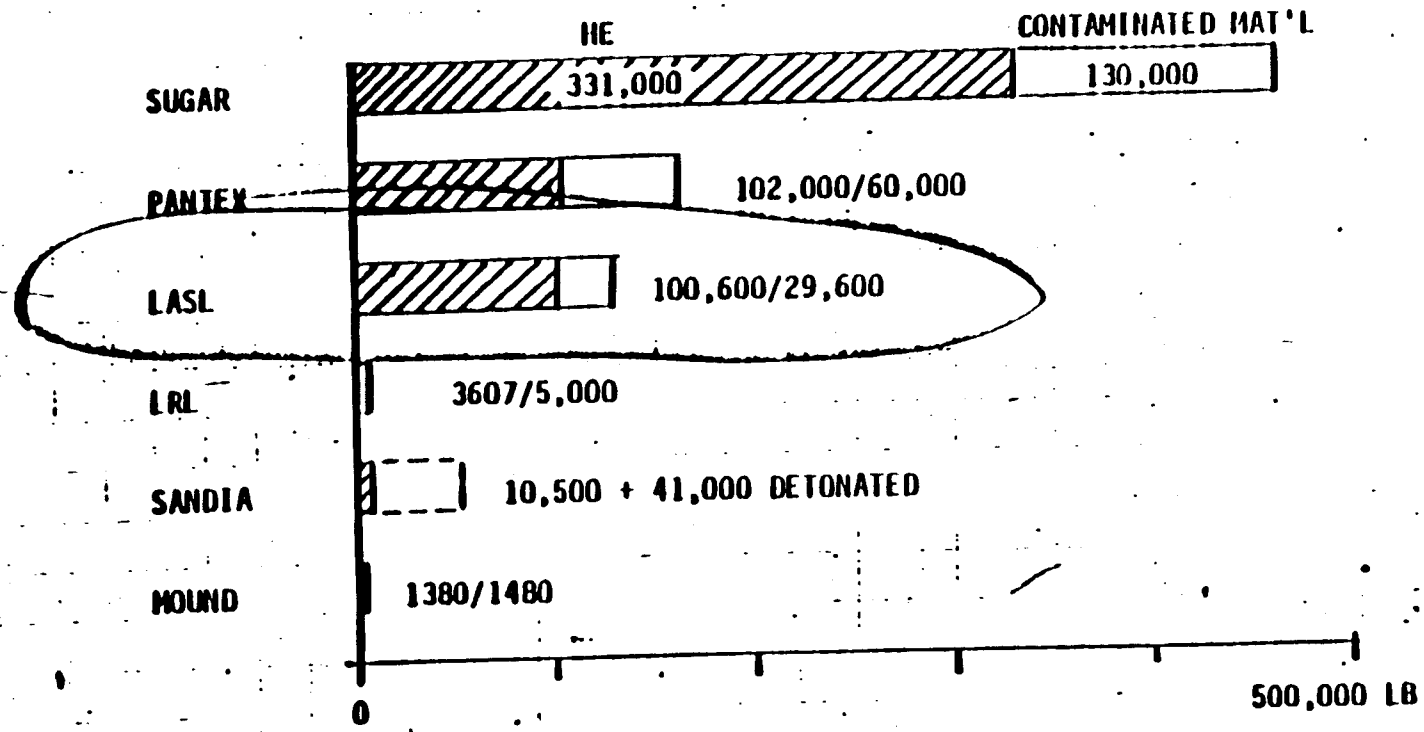
Estimated H. E. Burned in 1970

Type	Amount (lbs.)
LX-09	11,100
LX-07	1,750
9404	3,000; 5,200[t]
Comp. B-3	82,500[t]
XTX	90
Baratol	22,000
HMX	1
9007	21
9407	3
Tetryl	25
LX-04	3; 9,200[t]
PBX N-5	2
9010	50; 580[t]
TNT-NC	50
PETN	55
Cyclotol	198,000

Remarks: Contaminated trash is burned in a wire enclosure to trap large particulate matter. Much of the scrap explosive is in the form of large chunks with a minimum of contamination. Tear down material is denoted with a t. All other material is production scrap.

TABLE I - Waste Explosive and Contaminated Waste Disposal at Burlington AEC Plant

PRELIMINARY SUMMARY, HE BURN AMOUNTS
(LB/YEAR)



HE	MATERIAL	TOTAL
590,000	~ 230,000	820,000

1975 TREND: ~ 1,000,000 LB or 500 TONS

PRELIMINARY SUMMARY, DETONATED TEST AMOUNTS

(LB/YEAR)

Sugar	1300
Pantex	7223
LASL	*
LRL	2565
Sandia	* (Sometimes 10,000 lb. in a test)
Mound	56.4
Total	11,150 lb.

*To be obtained in next quarter

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

16-000075

MEMORANDUM

TO: S.V. Jackson, S-4, MS F611

DATE: April 25, 1983

THRU: L. C. Borduin, H-7, MS E518

MAIL STOP/TELEPHONE: E516/7-5397

FROM: John L. Warren, H-7

SYMBOL: H-7C 83-28

SUBJECT: DOE HAZARDOUS MIXED WASTE TECHNOLOGY PROGRAM

In response to a request from S-4, the following information was gathered as part of the DOE Hazardous Waste Technology Program. The hazardous chemical wastes and mixed wastes that are either stored, treated, or disposed of at Los Alamos National Laboratory are characterized in this document and on the attached tables.

To avoid duplication, a description of the facilities and sites employed in waste handling activities is provided in this text rather than on the tables provided by S-4. The description of the waste follows, with many of the chemicals listed generically rather than specifically (e.g., acid waste rather than nitric acid).

Eight facilities were used during FY82 for waste management activities. Of these, one is for storage, four are used for treatment, and three are disposal sites.

The storage facility is used for the accumulation of PCB contaminated items and oil that will be disposed of at an approved PCB incineration facility. Building 61 at TA-21 is dedicated for this purpose and meets the requirements of Annex III of the February 17, 1980 Federal Register (PCB Disposal and Marking) for PCB storage facilities. A temporary, curbed, asphalt holding pad behind Building 61 serves as a storage area for oil awaiting analytical results for PCB contamination level.

Cyanide, chromate, and acid/base wastes are treated in a small batch plant at TA-50. The system consists of a vented 150 gallon treatment tank with gas and caustic supply lines. The current plant is being replaced to allow treatment of larger volume and more complex waste streams. Anticipated start-up date for this new plant is early 1984.

Two plants are used for the treatment of radioactive liquid waste. The TA-50-1 facility provides a bar screen, grit chamber, raw waste storage tanks, flash mixers, chemical feeders, flocculator-clarifiers, gravity filters, distributor for CO_2, ion-exchange columns, spent regenerant storage/treatment tank, sludge storage tanks, vacuum filter, and treated waste storage tanks. Chemicals used for separation and concentration of alpha-emitting radionuclides include ferric sulphate, lime, trisodium phosphate, and coagulant aids. The sludge produced by chemical treatment is dewatered by vacuum filtration to 30-40% solids, placed in lined 215-L (57-gal) steel drums if the transuranium radionuclide activity is >100 nCi/g, and forwarded to TA-54 (Area G) for retrievable, 20 year storage. The sludge in the drums looks like wet clay, but no free water is apparent. To further assure the absence of free water, about 10 pounds of Portland cement powder is placed in the bottom of the drum liner before the sludge is added, and another 10 pounds of cement is placed on top of the sludge after the drum is filled.

The second facility, TA-21-257, provides a bar screen, grit chamber, raw waste storage, flash mixer, chemical feeders, flocculator, sedimentation tank, filter sump, recarbonators, pressure filter, and treated waste storage tanks for treatment of low-level radioactive wastes. Other concrete and stainless steel storage tanks are provided for a variety of higher level batch wastes. Most of these are treated by neutralization, if necessary, in special stainless steel watercooled tanks. Neutralized and alkaline wastes are transferred to a mixer-equipped feed tank, then fed to a pug mill where cement from a silo is added. Nonretrievable cement paste is discharged to large shafts in Area T, a disposal site west of the building. The system was modified in late FY 1975 to provide for storage of the paste requiring retrievability in 6.1-m (20-ft)-long by 0.76-m (2.5-ft)-diameter galvanized, welded, corrugated-metal pipe (CMP) sections. Sludge from the chemical treatment plant providing feed to the pug mill system does not require retrievability; it is discharged to asphalt-lined shafts in the tuff in Area T. Appropriate samples are taken at all phases of the operations.

Waste high explosives are collected, packaged, stored, and periodically burned at the S-Site burning ground. Accumulations of waste in sumps are collected in a special truck, taken to filter beds at the S-Site burning ground, dried, and burned. Combustible oils and solvents, paper, and wood contaminated with high explosives are collected and burned in an incinerator at S-Site or in a burn pit at TA-40.

As mentioned, three sites receive hazardous chemical waste for disposal. Area T, as described above, is used only for disposal of cement paste waste. The second site is TA-54, Area G. This area is situated on Mesita del Buey in TA-54 and is the main active radioactive solid waste burial/storage site at the Laboratory. The area has been used since 1957 and is expected to remain active through the foreseeable future. In FY 1977, the active portion of the site was expanded to a current total area of 2.55×10^5 m^2 (63 acres); future expansion of this area is planned. Burial/storage facilities within the area include pits, shafts, trenches, and pads of varying dimensions. A more detailed description of the use of these facilities and of current waste management operations is contained in the LASL Final Environmental Impact Statement.

Certain "nonreactive" hazardous chemical wastes have been buried in pits and shafts along with radioactive wastes at Area G. Such wastes include asbestos, beryllium residues, empty pesticide containers, PCB-contaminated solids [transformers, capacitors, solids (before 1978)], and solid trash-type wastes contaminated with known or suspected carcinogens. Between 1976 and 1979 much of this waste was buried in a separate pit (Pit 19) at the site, although there were exceptions due to very large volumes (e.g., PCB-contaminated transformers). In 1980, approval was granted by the EPA for disposal of PCB-solid waste in special facilities at Area G.

All mixed waste is either stored or buried at this site. For safety reasons, the majority of buried waste is placed in shafts for greater isolation from intrusion. For example, coyotes would create an intrusion concern when digging up and eating biological wastes if it were buried in the pit rather than in the shaft.

Area L, 3.6×10^3 m^2 (0.88 acre), is located on Mesita del Buey in TA-54, and since 1964, has been the main active chemical waste disposal site at Los Alamos. From 1964 through May 1975, all chemical wastes were disposed of in one pit at the site. Beginning in June 1975, with the transfer of responsibility for disposal operations to the Waste Management Group, this pit was covered and shafts were used for waste chemical disposal.

Chemical disposal shafts measure 0.6 m (2 ft) to 2.4 m (8 ft) in diameter by up to 20 m (65 ft) deep. Different shafts are used for different categories of waste chemical (e.g., organics, inorganics, oils, etc.) to assure that incompatible chemicals will not mix and react. In addition, one small pit at the site is used for disposal of bulk quantities of treated aqueous waste. The water quickly evaporates from these wastes leaving a "salt cake" in the pit bottom. When this salt cake is within [illegible] of the top of the pit, backfill is applied. One

S.W. Jackson --- April 25, 1991
H-70 91-28

At the present time, the chemical waste records system at Los Alamos is a hand written, hand sorted system. A computer data base is currently being written to replace this system. As a result, most current data is recorded in generic terms rather than specific terms (e.g., organic rather than trichloroethane). Therefore, most of the chemicals reported on the attached forms will be described in generic terminology. An exception to this will be made when a significant volume of a specific waste was disposed of. All reported generation rates are for FY91 operations.

A copy of the 1982 Waste Management Site Plan is enclosed for additional reference. If there are any questions about the information provided in this text, the forms or the Site Plan, please contact Karen Balo, H-7, at 7-5397.

KAB/mec

Cy: J. Aragon, H-DO, MS P228
K. Balo, H-7, MS E516

16-000371

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

memorandum

TO: BRAD MARTIN, CLS-DO, MS E525

DATE: August 13, 1992

FROM: MIKE BARR

MAIL STOP/TELEPHONE: C930/7-6866

SYMBOL: WX-3-92-674

SUBJECT: **TA-16 BURNING GROUND HISTORY**

- In the past, from 1986 to 1988, the wastewater from the pressure filter tanks drained into a hypalon pond. Before then, it was allowed to drain into the field south of the filter tanks and eventually into a tributary of the Del Valle Canyon. Presently, the drainage is processed through a carbon filter/treatment unit, 16-363, before discharge to the canyon. The two are joined to a common line in a manhole; the common line then goes from the manhole to the filter treatment unit, TA-16-363. It is estimated that 50,000 gal/yr is now being processed through this unit. Structure 16-363, previously 16-228, was constructed in 1988.

- The basket wash facility was in operation from 1951-1966. There were modifications made to the building distribution scheme when trough TA-16-1129 was constructed and when trough 16-1136 was dismantled. The building is now used for equipment storage.

- Burning tray, TA-16-394, is used for burning oil and solvents contaminated with HE. The contaminated oils come from machines at TA-16-260 and TA-16-430 primarily, and contaminated solvents from buildings TA-16-340 and -460. Pad 16-394 was originally used as an HE slurry collection and burn pad but was converted to an oil/solvent pad about the time that filter vessels TA-16-401 and -406 were constructed.

- Burning slab's 16-388 and -399 were built in 1951 to burn solid HE. Burn tables were incorporated in 1988 for the purpose of eliminating ground contamination. In contrast, HE-*contaminated* equipment is burned at TA-16-387, the main flash pad.

UNCLASSIFIED INFORMATION

GROUP EM/ER

ER Program
1900 Diamond Drive, MS M992
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FAX Number: 505-665-4747

FROM: DAVID HICKENS

Phone No.: 5-4230
Verification phone number

TO: Barbara Hadley FAX No. 827-3889 827-4361

Phone No. 827-4308

TO: FAX No.

Phone No.

TO: FAX No.

Phone No.

TO: FAX No.

Phone No.

Message: Additional ITA supporting comment
GENEN (11) on the MDA P closure
plan NOD.
18 attachments and the 0118-2.

TOTAL PAGES (excluding cover): _____

TODAY'S DATE: [illegible]

[illegible] NMED indicated [illegible]

- The HE-water slurry that is emptied into filter vessels 16-401 & -406 is dried using forced heated air for 24-48 hours; the dry explosive is then burned. The two vessels are used alternately with slurry being dumped into one while the other is drying or being cleaned.

- Former burn pad, TA-16-392, received suspected uranium-contaminated washwater from the basket wash facility, TA-16-390. From about 1966 to 1980, the pad was occasionally used for burning HE-contaminated material that was also suspected of being contaminated with uranium. This pad has not been used since the early 1980s.

Cy: L.A. Stretz, WX-3, MS C930
M. J. Buksa, CLS-DO, E525
WX-3 Group File, MS C930

F. Reference memorandum, inspection, item 1.d

We are asking that this be done in fiscal year 1961, with GPP money.

G. Reference memorandum, inspection, item 1.e

The chute has been designed (reference SK-4413, sheet D-1) and an order has been placed for its fabrication.

H. Reference memorandum, inspection, item 1.f

I have told the Burning Ground Supervisor that he is responsible for all materials that are left at the burning ground. If this happens again, he is to notify me and the necessary corrective action will be taken immediately.

I. Reference memorandum, inspection, item 1.h

The kerosene has been moved.

J. Reference memorandum, inspection, item 1.i

If material arrives at the burning ground that is "unburnable and uncontaminated", and so marked, it is to be dumped into the canyon without being flashed. This is noted in GMX-3 SOP 12.3.7.

Twice, I have personally okayed dumping material into the canyon without it being flashed. Some steam condensate pipe, that was taken out of the equipment room at Building TA-16-260, was dumped without being flashed. Since we knew the history of the pipe, I did not believe it was necessary to flash it. Some aluminum wire baskets (AT baskets) were also dumped without being flashed. These baskets were used for transporting HE. The HE contamination on the baskets was very slight. I do not believe this created any safety hazard at the burning ground.

This subject is being handled at the present in the following manner. The Burning Ground Supervisor has been instructed not to dump unmarked, unburnable material into the canyon without flashing, unless he first clears it with me. If he believes unburnable material is uncontaminated, he is to ask me for permission to dump it without flashing. I shall investigate the history of the material, and if I am sure that dumping the material without flashing does not create a safety hazard, I shall give my approval. If there are objections to this system, please let me know so that I can change it to eliminate the objections.

August 29, 1960

M. L. Brooks

M. Reference memorandum, inspection, item 2

The sumps are now being inspected once every two weeks, and a reco of their condition is kept on Form GMX-3-829.

We now believe that the filter bags were not filtering properly be they were not washed before being placed into service. We washed some filter bags in the laundry (this was to take out the sizing in the clot and placed them into service. A three week's check on these bags showe they were filtering satisfactorily. All new bags are now being washed they arrive at GMX-3.

H. E. Ballance

HEB/kw

cc: C. R. West
W. C. Courtright (2)
E. Wilder
D. D. McCormick
T. B. Harris
P. F. Clark
GMX-3 Reading File
File

16-000394

RUSSO
STER
1-3 WILLIAMS
2 HIDY
BYERS
BARTHELL
MINNICK
ROYBAL G.
MONTOYA
FILE

TO : Group ENG-3

FROM : Group Eng-3

SUBJECT: REQUEST FOR SURVEY SERVICE

DATE: 9/1/65

File

LJ.1757

9-20-65

T. A. NO: 16 & 37 JOB TITLE: Material Disposal Area

LAB JOB NO: 1757 JOB ORDER NO: _____ DATE WORK REQUIRED: ASAP

DESCRIPTION OF WORK REQUIRED: Locate areas indicated by Ed Wilder known to be disposal areas and also attempt to locate burial area known to contain masses of metal.

TA-16: 1. Sketch on TA-16 map approx. location of old burning ground. (Near Bldg. 16-260)
2. Locate former designated burning area. (In vicinity of new burning area)
3. Try to locate burial area containing masses of metal.

TA-37: 4. Locate small burial area enclosed by fence.

SPECIAL SAFETY REQUIREMENTS AND/OR OPERATING PROCEDURES: Standard site regulations for TA-16 & TA-37.

FOR FURTHER INFORMATION CONTACT: B. P. Willis and/or Ed Wilder

APPROVED: REQUESTING GROUP SER/BPW DATE: 9/1/65 APPROVED: ENG-3 SE Russo/BPW

TO BE FILLED OUT BY ENG-3

SCHEDULED FOR: _____ STARTED: 9/2/65 COMPLETED: 9/3/65 MANHOURS: 2

TYPE OF SURVEY: (1) PRELIMINARY; (2) CONSTRUCTION; (3) MAPPING; (4) RECORDS; (5) OTHER

BOOK NO: E-639 PAGE: 10-11 NOTES REDUCED: _____ BY: _____

TRAVERSE SHEET NO: _____ DATE COMPUTED: _____ BY: _____

PLOTTED: 9/10/65 SCALE: 1"=50 BY: Donahue INFO. INCORP. ON: Items Engineer 62-02, Item 4 of 37-61, Items 1 & 2 on R-102, Shown on bottom TA-41-1

TO GROUP OFFICE FOR DISTRIBUTION: 9/10/65 INFO. TO REQUESTOR: 9/10/65 BY: [illegible]

JOB HISTORY:

Completed Survey 9/3/65

TA-16: Item 1. Marked on attached TA-16 Site Loc. Pl. (See Field Book E-639, page 10)
Item 2. Located within present dump ground situated north of present burning ground area.
Item 3. Metal was located. Material is being dug out and will be disposed of in present dump north of burning ground area.

TA-11: Item 4. See Field Book E-438 (TA-0) page 11.

Dim Eng R-102 Revised to show locations of Items 1 & 4 on 9/10/65 as shown "R" & "S"

Brass Cap Monuments No. 650 & 651 were set 9/12/65 to tie the area into the project coordinate system.

1 Eng-3-1
Rev. Issued 3-1-62

16-000398

ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO 87544
TELEPHONE:

OFFICE MEMORANDUM

TO: L.J. 1757 File (To Be Attached to Survey Request Dated 9/1/65)

DATE: September 30, 1965

FROM: B. P. Williams

SUBJECT: REMOVAL OF BURIED MATERIAL TO DUMP AREA "P", TA-16

SYMBOL: ENG-3

9/30
attach to proper
Survey request &
file in LJ 1757

During the spring of 1965, Ed Wilder, GMX-3, called the ENG-3 Group Office and reported that some type of metal material was thought to be buried in the old exclusion area of TA-16, which should be dug out and disposed of, provided the material could be located with some type of detector within the general area in which it was supposed to be buried. His call was in response to a request made by ENG-3 regarding information from anyone knowing of any materials disposal areas within the project which should be made a matter of record through L.J. 1757.

A survey request, dated 9/1/65, was initiated to locate several areas in S-Site vicinity, including the subject item. The survey party did the field work on 9/3/65 and located some type of metal mass, within the area they were to search, with a dip needle, marked the location with a flagged lath and notified Ed Wilder.

In a telephone conversation with Wilder the following week, it was learned that the object was dug out and was to be disposed of in the dump Area "P", situated north of the S-Site burning grounds.

Project grid coordinates of the point where the object was located are approximately S.43 + 00 and W.51 + 00.

16-000399

Work Order

For security, service, coordination & changes on this order the Eng-4 engineer must be contacted.

2 cc: Raymond & 1 cc: W. G. [illegible]

Date [illegible] | I.O. NO

LOCATION & STRUCTURE [illegible] | LAR JOB NO. | WORK ORDER NO

ENGINEER & PHONE NO [illegible] | ESTIMATE $ [illegible] | ACCOUNT NO

H & S: None | ENG-4.21 | Other:

C.U. 108.1 applies. | PROJECT NO

	N.H.	P.H.
Carpenters	132	182
Floor Crew Hoisters	132	182
Painters	133	183
L. M. & R.	134	184
Ironworkers Riggers	135	185
Tinners	136	186
Fitters	137	187
Refrig. Crew	137	187
Insulators	137	187
Sprinkler Crew	137	187
Electricians	138	188
Janitorial	139	
Supply & Transp		
Electric Utility	161	191
W. G. & S.	162	190
Engineering	164	
Telephone Company		

SUBJECT: CLEAN UP DEBRIS.

Remove a portion of [illegible] demolished debris from TA-16 area as directed by [illegible] Buildings, in accordance with attach C.U. #108.1 which will [illegible] at the job site by Site Engineer.

Enter on Area C P&P [illegible] position 22.

Debris to be moved to [illegible] burning ground canyon.

5/2/66

BPW (what waste area is this?) BPW 5/2/66

Area "P"

2 SER

3RM

Job L.J. 1757

5/4/66

Eng-2
ENG-3
ENG-4
ACTION
COMMENT
INFORMATION
FILE

INFORMATION COPY

Date											
Cost Center											
Hrs. Approved											
Actual											
Authority											
Overrun Approval											
Type											

Approved: CARL

Dispatched: 5-2-6

Work Order Number: 6284-83

ENG-3 ROUTING SLIP

	RUSSO, S. E.		LONDON, R.
	SIZER, J. A.		MINNICK, R.
	WILLIAMS, R.		MONTOYA, J.
	BARTHELL, J.		PALLONE, J.
	BYERS, N. O.		ROYBAL, G.
	DONAHOE, J.		ROYBAL, T.
	FRANK, C.		WEESNER, E.
/	GLASS, D.		WILLIAMS, H.
	HARRISON, R.		
	HIDY, H. A.		

COMMENTS: Don: The Dump Area north of the Zero Ground at TA-16 has been placed on Mylar Sheets S.2-W.1 & S.3-W.1 which will become a part of the LAL ISCR Nightmare Disposal Area Dump when that work is received.

[illegible]

4/7/65

AREA "P"

[illegible] 4/16/65

LASL-AEC-OFFICIAL

16-000397

LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO 87544
TELEPHONE:

OFFICE MEMORANDUM

TO M. L. Brooks

DATE: April 13, 1966

VIA : H. E. Ballance HEB 4/13/66

1. BPW - what disposal area is this AREA "P" BPW 4/15

FROM W. C. Courtright

2. [illegible]

SUBJECT DUMPING MATERIAL IN THE BURNING GROUND CANYON

SYMBOL H-3

3. File L.J 1757

References : 1. Group GMX-3 SOP 12.3.6
2. Memorandum from Safety Office to C. A. Reynolds, dated March 18, 1966, subject "Cleanup of TA-16 Burned Buildings"

Permission is requested to allow The Zia Company to dump several truckloads of noncombustible debris in the canyon north of TA-16-387. This material is noncombustible debris left from burning old explosive buildings and magazines at TA-16 and TA-11. This material should be essentially free of any HE contamination, since fire was used to destroy the buildings. However, it is felt that it should not be deposited in an area open to the public because of the slight possibility of hidden HE contamination. I do not feel that the possible amount of HE contamination is great enough to increase the explosive hazard in this dump. The material that is determined by a Group GMX-3 Certifying Agent to be possibly HE contaminated will be deposited in the HE burial pits at Mesita del Buey. No combustible material is to be included and arrangements to enter and leave the burning ground area will be made in advance by Group ENG-4 with T. B. Harris, GMX-3.

W. C. Courtright

WCC/ps

cc: R. W. Drake
R. Owen
S. E. Russo
H. E. Ballance
C. R. West
R. L. Thrap
T. B. Harris
R. L. Converse
E. L. Hilton
E. Wilder
GMX-3 Reading File
File

Approved by: M. L. Brooks 4/14/66
Date

M. L. Brooks

VIA : H. E. Ballance Original Signed by H. E. Ballance

W. C. Courtright

January 26, 1965

Copy to Glass 2/3 [illegible]

DUMPING MATERIAL IN THE BURNING GROUND CANYON

H-3

Reference : Group GMX-3 SOP 12.3.6

Pat Area P

Permission is requested to allow The Zia Company to dump about three truckloads of noncombustible debris in the canyon north of TA-16-387. This material is noncombustible debris left from burning old explosive buildings and magazines at TA-6. This material should be essentially free of any HE contamination, since fire was used to destroy the buildings. However, it is felt that it should not be deposited in an area open to the public because of the slight possibility of hidden HE contamination. I do not feel that the possible amount of HE contamination is great enough to increase the explosive hazard in this dump. No combustible material is to be included and arrangements to enter and leave the burning ground area will be made in advance by Group ENG-4 with T. B. Harris, Group GMX-3.

W. C. Courtright

W. C. Courtright

WCC/ps

cc: R. W. Drake
R. Owen
H. E. Ballance
T. B. Harris
File

Approved by:

Original Signed By
M. L. BROOKS

M. L. Brooks

1-27-65
Date

5	BUSSO
1	SIZER
4 2	WILLIAMS
2	HIDY
	BYERS
	BARTHELS
	MONNICK
	ROYBAL G.
	MONTOYA
	FILE

Info

Have the area [illegible] ASAP as we wish to set this up as a burial area and get it on a [illegible]

16-000318

SAFETY PROBLEMS WITH ABANDONED EXPLOSIVE FACILITIES

by
W. Clarence Courtright

Los Alamos Scientific Laboratory
Los Alamos, New Mexico

Presented at the
Armed Services Explosives Safety Board
11th Annual Meeting
at
Memphis, Tennessee

on
September 9 and 10, 1969

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The Los Alamos Scientific Laboratory, under the direction of the Engineering Department and Safety Group, has recently cleared some former firing sites and dismantled and removed about 75 abandoned explosives processing and service buildings including their associated utilities. The goal was to remove all hazardous materials from both above and below ground, eliminate all evidence of former occupancy, return the entire area to its natural state, and, in the case of one firing point, be able to allow public access. Procedures were developed for the safe removal of explosive and radioactive contaminated materials, structures, and drains. One of the more hazardous operations was the removal of underground explosive waste drains, some of which contained significant quantities of explosives. Although this was a cleanup job some of the same problems can be encountered and the same solutions applied in modification and maintenance work of operating explosive facilities. With the use of slides, I will describe the prior conditions, the methods we used, some of the conditions encountered, and the end results of this effort.

LASL, as we are commonly called, was created during World War II by the Manhattan Engineering District for the purpose of developing an atomic bomb. Since the work involved explosives, temporary explosives processing and storage buildings were built. As in many rush operations of an apparently temporary nature, the facilities were not the best for

safe operations. During the early uses of these facilities, many additions and changes were made on short notice and without advance planning. The result was a hodgepodge of temporary buildings and facilities that were not satisfactory for long-time use.

By Congressional action, Los Alamos was made a permanent facility in 1946. People then began to consider permanent structures to replace the temporary ones built during the war. Construction of new facilities was started in the late forties and most of the old temporary structures were replaced with new permanent ones. Very few of the old structures were dismantled when new structures were built to replace them. They were used for various explosive operations and dead storage for a few years and were eventually abandoned in place.

In the early 1960's it was decided that some of the abandoned buildings in the operating areas should be removed because of the fire hazard they created to some of the new facilities. These buildings could not easily be dismantled safely, since they were heavily contaminated with explosi It was decided to use an in-place controlled burning destruction method. To ensure good flashing and burning, additional combustible material was placed inside the buildings and the interiors were soaked with kerosene. During nonworking hours, the buildings were ignited remotely by the use of electric squibs and allowed to burn to ground level. This was done by the Fire Department during the winter months when the ground was covered with snow. The controlled burning program was successful in removing the hazards from those parts of the structures and equipment that were above ground, but was essentially ineffective on the equipment, drains and sumps that were at ground level or below grade. The structures were left in this condition for the next four or five years. The hazard of the underground explosive contaminated drains remained, and the burned debris created an eyesore.

Funds were appropriated to remove the still existing hazards, cleanup for the sake of appearance, and make the land available for further use when needed.

One of the firing sites was outside our normal Laboratory area. T particular site has been used for firing experimental explosive shots, most of which contained radioactive materials in the explosive assembly. This

facility and its land has been declared surplus to the Laboratory's needs, and the land was to be returned to the AEC who was to open it for public use. Since the public would have access to it, it was necessary to make sure that no hazards or dangerous attractive souvenirs were left in the area, especially for public relations considerations.

One of the considerations in doing this restoration work now was that many of the employees who had worked at these facilities were still employe by the Laboratory. They were available for consultation in determining wha operations had been carried on in each of the buildings or areas and could assist in determining what hazards might still exist. If we had waited another ten years or more, many of these people would have retired and would not be readily available for consultation and assistance. These people were a valuable asset in determining just what conditions did exist and were, in some cases, more reliable than the engineering drawings and records that were found in the files. Many hours were spent in assembling the available drawings and records on each of the old buildings, but there were many missing links. There were no complete "as-built" records. This is also true many times when modifications or extensive maintenance work is being planned.

I have divided the presentation into two areas: first, the removal and clearance of explosives process buildings and second, the clearing of a former firing site.

SLIDE 1. Following the war, prior to the construction of any permanent buildings, use of the temporary wartime facilities for explosive processing continued. There was a large collection of wooden process buildings and support facilities. There were few, if any, structures that had not been added to or modified.

SLIDE 2. The controlled burning program was accomplished as the first step for those wooden buildings no longer needed. The better buildings were maintained for support facilities, and a few are still in use today. The burned skeletons of those that were destroyed were left in place until money was appropriated for further cleanup and removal. The new permanent structures were made primarily of concrete and located around the perimeter of the old facilities.

SLIDE 3. Shows a typical abandoned building prior to controlled burning. Note that part of this building has concrete reinforced walls and the rest is of wood. Buildings, such as magazines that had earthen barricades against them, were burned without removing the earth. The combustible materials were removed very effectively and completely. The remaining work for the cleanup of that type of structure was just the removal of the concrete floor and leveling of the earthen barricade.

SLIDE 4. Shows a typical process building after the controlled burning. It can be seen how the heat thoroughly flashed the vacuum pipes, ducts, and all equipment in the building. Two explosive waste sumps can be seen in the foreground. In most cases the collection sumps were exposed to very little heat from the fire, at least not enough to consider them flashed. We did not develop a controlled burning method that would ensure complete flashing of the collection sumps at or below ground level.

SLIDE 5. Shows a section of vacuum line which detonated during the controlled burning and was positive evidence that the burning did provide effective flashing. Several small detonations were heard during the controlled burning. Some of our facilities had common utility buildings which served several smaller buildings. In these cases, a central vacuum system served several bays or small structures. The pipes between buildings were not exposed to flashing during the controlled burning operation and therefore were still explosive-contaminated. These contaminated pipes were removed by the use of an external pipe cutter with water running over the cutting area. The ends of contaminated pipes were capped with plastic and taped to prevent loose HE from falling out during handling and moving to a wash-down building for explosive decontamination.

SLIDE 6. Shows a building during the process of removal of the debris from above the floor level. Since the controlled burning did not remove the underfloor and underground hazards, the next step during the cleanup was to remove the flashed debris above the floor level. This was done by using only hand tools to cut or remove all the pipes and equipment. The use of cutting torches or power tools was not permitted

during this operation. It is surprising how much work can be done using only hand-operated pipe and bolt cutters. An economical bonus of limiting the work to standard hand tools was that laborers could do this work and it did not require more expensive craftsmen such as welders. We felt that the reduced per-hour cost more than offset the extra speed that could have been gained by the use of a cutting torch, even without regard to the safety considerations. The personnel for this demolition work were construction workers who did not normally work with or around explosives. Before each major portion of the job, an extensive standard operation procedure was prepared by the representatives of the Engineering and Safety Departments and approved by the Explosive Technical Group. Before the work began an orientation program was conducted for the workers and their supervisors, and all the general safety rules and conditions in the SOP's were outlined in simple terms. They were shown samples of various kinds of explosives that they might encounter. The workers were instructed that if they found any explosives or anything they thought might be explosives, they were to stop work and immediately notify their supervisor. This proved very profitable, and the workers were conscientious about reporting anything that even resembled explosives.

SLIDE 7. Shows a building where essentially all the removable burned debris has been removed to floor level. Some waste drains can still be seen above the floor level. The next step was to remove the outside underground sumps and drains up to the edge of the foundations.

SLIDE 8. Shows an explosive collection sump being cleaned out. When we knew of or found large quantities of explosives, the regular high explosive disposal crew was called in to remove the explosives. In these types of situations water was placed in the sump and allowed to stand for several days, then the sludge was removed by hand and taken to the burning ground for destruction. This particular sump contained the greatest quantity of explosives found, estimated to be about 1500 pounds. I do not believe that the collection system was cleaned when the building was abandoned, or for some time before. This is an example of what one can find around old explosive process buildings where the operations were not well controlled and the buildings were later abandoned.

SLIDE 9. Shows a sump that has been cleaned and excavated, and is ready for removal from the area. Several instances were encountered in which the explosive-bearing water had gone through cracks or broken joints of the sumps and drains, and deposited concentrations of explosives in the adjacent ground. Such soil was kept slightly damp, and the concentrations were removed by hand digging with aluminum shovels. Large quantities of water could not be used because it would make the explosive indistinguishable from the soil. The explosive-contaminated soil was put in garbage cans for removal to the burning area for burning with more concentration waste explosive. Since this work was done by hand it was very slow and tedious. The decision on just how far to go with this type of cleanup was difficult. How clean is clean? Our general guide to the workers was to remove material as long as they could distinguish the presence of explosives. They then called the safety engineer who made a decision on each case based on his opinion of the remaining hazard.

SLIDE 10. Shows some of the pieces of explosives that were found outside of sumps. They were formed by explosive-bearing water leaking or overflowing from the collection system and the explosive then solidifying in various voids. In addition to explosive from leaks in the collection systems, we found concentrations of explosives on and in the ground just outside the doors of some buildings. Apparently the operators did not always wait for floor washings to go through the collection systems, and swept or washed them out the doors. Loose and deteriorated explosives were also found in the so-called "cap" magazines which were small, barricaded, temporary, open storage facilities at firing sites. Weather and time had deteriorated and broken the charges into small pieces, and we found pieces on the surface and buried as deep as one foot in the ground.

SLIDE 11. The process of uncovering and exposing the drain lines for the explosive collection sumps was a delicate and time-consuming job. The horizontal and vertical positions of the lines were located by hand digging at 20 to 25-foot intervals. Next, a front-end loader was used to remove the overburden to within an estimated one foot of the line. The remain work was done by hand digging so that the drains would not be broken or disturbed. Some of the engineering drawings were helpful in locating the

general areas of underground drains, but, in most cases, it was necessary to accurately locate them by hand digging.

SLIDE 12. Shows an example of the maze of uncovered drain lines and sumps after the lines were exposed by careful digging. Since there were add-on items after the original construction, there was crisscrossing of lines. At this particular location there were three separate drainage systems, all installed at different times. Sometimes underground electrical and steam service was intermixed with these underground drainage systems. Drawings that showed all drains and other utilities were seldom found.

SLIDE 13. Here is an exposed sump drain line ready to be removed. A method was developed for removing these drains remotely. The drains from the sumps were tile, some with mortar joints and some just laid end-to-end. In either case we were concerned about HE having settled in the joints and thus being exposed to pinching or crushing action when the drains were moved.

SLIDE 14. The method used to safely remove the explosive-contaminated drains was to build a clamp device like a large pair of old-time ice tongs. This was fastened to the end of the crane line and placed around a section of the exposed drain. A lift was then made which raised one or two sections of line at a time, depending upon where the break occurred. All personnel were evacuated to barricaded locations except the crane operator who was in the protected cab. The crane was always located at right angles to the ditch, so that the operator was not directly in line with the drain pipe when the initial lift was made. Once the section of pipe was broken free, it was set to one side for later cleaning. Then a helper would come from a barricaded area and place the tongs on the next section of pipe.

SLIDE 15. Shows some of the removed pipes which contained significant "quantities of explosives." From the evidence found in some of these drains we suspect that during their use, some became completely plugged. Operators were then unable to get a flow through them and to expedite things maintenance people had to come in a lay new lines nearby. The plugged lines were abandoned in place. An example of this is the pipe on the left which was completely plugged with HE. Also shown is an example of explosives settling in the joints of drain pipes which bore out our concern about pinch points during removal of this type of pipe.

SLIDE 16. Most of the drains were four-inch drains of vitreous clay, but some were case iron. Most of the drains from the operating bays to the sumps were cast iron while those from the sumps were of the vitreous clay. The cast iron drains could not be broken and removed by the remote crane lifting operation. We used a chain pipe cutter on the cast iron drains. The final cutting was done from a protected location. Water was run on the outside of the pipe as an extra precaution to reduce any heat buildup. One may ask why we did not attempt to steam, wash, or flush these drains before removing them. Where possible, we did wash and flush them, but, generally, they were so plugged with explosives or dirt that we could not get a flow through them. Also, neither hot water nor steam was available at many of these locations and it would have been difficult to provide them. Even when water would flow through these drains, there was no way of knowing how effectively the explosives had been removed from the joints and pockets. In some locations the pipes were found crushed or collapsed causing the plugging. When sections of pipes were removed, ends were covered with plastic and taped to prevent the spilling of explosives during handling. They were then transported to our explosive wash facility. If we had a particularly sensitive situation, the pipe sections were placed in a tank of water for transporting and handling. At the wash facility, the drain pipes were cleaned with hot water and steam to remove all visible explosive contamination. This building is used for cleaning of explosive-contaminated equipment and is served by the explosive waste collection system.

SLIDE 17. After all the drains, sumps, and other utilities had been removed from outside the building foundations, the next step was to remove the explosive-contaminated floor and the drains or troughs under or in the floor. To reduce the possibility of an impact or friction ignition the area was flooded with water and then the protected crane with a headache ball was used to break up the floors and drains. When the floor was completely broken, a close inspection was made to determine the locations and condition of the drains. The area was wet thoroughly again, and the broken pieces of concrete, pipe, drains, etc., were removed by hand. It was during this operation that we experienced our only serious injury which was a strained back from lifting the piece of broken concrete.

SLIDE 18. The next step, after the floors had been broken up and the under-floor drains and contaminated portions removed, was the removal of the remaining dividing walls. We felt that the potential explosive contamination by now was minimal. A headache ball was used, but the large amount of reinforcing steel in the concrete did not yield easily. In this particular picture you see a slight puff of smoke leaving the wall as the headache ball strikes. We assume that this was not explosive detonating, but who knows for sure. The cab of the crane was protected with half-inch plate steel. There were three 6 x 12 inch, two-inch-thick bullet-proof glass ports for viewing so that the operator was not working completely blind.

SLIDE 19. Some of the buildings had enclosed firing chambers where small explosive charges, some containing radioactive material, had been fired. The walls of these chambers were impregnated with pieces of normal uranium and had counts ranging from 100 to 80,000 counts per minute per 60 square centimeters of alpha and 2 to 20 millirem per hour of beta plus gamma. In attempting to destroy reinforced chambers, especially those lined with steel, we found a cutting torch helpful to cut up some of the metal and reinforcing bars. These chambers had been thoroughly flashed by the controlled burning program, and the potential of explosive contamination remaining was essentially zero. The men using the cutting torches wore full-face masks to protect them from radioactive fumes that might be produced by the cutting operation.

SLIDE 20. After all the debris had been removed, the ditches and excavations were backfilled and the area leveled to the original terrain. In some areas a natural grass was planted, and in others, nature was allowed to take over and cover the areas. The material removed during the cleanup was of three types: (1) explosive-contaminated combustibles, (2) explosive-contaminated noncombustible, and (3) noncontaminated noncombustible. The combustible material was piled in a large windrow in an open area and then burned during our rainy season. Since there was some explosive contamination in the combustible material such as covers for sumps and open drains, we did not want to place it in the public dump. The noncombustible items that were known to be, or possibly, explosive-

contaminated were placed in our explosives contaminated burial pit. This is a controlled burial location for explosive-contaminated items that are not economically feasible to clean for salvage or worth the cost of flashing. Some of the drain pipes and the badly contaminated concrete sumps were placed in this location. There were 30 truckloads of this material. The noncombustible material that was considered free of explosive contamination was disposed of in our regular controlled disposal area which is not available to the public. There were over 1325 truckloads of this material.

SHOT 21. When the decision was made to discontinue operations at one of the firing sites, we agreed to clean up the area so that it could be returned to the AEC without any restrictions. Since this area had been used as a firing site, there were numerous detonations, most of which contained in the explosive assembly a lanthanum 140 source, sometimes amounting to several thousand curies. Lanthanum has a relatively short half-life, but it was contaminated also with strontium 90, which left much of the area slightly radioactively contaminated with this beta emitting material. The sources had been prepared at this location, and the assembly building and its associated plumbing and waste pits were heavily radioactively contaminated, principally with strontium 90. In addition to the radioactive contamination at the assembly building location, there was much debris scattered around the countryside by the explosions from the firing locations. This debris consisted mostly of twisted metal, wire, and scrap wood. Since the area was to be returned to its natural state, it was necessary that all this material be picked up and that the area be searched for any hazardous material. Calculations and inspection of the area indicated that the maximum fragment range was about 2000 feet. We decided to clear a 2500-foot radius from both of the firing points. The removal of the radioactive contamination from the waste pits from the source preparation building was done by our own service contractor. More than 550 dump-truck loads of material were removed in this part of the operation. This material was taken to our radioactive contaminated burial pit for disposal. For the general cleaning of the firing area, two 13-man Indian fire fighting crews were contained. They were available from the nearby pueblos and were trained to work as tea

TA-10 Bayo Canyon

SLIDE 22. The Indian crews organized into a "scavenger hunt," and the amount of debris they found near the firing points was tremendous. The men walked and sometimes actually crawled shoulder-to-shoulder in the concentrated areas. As the distance from the firing points increased, the amount of material decreased, and the men were able to spread farther apart as the debris got thinner and the pieces larger.

Full protective clothing was not necessary, but film badges and protective gloves were worn by all personnel working on the job to protect them against cuts and possible radioactive contamination. Each man carried a gunny sack to hold the debris that he gathered. Most of the debris showed very little radioactive contamination. It was found that when several sacks of material were piled together, a count of from 0.1 mr/hr to 1 mr/hr could be obtained. The filled sacks were deposited at collection points and later hauled away to the contaminated burial pit. There were over 90 dump-truck loads of debris picked up by hand.

SLIDE 23. The terrain some distance out from the firing points was very rough and included many sheer cliffs; however, any location where shrapnel could have rested was searched. The search crews were at arm's length when searching the woods and cliffs in the outer area. Pieces of debris were found as far away as 1850 feet.

SLIDE 24. The most significant find of this search was 32 MK-43 igniters. There had been a small temporary wooden "cap" storage magazine, and, apparently when it was removed from the site, these igniters had fallen through the floor and been left there for at least nine years.

SLIDE 25. Twelve pieces of normal uranium were also found by the searchers, all at different locations and as much as 400 feet away from the firing pad. The total weight of these pieces was 23-1/2 pounds.

SLIDE 26. An interesting find was the heads and antlers of two buck deer who, during a fight, had become entangled and died in some of the old firing cables lying about the area.

From the preceding presentation I believe you can see a few of the safety problems that can be created by abandoning explosives facilities without consideration of future problems. I hope you now have an

appreciation for what can or should be done when a facility is deactivated or modified for different operations.

Some of the safety lessons that have been brought home to us because of these cleanup operations and that you should be able to make use of in your own plants are:

1. Waste collection system must be properly designed to provide for successful operation with provisions such as open drain lines that are always accessible for cleaning and inspection.

2. Standard operating procedures for handling, cleanup and disposal of waste explosives must be properly prepared and properly enforced.

3. There must be continuous updating and maintenance of permanent records of as-built drawings of facilities and associated utilities.

4. Responsibility for shutting down and cleaning up a facility up the completion or temporary stoppage of its use must be assigned and funds provided. Operations for deactivation, modification or cleanup must be recorded for future reference.

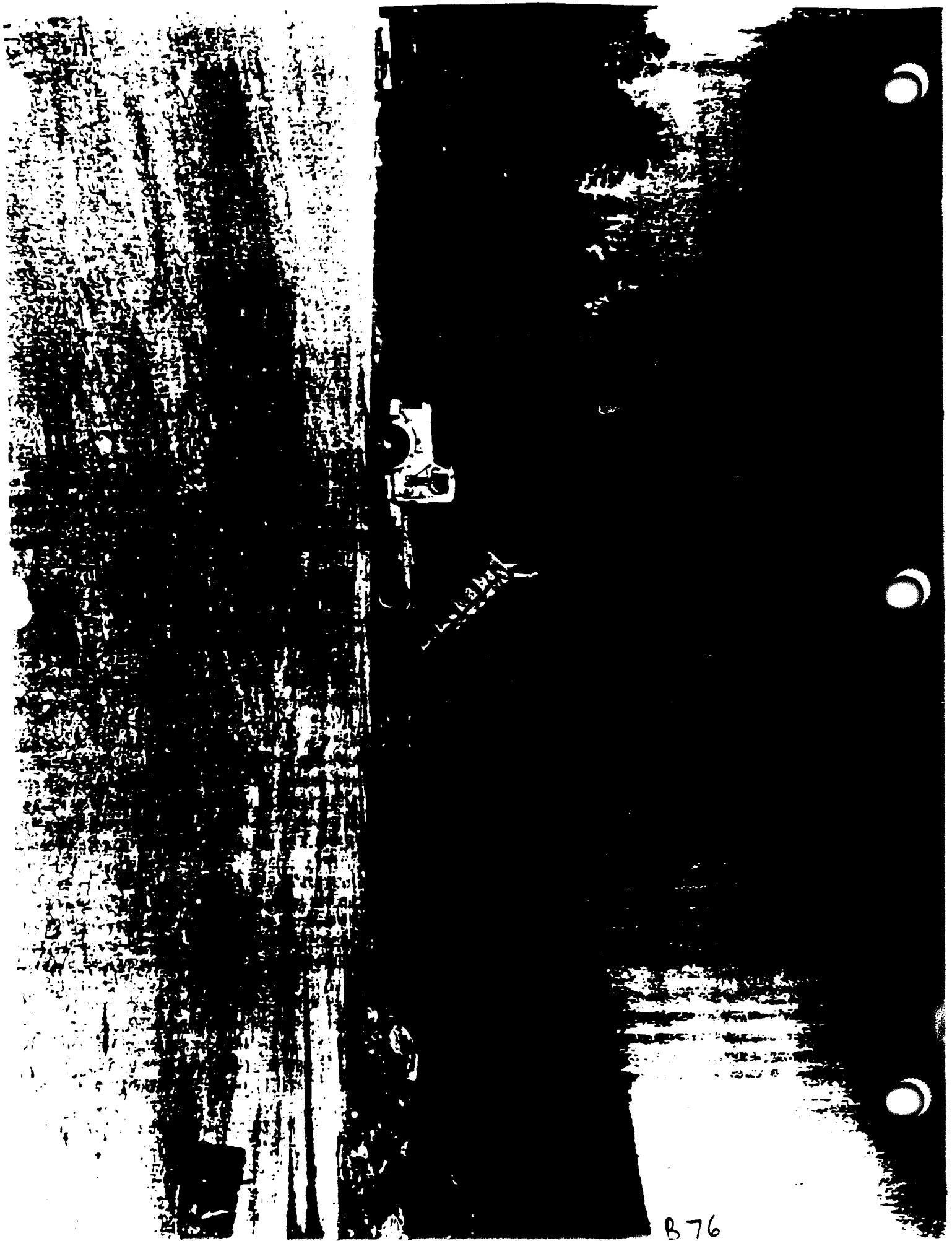
5. Most explosives do not become less sensitive or go away with time or exposure to the elements. The cleanup problem and the hazard removal is going to have to be faced by someone sometime.

6. You may get by with careless and sloppy operations for a time, but eventually the consequences have to be dealt with. It is more efficient and safer to do it right at the time.

7. In the modification, maintenance, demolition or cleanup of explosive facilities, one cannot be too cautious or deliberate in the preparation. The most unlikely conditions and circumstances are possible because you are dealing with the former actions of human beings who were influenced by a wide range of ideas, circumstances, and pressures.

You can see by this presentation that this type of operation is quite expensive, time-consuming, and filled with many unknown hazards. I hope

that you will consider the cleaning and shut-down problems in preparing and approving SOP's for your current operations. When it is known that an explosives facility is to be shut down, you should use your influence to see that management does not allow it to be left in a condition that presents unknown hazards to future users of the facility or the land that it occupies.



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16-000016

UNIVERSITY OF CALIFORNIA
LOS ALAMOS SCIENTIFIC LABORATORY
(CONTRACT W-7405-ENG-36)
P.O. BOX 1663
LOS ALAMOS, NEW MEXICO

LB 9/19/70

CHECK OUT #16-000057

IN REPLY REFER TO: GMX

19 August 1970

Mr. E. E. Wingfield, Chief, Operations Branch
Los Alamos Area Office
U. S. Atomic Energy Commission
Los Alamos, New Mexico

Dear Mr. Wingfield:

This letter responds to yours of 3 August 1970 to Mr. Bradbury on the subject "Waste HE Disposal Questionnaire".

This Laboratory uses open air burning as the principal method of disposing of waste HE, in accordance with the provisions of the Army Materiel Command Safety Manual. We also employ open air burning to dispose of substantial amounts of combustible materials which have been involved in our HE operations and which are either known to be, or suspected to be, contaminated with HE. The latter materials range from wiping tissues to portions of wooden stands used to support experimental charges and remaining after the charge was fired. Because the volume and character of these two types of burns are so different (and they are not done simultaneously) it seems appropriate to give two answers to several of the questions in the ALO questionnaire, one response for the burns of HE waste, and one for the other burns of HE-contaminated materials.

Using the numbers of the ALO questions, our answers would be:

1. (HE) 1900 lb/wk average; 3.6 burns/wk average.

2. (HE) Amounts of these per burn are essentially trivial.
(HE-contaminated Waste; burned separately) 4200 lb/wk average.

3. (Both) DuPont S-94 electric squibs; excelsior, kerosene, flake TNT, roofing felt.

4. (HE) 36 minutes/week average.
(HE-Contaminated Waste) for prompt burns, 1 hr/week average; some burns smolder for 48 hours.

5. (HE) does not exceed 1 on Ringlemann scale.
(HE-contaminated Waste) maximum density 3-4; over No. 1 avg. 2 hr/wk.

6. No.

7. Not that we are directly aware of; we believe that a State of New Mexico official approached the County on the matter (Mrs. Geraty of the LAAO Counsel's Office is familiar with this).

8. No.

9. No.

10. No methods of significant improvement are apparent to us at this time.

11. It may be appropriate.

12. Yes, but they presently have other things to do.

13. The problem of HE disposal is probably less difficult than that of disposing of HE-contaminated materials. It would undoubtedly be quite expensive to achieve a safe, marked reduction in the volume of the latter.

Sincerely yours

D. P. MacDougall

D. P. MacDougall

cc: R. E. Schreiber, TAD
R. Reider, H-3
M. L. Brooks, GMX-2
R. L. Spaulding, GMX-7
H. F. Schulte, H-5
Mail & Records (2)
File

16-000012

OFFICE MEMORANDUM

TO: J. B. Panowski

DATE: June 1, 1971

FROM: P. G. Salgado

SUBJECT: EFFLUENT SCOPE COMMITTEE

SYMBOL: GMX-3

On May 20, 1971, a meeting was held to discuss the Group GMX-3 approach to an effluent inquiry. Those participating were:

H. F. Schulte - Group H-5	C. R. West
F. W. DuBois	M. Schwartz
J. B. Panowski	P. G. Salgado

J. B. Panowski explained our mechanism for obtaining the amounts of HE destroyed in burns and carried away in effluent streams and the amounts of solvents drained from the Site. The solvents drained from the Site will be reported as that quantity of LASL stock and special order solvents delivered from the warehouse to S-Site users (except for the solvents expended by the two largest users, Buildings TA-16-306 and 340; these will be reported individually according to actual use). The HE burned will be reported by weight from records kept by Burning Grounds personnel. The HE in effluent streams will be estimated from approximate building discharge stream flow rates and the average concentrations of HE in streams as determined from chemical analyses. In addition to the effluent HE and solvents, a list will be provided of the S-Site buildings from which there is no or negligible effluent.

The question was asked as to the composition of the HE combustion gas. Panowski replied that we have inquired of our local experts and the anwser is not known. The carbonaceous materials probably go to CO_2 and the hydrogen goes to water but the composition of nitrogen gases is not known. A suggestion was made by Schwartz that a small experiment could be conducted at the Burning Ground to recover free burn off gas and analyze it for a qualitative evaluation of composition.

The use of the form provided by Schulte was reviewed. It was generally agreed that the forms could be used freely to describe S-Site situations and rigid conformance to the form outline would not be necessary.

A description of downstream soil and effluent sampling in the canyons adjacent to S-Site was presented. Schulte approved of our downstream soil sampling procedure, and he suggested that we sample and analyze for boron to determine the persistence of boric acid, which was used extensively at S-Site many years ago.

It was agreed that it would be appropriate to publish several papers associated with environmental protection based on work already completed and work underway at S-Site as follows.

Authors	Subject
F. W. DuBois and J. F. Baytos	"HE Deterioration in the Soil Through Weathering and Bacteriological Effects"
J. F. Baytos	"Sump Drain Pocket Analyses"
M. Schwartz	"HE Solubility and Analysis"

H. F. Schulte felt that once we have listed all our effluents, we will find that most discharged components will be small and of no concern. However, he felt that we may find a few of our discharge materials to be worrisome and we may be required to consider our handling of these wastes more critically. He felt that we may have to consider the triple question, "How far away can we tolerate what concentrations of what materials?" He felt that our discharges to the soil are not getting very far away. Clay is a good absorber and material is bound strongly to clay. Transfer of our waste then becomes related to the physical washing away of clay.

J. B. Panowski closed the meeting by presenting an "in-perspective" view of the magnitude of the S-Site's waste disposal problem in the form of the following table.

EFFLUENT COMPARISONS
(No "trash" included)

A. S-Site	Disposal (6 months)	Rate (lbs/hr)
Solvents	3,284 gal	5.25
HE	49,400 lbs	11.40
Total		16.7
Composition	Hydrocarbons, CO_2, N_2, H_2O, NO_x	

B. One Automobile (15 miles/gal Octane at 0.703 g/cm³ or 5.9 lbs/gal)

	Disposal (one hour)	Rate (lbs/hr)
Gasoline	4 gal	23.6
Composition	Hydrocarbons, CO, CO_2, N_2, NO_x, SO_2	

C. Summary

S-Site	16.7 lbs/hr
One automobile	23.6 lbs/hr

for H. L. Flough
P. G. Salgado

PGS/sf

cc: Jesse Aragon
H. E. Ballance
J. B. Bourne
C. Boggs
W. C. Courtright
C. R. DePoorter
F. W. DuBois
H. B. Fletcher
J. J. Garcia
R. S. Gauler
F. A. Hauser
D. D. McCormick
A. Popolato
M. Schwartz
W. A. Spencer
C. R. West
GMX-3 Reading File
File

16-000038

OFFICE MEMORANDUM

H. F. Schulte July 28, 1971

VIA : Jesse Aragon

J. B. Panowski and P. G. Salgado

AUG 7 '71 AM

GROUP GMX-3 EFFLUENTS

GMX-3

Reference : Memorandum from Harry F. Schulte to Group Leaders, dated April 22, 1971, subject "Effluents from AEC Facilities"

In response to the reference memorandum, we have surveyed effluent materials from Group GMX-3 operations. In accordance with the agreement reached in our meeting on May 20, 1971, we are reporting these effluents (1) as best estimates from specific buildings, which are large users of solvents and explosives or users of materials of special concern and (2) as an itemized breakdown of material issued to individual buildings.

GMX-3 has a large number of buildings and auxiliary facilities. So that you will not have to reduce the information from a formidable number of "Survey of Effluent Stream" forms, we are providing the following information:

Table 1 Numbers of GMX-3 buildings that emit no or negligible effluent

Table 2 Numbers of GMX-3 buildings that emit explosives, solvents, or gases in moderate amounts

Table 3 Numbers of GMX-3 buildings that emit large amounts of explosives, solvents, gases, or materials of particular concern

Table 4 Numbers of GMX-3 structures that are associated with the Burning Ground and disposal facilities

Table 5 Numbers of GMX-3 buildings that are the responsibility of agencies other than GMX-3

Appendix A Forms for buildings listed under Items 3 and 4, above

Appendix B Quantities of "materials of concern" supplied to GMX-3 building including those listed under Item 2, above

In assessing the effluent from GMX-3, the data on the forms should be given credence over the list of materials delivered. In these cases, records of usage at the buildings indicate that the material delivered, in excess of that used, is still on hand. In cases where there are no forms, the effluent may be considered to be equal to those materials delivered.

As shown in Appendix B, the GMX-3 effluents of major concern are solvents and high explosives because of the quantity of material involved. Approximately 3600 gallons of various solvents are delivered to our operating buildings over a six-month period. These solvents leave the buildings by various routes, but we feel that virtually all this material either evaporates into the atmosphere within a short distance, perhaps half a mile, of the site boundaries or is burned as part of our disposal activities. With respect to waste explosives, we burn approximately 50,000 pounds during a six-month period and estimate that another 125 pounds is carried a short distance downstream in our sump effluent.

In an attempt to get some perspective for the scope of the GMX-3 effluent problem, we have compared the site solvent and HE effluent with that of an automobile as shown below.

EFFLUENT COMPARISONS

A. GMX-3	Disposal (6 months)	Rate (lbs/hr, 24-hr day)
Solvents	3,570 gal (≈ 7 lbs/gal)	5.7
HE	49,400 lbs	11.3
	Total	17.0
Products	Hydrocarbons, C, CO_2, N_2, H_2O, NO_x	

B. One automobile (15 miles/gal: Gasoline at 0.7 g/cm³ or 5.9 lbs/gal)

	Disposal (one hour)	Rate (lbs/hr)
Gasoline	4 gal	23.6
Products	Hydrocarbons, C, CO, CO_2, N_2, NO_x, SO_2, H_2O, $Pb(C_2H_5)_4$	

C. Summary

GMX-3	17.0 lbs/hr
[illegible]	[illegible]

This information is the best available at this time and we are sending it to you with the thought that such interim information may be useful in outlining the scope of the overall problem. We expect to have additional quantitative information after analysis of liquid and soil samples from our effluent streams. These data will be forwarded to you when available.

J. B. Panowski

P. G. Salgado

JBP/PGS/sf

Enclosures: As cited above

cc: E. H. Zyster
R. W. Drake
D. D. Meyer
C. W. Christenson
H. S. Jordan
Jesse Aragon
C. R. West
GMX-3 Reading File
File (2)

TABLE 1

GMX-3 BUILDINGS FROM WHICH
POLLUTION EFFLUENTS ARE EFFECTIVELY NEGLIGIBLE

TA-16- 7	TA-16-209	TA-16-343	TA-16-520	TA-37- -
10	220	344	525	8
27	221	345	TA-11- 1	9
54	223	360	2	10
58	224	400	3	11
59	225	411	4	12
61	226	413	6	13
65	261	414	24	14
73	263	415	25	15
88	277	417	30	16
89	278	435	36	17
90	281	437	TA-28- 1	18
91	283	462	2	19
92	285	463	3	20
93	286	476	4	21
99	300	477	5	22
164	303	478	TA-37- 1	23
191	304	489	2	24
200	305	515	3	25
203	308	516	4	26
206	319	517	5	27
207	341	518	6	
208	342	519		

TABLE 2

GMX-3 BUILDINGS THAT EMIT SMALL OR MODERATE AMOUNTS
OF EXPLOSIVES, SOLVENTS, GASES,
OR OTHER MATERIALS OF PARTICULAR CONCERN
(No forms are provided.)

TA-16- 7	TA-16-267	TA-16-307	TA-16-450
92	280*	308*	460
260	301*	410	
265	302*	430*	

* Effluent from building consists of small quantities of solvents and HE that are carried to the sump and reported as burned.

TABLE 3

GMX-3 BUILDINGS THAT EMIT LARGE QUANTITIES OF EXPLOSIVES, SOLVENTS, GASES, OR OTHER MATERIALS OF PARTICULAR CONCERN
(Forms are provided.)

TA-16-193	TA-16-306
202	340
222	370

TABLE 4

GMX-3 BURNING GROUND AND DISPOSAL STRUCTURES

TA-16-386	TA-16-389	TA-16-394
387	390	399
388	392	401
		412

TABLE 5

BUILDINGS ASSOCIATED WITH GMX-3 FOR WHICH POLLUTION EFFLUENTS WILL BE REPORTED BY OTHER AGENCIES

TA-16- 16	TA-16-531	TA-16-540
180	532	542
192	533	560
195	534	
210	535	
530		

APPENDIX F

COMPOSITION OF EXPLOSIVES USED AT THE LABORATORY (EXCERPTED FROM THE RFI WORK PLAN FOR OU 1082, ADDENDUM I, APPENDIX D)

1.0 INTRODUCTION TO HIGH EXPLOSIVES USED AT THE S-SITE COMPLEX

There are several types of explosives and associated co-constituents that may be present in soils and/or sediments at sites where explosives were or are currently processed, assembled, machined, stored, tested (i.e., detonated), or disposed. Potential contaminants from these operations may consist of the residual parent explosive and other co-constituents, such as inorganic metals, production impurities, degradation products, or products of detonation and/or combustion. The migration and dispersal characteristics of these potential contaminants in the environment are governed by the physical and chemical properties of the constituents, as well as by the physical characteristics of the sediments and soils on site. Some of these potential contaminants are carcinogens or systemic toxicants and may pose a health hazard upon exposure through inhalation, incidental ingestion, and dermal contact.

Explosives used at the Los Alamos National Laboratory (LANL) may be divided into three classes: 1) primary or initiating, 2) boostering, and 3) secondary (bursting charge) or high explosives (LANL 1986, 15-16-315). High explosives (HE) that contain HMX (cyclotetramethylenetetranitramine), RDX (cyclonitrite, cyclotrimethylenetrinitramine), or TNT (trinitrotoluene) as explosive components represent the vast majority of explosives that have been processed at Technical Area (TA) 16.

Primary explosives are not currently processed at the Laboratory but are used in squibs, low-energy detonators, fuses, explosive bolts and fasteners, and are assembled into test devices. Primary explosives are extremely sensitive to friction, heat, and impact, and some are sensitive to an electrical discharge. When exposed to flame, these explosives can be expected to detonate without burning. Lead azide and lead styphnate are examples of primary explosives. These and other detonator materials were used, processed, and disposed of at S-Site during the 1940s and 1950s.

The majority of detonators handled and assembled into test devices at these locations are the exploding bridge wire type which contain boostering explosives. High-energy exploding bridge wire detonators approved for use at LANL may be found in the Fabrication and Assembly Group's (WX-3) Standard Operating Procedure (SOP) 1.1.0, Explosives (LANL 1986,

15-16-315). Boostering explosives are less sensitive to explosion initiators than primary explosives, but may be set off by heat, friction, or impact. These explosives may detonate when burned in large quantities. Examples of boostering explosives include HMX, PETN (pentaerythritol tetranitrate), RDX, and tetryl (trinitrophenyl methylnitramine).

HMX, PETN, and RDX are also processed in the first steps of making molding powders for secondary or high explosives such as plastic-bonded explosives (PBX) and extrudable explosives [e.g., Extex (XTX)].

Most of the explosives processed at S-Site are secondary or high explosives (LANL 1986, 15-16-315). These explosives require more energy for initiation than either primary or boostering explosives. All will detonate if they receive a strong shock from an impact or from a boostering explosive. Unless confined, secondary explosives will burn without detonating. Examples of high explosives include baratol, the cyclotols, TNT, several PBXs, and extrudable explosives.

The types of secondary or high explosives that may be processed at TA-16 fall into the categories of established explosives, developmental explosives, and detonators. Table D-1 lists the nominal compositions of established secondary explosives that contain HMX, RDX, or TNT; these include the explosives most commonly used at TA-16. Table D-2 lists the nominal compositions of established secondary explosives used at TA-16 that do not contain HMX, RDX, or TNT. The type of bonding materials used in these explosives (e.g., plasticizers, polystyrenes, waxes, etc.) are not considered to be of human health or environmental concern and are not included in these tables. Developmental explosives contain the same types of chemicals that compose the established explosives; however, they are generally used in extremely small quantities (<100 lbs) in a limited number of TA-16 facilities (TA-16-340 and TA-16-460). However, there are some additions to this list. These are included in Table D-3. A complete listing of each of these explosives may be found in WX-3 Standard Operating Procedure (SOP) 1.1.0, Explosives (LANL 1986, 15-16-315). Table D-4 summarizes the explosives components of concern from Tables D-1 through D-3, with estimates of the total quantities of each that have been processed at TA-16 over the past 50 years. These estimates were made by Mr. L. Hatler of

TABLE D-1
NOMINAL COMPOSITION OF ESTABLISHED EXPLOSIVES THAT CONTAIN HMX, RDX, OR TNT (LANL 1986, 15-16-315)

CHEMICAL EXPLOSIVE	Al	BA	BDNPA/ BDNPF	BN	CEP	DEHS	DOP	FO or MO	HMX	$NaNO_3$	NC	PETN	RDX	TATB	TNT	TOP	OTHER
Baratol *				76%											24%		
Boracitol		60%													40%		
Composition A-3													91%				9%
Composition A-4													97%				3%
Composition A-5													98.5%				1.5%
Composition B *													60%		40%		
Composition B-3													60%		40%		
Composition C-3													88%				12%
Composition C-4						5.3%		1.6%					91%				
Cyclotol, 75/25													75%		25%		
Cyclotol, 70/30													70%		30%		
DBA-1										X					X		X
EDC-8												76%					24%
EDC-28													94%				6%
EDC-32									85%								15%
EDC-37											1%		91%				8%
EDC-38									9.5%								5.5%
HBX-1	17%												40%		38%		5%
HMX									100%								
LX-04									85%								15%
LX-07									90%								10%
LX-14									95.5%								4.5%
Octol									75%						25%		
PBX-9001							1.5%	1.5%					90%				8.5%
PBX-9007							0.5%						90%				9.5%
PBX-9010													90%				10%
PBX-9011									90%								10%
PBX-9205							2%						92%				6%
PBX-9206									92%								8%
PBX-9401													94.2%			2.2%	3.6%
PBX-9404 *					3%						3%		94%				
PBX-9405					3%						3%		94%				
PBX-9407													94%				6%
PBX-9501 *			2.5%						95%								2.5%
PBX-9503									15%				80%				5%
PBXW-113									88%								12%
Pentolite												50%			50%		
RDX													100%				
TNT															100%		
TNT/NC											20%				80%		
Tritonal	20%														80%		
XTX													80%				20%

* Th[illegible] xplosives represent those processed in the largest quantities

All [illegible]ges are wt % (LANL 1986, 15-16-315)

Al Aluminum powder
BA Bor[illegible]
BDNPA [illegible] acetal
CEP Chloroethyl phosphate
DEHS Di(2 ethylhexyl)sebacate
DOP Dioctyl phthalate
[illegible] Motor oil
[illegible]3 Sodium nitrate
NC Nitrocellulose, cellulose nitrate
RDX Cyclonite, cyclotrimethylenetrinitra[illegible]
TATB Triaminotrinitrobenzene
TNT Trinitrotol[illegible]

TABLE D-2

COMPOSITION OF ESTABLISHED SECONDARY EXPLOSIVES THAT DO NOT CONTAIN HMX, RDX, OR TNT (all percentages in wt %) (LANL 1986, 15-16-315)

EXPLOSIVE	COMPOSITION
Al ANFO	Aluminum powder (Al)/ammonium nitrate (AN)/fuel oil (FO)
AN	100% ammonium nitrate
ANFO	Ammonium nitrate/fuel oil
BDNPA	100% Bix(dinitropropyl acetal)
Black powder	74% Potassium nitrate/104% sulfur/14.6% other
BTX	5,7-Dinitro-1-picrylbenzotriazole
DATB	100% Diaminotrinitrobenzene
Datasheet C	63% Pentaerythritol tetranitrate (PETN)/8% nitrocellulose (NC)/ 29% other
Datasheet D	75% Pentaerythritol tetranitrate/25% other
DINGU	100% Dinitroglycoluril
DNPA	100% 2,2-Dinitropropyl acrylate polymer
EDC-8	76% Pentaerythritol tetranitrate/ 14% other
High energy propellants	100% Solid propellants
HNS	100% Hexanitrostilbene
K-10	65.3% Dinitroethylbenzene/34.7% trinitroethylbenzene
NC	100% Nitrocellulose
Nitromethane	100% Nitromethane
NQ	100% Nitroguanidine
NTO	100% 1,2,4-nitro-triazole-5-one
PBX-9502	95% Triaminotrinitrobenzene/5% other
PETN	100% Pentaerythritol tetranitrate
PYX	100% 2,6-Bix(picrylamino)-3,5-dinitropyridine
Smokeless powder (single base)	Nitrocellulose/inorganic nitrates
Smokeless powder (double base)	Nitrocellulose/inorganic nitrates/nitroglycerin or nitroglycol
STRATABLAST C	Slurry blasting explosive
TAGN	100% Triaminoguanidine nitrate
TAL-1005E	Slurry blasting explosive
TATB	100% Triaminotrinitrobenzene
Tetryl	100% 2,4,6-Trinitrophenylmethylnitramine
TNS	100% Trinitrostilbene
TPM	100% Tripicrylmelamine
XTX-8003	80% Pentaerythritol tetranitrate/20% other

LANL 1986, 15-16-315. All percentages in wt %.

TABLE D-3

ADDITIONAL CHEMICALS THAT ARE COMPONENTS OF DEVELOPMENTAL SECONDARY EXPLOSIVES (all percentages in wt %) (LANL 1986, 15-16-315)

EXPLOSIVE	CHEMICAL
X-0231	40 - 90% Tungsten
X-0232	40 - 90% Tungsten
X-0233	40 - 90% Tungsten
X-0239	40 - 90% Tungsten
X-0249	0 - 70% Barium carbonate
X-0250	0 - 70% Cyanuric acid
X-0251	0 - 70% Barium carbonate
X-0252	0 - 70% Cyanuric acid
X-0254	Barium carbonate
X-0256	Less than 44.9% Barium carbonate
X-0258	Less than 46.8% Barium carbonate
X-0260	Less than 47.1% Barium carbonate
X-0262	Less than 46.7% Barium carbonate
X-0264	Less than 45.2% Barium carbonate
X-0266	Less than 47.1% Barium carbonate
X-0268	Less than 27.4% Barium carbonate
X-0271	Approximately 0.5% Decycigallophenone
X-0276	35.9% Copper
X-0277	33% Iron
X-0279	40.8% Cesium nitrate
X-0284	0 - 70% Potassium nitrate
X-0294	Approximately 15% MAN
X-0295	Approximately 30% MAN

EXPLOSIVE	CHEMICAL
X-0302	100% FKM
X-0364	52.4% ADNT
X-0365	39% EDD
X-0366	50% EDD
S-0367	50% EDD
X-0368	7.5% Potassium nitrate
X-0369	40.3% Potassium nitrate
X-0370	36.2% Potassium nitrate
X-0382	3.75% Potassium nitrate
X-0386	6.4% Potassium nitrate
X-0387	7.4% Potassium nitrate
X-0388	4.9% Potassium nitrate
X-0389	85.24% Tungsten
X-0390	85.36% Tungsten
X-0415	40% EAK
X-0416	60% EAK
X-0417	80% EAK
X-0421	80% EAK
X-0460	11.5% TCP/18% CT
X-0466	Less than 30% cyanuric acid
X-0467	Less than 30% zinc oxide
X-0515	50% Cyanuric acid
X-0516	50% Zinc oxide

ADNT 3,5-Dinitro-1,2,4-triazole
CT Calcium tartrate
EAK Mixture of ethylene diamine dinitrate, ammonium nitrate, and potassium nitrate
EDD Ethylene diamine dinitrate
FKM Mixture of HMX, nitrate, esters, oxidizers, and binders
MAN Methyl amine nitrate
TCP Tricresyl phosphate

TABLE D-4

SUMMARY OF HE COMPONENTS USED AT TA-16 THAT ARE POTENTIAL CONTAMINANTS OF CONCERN

HE COMPONENT	AMOUNT (lbs)	NOTES
ADNT		
Ammonium nitrate	< 2 500	
Barium nitrate	> 500 000	
BDNPA	2 500	Plasticizing agent
BDNPF	2 500	Plasticizing agent
BTX	< 100	
CT		
Cyanuric acid	25 000 - 50 000	Mock HE component
DATB	10 000 - 25 000	
Decycigallophenone	< 100	Cast HE additive, viscosity
Di(2-ethyl) sebacate	< 100	Cast HE additive, viscosity
Dinitroethylbenzene	< 10	
Dinitroglycolutil	< 500	
DNPA	6 000	Plastic
EAK	< 2 500	
EDD	< 2 500	
FKM	<1 000	
Hexanitrostilbene	< 100	
HMX	> 500 000	
MAN	< 1 000	
Nitrocellulose	2 000 - 5 000	
Nitroguanadine	50 000 - 100 000	
Nitromethane	< 50 000	Liquid HE
NTO	500 - 1 000	
PETN	10 000 - 15 000	
PYX	< 1 000	
RDX	> 500 000	
TAGN	< 100	
TATB	100 000 - 500 000	
TCP	< 100	
Tetryl	1 000 - 5 000	
TNT	> 500 000	
Trinitroethylbenzene	< 10	
Trinitrostilbene	< 100	
Trioctyl phosphate	< 1 000	
Tripicrylmelamine	< 1 000	

Note: Abbreviations are identical to those in Tables D-1 through D-3.

Group WX-3, who has worked at TA-16 since 1968 (Hickmott and Martin 1993, 15-16-448).

2.0 POTENTIAL CONTAMINANTS OF CONCERN FROM EXPLOSIVES

The type of potential contaminants present at a particular site is directly dependent upon the type of operation conducted at the site (i.e., processing, assembly, machining, storage, testing, and/or disposal) and the type of explosive and test device used in the operation. Products of environmental degradation (e.g., photolysis and/or microbial degradation) of the potential contaminants located at each site may also be present. Table D-5 presents the type of potential contaminants of concern (PCOCs) associated with various explosive operations conducted at the Laboratory. Table D-6 presents the potential explosive impurities and environmental degradation products likely to be of concern in the environment that are associated with explosives that contain HMX, RDX, TNT, PETN, and tetryl.

TABLE D-5

CONSTITUENTS OF POTENTIAL CONCERN ASSOCIATED WITH EXPLOSIVE OPERATIONS AT THE LABORATORY

CONSTITUENTS OF POTENTIAL CONCERN	OPERATION			
	PROCESSING OPERATIONS	ASSEMBLY AND STORAGE	MACHINING	TESTING AND OPEN-AIR BURNING
Parent explosive (explosive, inorganic metal co-constituents, production impurities)	X	X	X	X
Inorganic metals (that compose the explosive device)			X	X
Products of incomplete detonation and/or incomplete combustion (nitroaromatics, lead, friable asbestos, polynuclear aromatic hydrocarbons)				X
Products of environmental degradation	X	X	X	X

Although Table D-6 lists a large number of potential co-contaminants of HE that may be detected in the environment, most have only been observed in laboratory experiments. The following HE impurities and degradation products have been observed in field investigations: in TNT - 2,4 DNT,

TABLE D-6

EXPLOSIVE CONSTITUENTS OF POTENTIAL CONCERN IN THE ENVIRONMENT

PRINCIPAL TYPE OF EXPLOSIVE	PARENT EXPLOSIVE (explosive, metal co-constituents)	PARENT EXPLOSIVE (production impurities)	INORGANIC METALS (that compose the explosive device)	PIDs and/or PICs	PRODUCTS OF ENVIRONMENTAL DEGRADATION	CONSTITUENTS DETECTED IN THE ENVIRONMENT
HMX	See Tables D-1, D-2, and D-3	RDX, aliphatic and cyclic nitro-compounds (a)	See Table D-11	Barium, lead, friable asbestos, polycyclic aromatic hydro-carbons (PAHs)(b)	Nitrate ions, nitrite ions, ammonia, formaldehyde, organic nitro-compounds, hydrogen cyanide (a), mono-, di-, and trinitroso-RDX analogues, hydrazine, 1,1-dimethylhydrazine, 1,2-dimethylhydrazine, methanol (a)	Parent explosive (HMX, RDX, aliphatic and cyclic nitro-compounds), inorganic metals, PIDs and PICs (lead, friable asbestos, PAHs) (a)
RDX	See Tables D-1, D-2, and D-3	HMX, aliphatic and cyclic nitro-compounds (a)	See Table D-11	Barium, lead, friable asbestos, PAHs (b)	Similar to those of HMX (a)	Parent explosive (RDX, HMX, aliphatic and cyclic nitro-compounds), inorganic metals, PIDs and PICs (lead, friable asbestos, PAHs) (a)
TNT	See Tables D-1, D-2, and D-3	2,4-DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB (a)	See Table D-11	Barium, TNT, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, 1,3-DNB, lead, friable asbestos, PAHs (b)	1,3,5-TNB, TNBOH, TNBAL, TNBA, anthranils (e.g., 2,6-dinitroanthranil), nitriles (e.g., 2,4,6-trinitrobenzonitrile), amines (2-amino-4,6-DNT, 4-amino-2,6-DNT, 3,5-dinitrophenol, 2-amino-4,6-dinitrobenzoic acid) (a), 2-NT, 3-NT, 4 NT, 2,3-DAT, 2,4-DAT, 2,6-DAT, 2,4,6-TAT, 2-Nitro-6-AT, 4-Nitro-6-AT (c) Nitrocresols (i.e., 2 Nitro-m-cresol), Dinitrocresols (i.e., dinitro-o-cresol) (c)	Parent explosive (TNT, 2,4 DNT, 2,6-DNT, 1,3-DNB, 1,3,5-TNB), inorganic metals, PIDs and PICs (lead, friable asbestos, PAHs), environmental degradation products (2-amino-4,6-DNT, 4-amino-2,6 DNT) (a) 2 NT, 3 NT, 4 NT, 1,2 DNB, 3 Nitroaniline, 2 Methylaniline, 2 Nitro-4AT, 2 Nitro 6AT, 3 Nitro 4AT, 3 Nitro 2AT, 2,4-DiAT, 2,6-DiAT (c)

TABLE D-6 (continued)

EXPLOSIVE CONSTITUENTS OF POTENTIAL CONCERN IN THE ENVIRONMENT

PRINCIPAL TYPE OF EXPLOSIVE	PARENT EXPLOSIVE (explosive, metal co-constituents)	PARENT EXPLOSIVE (production impurities)	INORGANIC METALS (that compose the explosive device)	PIDs and/or PICs	PRODUCTS OF ENVIRONMENTAL DEGRADATION	CONSTITUENTS DETECTED IN THE ENVIRONMENT
PETN	See Tables D-1, D-2, and D-3	PE-tri-N, di-pentaerythritol hexanitrate, tri pentaerythritol acetonitrate (a)	See Table D-11	Lead, friable asbestos, PAHs (b)	Pentaerythritol (PE or Pe-tri-N) (a)	Parent explosive, inorganic metals, PIDs and PICs (lead, friable asbestos, PAHs), environmental degradation products (a)
Tetryl	See Tables D-1, D-2, and D-3	No production impurities of consequence (a)	See Table D-11	Lead, friable asbestos, PAHs (b)	N-methylpicramide, picric acid, methylnitramine (a)	Parent explosive, inorganic metals, PIDs and PICs (lead, friable asbestos, PAHs) (a)

Notes: For the explosive and metal co-constituents of the parent explosives, see Tables D-1, D-2, and D-3.
For inorganic metals that compose the explosive device, see Table D-11.

Legend:

2-amino-4,6-DNT	2-amino-4,6-dinitrotoluene
4-amino-2,6-DNT	4-amino-2,6-dinitrotoluene
1,3-DNB	1,3-dinitrobenzene
2,4-DNT	2,4-dinitrotoluene
2,6-DNT	2,6-dinitrotoluene
1,3,5-TNB	1,3,5-trinitrobenzene
HMX	cyclotetramethylene-tetranitramine
PE-tri-N	pentaerythritol
PETN	pentaerythritol tetranitrate
PAH	polycyclic aromatic hydrocarbon
RDX	cyclonitrite, cyclortrimethylenetrinitramine
NT	nitrotoluene
DAT	diaminotoluene
TAT	triaminotoluene
AT	aminotoluene
TNBA	2,4,6-trinitrobenzoic acid
TNBAL	2,4,6-trinitrobenzaldehyde
TNBOH	2,4,6-trinitrobenzyl alcohol
TNT	2,4,6-trinitrotoluene

Footnotes:

(a) Layton et al 1987, 15-16-447
(b) US ATHMA 1986, 15-16-457
(c) Karg and Koss 1993, 15-16-555

2,6 DNT, TNB, DNB, NT, nitroaminotoluenes, nitrocresols, diaminotoluenes, and dinitrocresols; in RDX - HMX, nitrate; and in HMX - RDX. Thus, at TA-16 we will focus our investigation of HE co-contaminants on DNT, TNB, and DNB, all of which are determined by high performance liquid chromatograph (HPLC). Many other of these byproducts, such as the nitrocresols, will be determined by GC-MS during analyses for semivolatiles.

WX Division SOPs describe components of both standard and developmental explosives. The principal constituents of the explosives are generally the explosive components themselves, such as HMX, RDX, and TNT. However, subsidiary contaminants present in the explosive formulations may include: polycyclic aromatic hydrocarbons (PAH), metals, cyanide, and asbestos. Each of these co-contaminant types is described below. Inorganic metals that may compose the explosive device include, but are not limited to: lead, uranium, copper, or iron.

2.1 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons have been detected at firing sites and burning grounds. They may be the product of incomplete detonation or combustion of those explosives that contain motor or fuel oil or may be the product of incomplete combustion of fuels used to ignite explosives at disposal areas. At TA-16, these contaminants are most likely to be found at open burn/open detonation sites and at firing sites, rather than in association with process buildings.

The manner in which individual PAHs behave in the environment is linked directly to the molecular weight of each potential contaminant. For example, low molecular weight PAHs (e.g., acenaphthylene, anthracene, fluorene, and phenanthrene) are associated with significant volatilization compared to high molecular weight PAHs (e.g., benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) (Clement International Corporation 1990, 0873). Thus, it is likely that high molecular weight PAHs will be found in the soils and sediments.

In addition, sorption of PAHs to soil and sediments increases with increasing soil organic carbon content. The higher molecular weight PAHs have K_{oc}

values in the range of 10^{-5} to 10^{-6}, indicating a stronger tendency to adsorb to organic carbon (Clement International Corporation 1990, 0873). This tendency for sorption also governs the manner in which the individual PAHs will move in surface or groundwater. The high molecular weight PAHs will be transported in water adsorbed to particulates, whereas the lower molecular PAHs will tend to volatilize. Microbial metabolism is the major process for degradation of PAHs in the soil environment. Photo oxidation, chemical oxidation, and biodegradation are only of importance in water environments. Hydrolysis is not considered to be an important degradation process for PAHs (Clement International Corporation 1990, 0873).

2.2 Potential Metal Contaminants

Metals used in processing operations and in assembly and storage locations may be co-constituents of the parent explosive (see Tables D-1, D-2, and D-3). Metals may be co-constituents of parent explosives or may have composed the device that housed the explosive. Such metals may include barium, beryllium, lead, uranium, copper, and iron. These metals will be found in largest quantities at open burn/open detonation sites at TA-16. They will also be present at firing sites. Those that are components of the explosives themselves will be found associated with process buildings.

The primary factor governing the distribution of potential metal contaminants in the environment is soil pH. With the exception of lead, the potential metal contaminants will tend to be more mobile in acidic soils. Lead is mobile in soils under both alkaline and acidic conditions. Two metals of particular concern at TA-16 are barium and beryllium.

Barium exhibits low mobility in soil. Barium mobility is limited by adsorption in soils with high cation exchange capacity (Clement International Corporation 1992, 0874). Thus, in fine soils or soils with high organic content, barium is expected to be located near the soil surface.

Scanning electron microscopic and electron microprobe investigations of soils from the TA-16 burning ground (Brown et al. 1992, 15-16-389) and from within Cañon de Valle (Eppler unpublished data) show that barium is present in at least four forms within contaminated soils and sediments: 1) as barium carbonate, 2) as barium sulfate, 3) as barium adsorbed on organic

particles, and 4) as a barium-iron-titanium silicate in reaction rims overgrowing steel fragments. No barium nitrate was found. Barium sulfate appears to predominate in Cañon de Valle and barium carbonate dominates in the Area P landfill and in a small drainage from the burning ground. Barium sulfate is quite insoluble and barium carbonate is moderately soluble.

Beryllium is also expected to have limited mobility in most soil types. Beryllium tightly adsorbs to soils by displacing divalent cations that share common sorption sites (Syracuse Research Corporation 1992, 0872).

2.3 Cyanide

Cyanuric acid, a co-constituent of some developmental secondary explosives and a component of mock HE (see Table D-3), contains cyanide. Upon heating, cyanuric acid evolves hydrogen cyanate (CHNO), which is soluble in water, decomposing to carbon dioxide and ammonia (Budavari et al. 1989, 15-16-454). Thus, cyanide may be detected at processing areas for developmental secondary explosives and mock HE. AT TA-16, outfalls associated with the 300-Line are most likely to be contaminated with cyanuric acid. However, it is unlikely that cyanide will be detected at testing or disposal sites.

The fate of cyanide in soils and/or sediments is pH dependent. Cyanide may adsorb to suspended solids and sediments, although adsorption is probably insignificant when compared to volatilization. The adsorption of cyanides increases with increasing iron oxide, clay, and organic material. However, instead of being more mobile in acidic environments, cyanide adsorption increases with increasing acidity (~~ATSDR 1991~~ Syracuse Research Corporation 1992, 15-16-451).

In the soil, cyanide may be present as hydrogen cyanide, soluble alkali metal salts, or as immobile metallocyanide complexes. Under aerobic conditions, low concentrations of cyanide undergo biodegradation with the formation of ammonia followed by nitrate. Under anaerobic conditions in the subsurface environment cyanides denitrify to gaseous nitrogen (~~Clement International Corporation 1991~~ Syracuse Research Corporation 1992, 15-16-451).

2.4 Asbestos

Asbestos is nonvolatile and insoluble. Thus, its fate is primarily controlled by deposition after airborne transport. However, some fibers are sufficiently small that they may remain suspended in the atmosphere or water and be transported long distances. Asbestos is not known to undergo significant transformation or degradation in the environment (Clement International Corporation 1990b, 15-16-450). Asbestos is most likely to occur at firing sites and WW II waste disposal sites at TA-16.

3.0 FATE AND TRANSPORT OF EXPLOSIVES AND EXPLOSIVES BY-PRODUCTS

In addition to environmental degradation, other factors affect the potential fate and migration of PCOCs in the environment. These include the physical and chemical properties of the constituents and their degradation products as well as the physical and geochemical characteristics of the sediments and soils on site. Factors such as soil pH, soil cation-exchange-capacity (CEC), water infiltration rate, soil porosity, along with chemical-specific factors [e.g., water partition coefficient (K_{oc}), and soil retention factors (K_d)] are key to understanding the potential migration patterns of these constituents. A summary of aspects of the environmental fate of some explosives is presented in Table D-7.

A site-specific investigation into the decomposition of HE used at TA-16 was initiated in the late 1960s. Test cylinders were spiked with HE, loaded into transite tubing, and buried at test plots at TA-11. The amount of HE remaining after four and one-half years (DuBois and Baytos 1972, 15-16-286) and twenty years (DuBois and Baytos 1991, 0718) was measured. Over ninety percent of the TNT had disappeared over twenty years; however, more than seventy percent of the RDX, HMX, and PETN remained.

Layton et al. (1987, 15-16-447) provide a detailed discussion of the distribution of HE in environmental media. They calculate the distribution of a number of HE, including TNT, HMX, RDX, and HE byproducts including DNT and DNB, in reference landscapes using the program GEOTOX. They also summarize existing data confirming HE and HE byproducts at open burn/open detonation sites nationwide.

TABLE D-7

ENVIRONMENTAL FATE OF EXPLOSIVES AND HE BYPRODUCTS

CONSTITUENT OF POTENTIAL CONCERN	WATER SOLUBILITY (mg/L)	Log K_{oc}	HENRY'S CONSTANT (atm-m^3/mol)	ENVIRONMENTAL FATE	PRIMARY LOCATION IN ENVIRONMENT
2-amino-4,6-DNT	2 800 (a)	0.15 (a)	-4 E-9 (a)	Gradual movement through soils and groundwater, should bind to humic acids and other organic matter (a)	Subsurface soils and groundwater (a)
4-amino-2,6-DNT	2 800 (a)	0.26 (a)	-1 E-9 (a)	Gradual movement through soils and groundwater, should bind to humic acids and other organic matter (a)	Subsurface soils and groundwater (a)
1,3-DNB	533 (b)	1.56 (b)	1.8 E-7 (b)	Gradual movement through soils and groundwater (a)	Subsurface soils and groundwater (a)
2,4-DNT	280 (b)	2.4 (b)	1.86 E-7 (b)	Gradual movement through soils and groundwater, diffusion of both vapor and aqueous phases through soil in soils receiving limited water infiltration (a)	Subsurface soils and groundwater (a)
2,6-DNT	206 (b)	1.89 (b)	4.86 E-7 (b)	Gradual movement through soils and groundwater, diffusion of both vapor and aqueous phases through soil in soils receiving limited water infiltration (a)	Subsurface soils and groundwater (a)
HMX	2.6 (a) or 5.0 (a)	2.11 (a)	1 E-16 (a)	Leaching through soils	Subsurface soils and groundwater (a)
PETN	2 (a) or 32 (a)	1.83 (a)	4 E-10 (a)	Leaching through soils	Subsurface soils and groundwater (a)
PE-tri-N	Very soluble (a)	Not available	Not available	Very stable in sunlight, resistant to microbial degradation (a)	Subsurface soils and groundwater (a)
RDX	42.2 (a)	0.89 to 2.43 (a)	6.58 E-12 (a)	RDX does not strongly adsorb to soils and sediments, soil adsorption affects RDX migration only in soils with an organic content >0.25 wt % (a)	Subsurface soils and groundwater (a)
Tetryl	75 (a)	2.43 (a)	2.0 E-12 (a)	Leaching through soils (a)	Subsurface soils and groundwater (a)
1,3,5-TNB	385 (b)	2.82 (b)	9 E-8 (b)	Gradual movement through soils and groundwater (a)	Subsurface soils and groundwater (a)
TNT	123 (a)	2.67 to 3.2 (a)	2.6 E-9 (a)	Migration of TNT is affected in soils with a cation exchange capacity (CAC) >10 meg/100 g; vapor-phase diffusion only important in soils where water infiltration is low (a)	Subsurface soils and groundwater (a)

(a) Layton et al. 1987, 15-16-447
(b) Burrows et al. 1989, 15-16-455

The most important result of the modeling is that all of the HE and HE byproducts are calculated to be distributed into both surface soils (A soil horizons) and subsurface soils (B soil horizons). In the western ecoregion models TNT, DNT, and RDX were all predicted to favor subsurface over surface soils. This modeling may not be directly relevant to TA-16 because a near-surface groundwater reservoir was included in the models.

The compiled data on concentrations of HE and HE byproducts for a wide variety of facilities also suggest that HE is distributed in surface and subsurface soils (Layton et al. 1987, 15-16-447). In general, the actual field data suggest greater concentrations of HE in surface soils than predicted by the GEOTOX modeling.

The implication for TA-16 of these data is that subsurface sampling for HE will be necessary at those sites where HE contamination is likely, such as at TA-16-260 and sump outfalls. However, the lack of evidence for decoupling of surface and subsurface HE suggests that surface screening can be used to locate subsurface HE contamination.

4.0 TOXICITY OF HE CONSTITUENTS

Several of the explosives, co-constituents, degradation products of the explosives, and associated experimental materials are carcinogens and/or systemic toxicants. Nearly all of the potential contaminants may exert their toxic effect (i.e., either carcinogenic and/or systemic effect) through any of the direct routes of exposure (i.e., inhalation, incidental soil ingestion, ingestion of water, and dermal exposure). The exceptions to this include the carcinogenic metals (cadmium, chromium VI, and nickel) and the carcinogenic mineral asbestos, which are considered by the US Environmental Protection Agency (EPA) to be carcinogenic only through the inhalation route of exposure.

Table D-8 lists the potential inorganic contaminants considered by the EPA to be carcinogenic only through the inhalation route of exposure (EPA 1992, 0830). They are placed in order of highest carcinogenicity to lowest carcinogenicity. The class of carcinogen refers to the evidence used to support the carcinogenic classification. For example, the evidence supporting

TABLE D-8

CARCINOGENIC INORGANICS VIA INHALATION – HE DEVICE CONSTITUENTS

CONSTITUENT	CLASS OF CARCINOGEN	TARGET ORGAN
Chromium VI	A	Lung
Asbestos	A	Lung
Cadmium	B1	Respiratory tract

TABLE D-9

CARCINOGENIC CONSTITUENTS VIA ALL ROUTES OF EXPOSURE – HE AND BY-PRODUCTS

CONSTITUENT	CLASS OF CARCINOGEN	TARGET ORGAN FOR ORAL ROUTE
Inorganics		
Beryllium	B2	Multiple organs
Organics		
PAHs (e.g., benzo[a]pyrene)	B2	Stomach
2,4-DNT	B2	Liver
2,6-DNT	B2	Liver
RDX	C	Liver
TNT	C	Bladder

TABLE D-10

ORGANIC SYSTEMIC TOXICS – HE AND BY-PRODUCTS

CONSTITUENT	ORAL RfD (mg/kg/day)	TARGET ORGAN OR EFFECT
1,3,5-TNB	5.00E-5	Spleen
1,3-DNB	1.0E-4	Spleen weight
Nitrobenzene	5.00E-4	Liver, kidney
2,4,6-TNT	5.00E-4	Liver
2,4-DNT	2.00E-3	Neurotoxic
RDX	3.00D-3	Prostate
Tetryl	1.00E-2	Liver, kidney, spleen
HMX	5.00E-2	Liver

the carcinogenic classification of A for a potential contaminant is stronger than that for a constituent with a carcinogenic classification of B.

Table D-9 lists the potential inorganic and organic contaminants that are explosives' components considered by the EPA to be carcinogenic through all direct routes of exposure (EPA 1992, 0830). The target organs identified are for the oral route of exposure. These potential contaminants are placed in decreasing order of carcinogenicity within each class of chemical (i.e., inorganics and organics).

All of the aforementioned constituents have the potential to exert a systemic toxic effect through all direct routes of exposure. However, systemic health criteria have not been developed for all of these constituents. Tables D-10 and D-11 list the constituents, oral target organ designation, and oral reference criteria [i.e., reference dose (RfD) in mg/kg-day] available from

TABLE D-11

INORGANIC SYSTEMIC TOXICS – HE DEVICE COMPONENTS

CONSTITUENT	ORAL RfD (mg/kg/day)	TARGET ORGAN OR EFFECT
Lead	10 ug/dl (blood) [a]	Central nervous system
Cadmium	5.00E-4	Kidney
Uranium	3.00E-3	Kidney
Beryllium	5.00E-3	Not available
Chromium VI	5.00E-3	Central nervous system
Vanadium	7.00E-3	Not available
Cyanide	2.00E-2	Myelin degradation
Nickel	2.00E-2	Decreased body weight
Barium	7.00E-2	Blood pressure
Boron	9.00E-2	Testicular effects
Manganese	1.00E-1	Central nervous system
Nitrite	1.00E-1	Methemoglobemia
Zinc	2.00E-1	Anemia
Copper	1.30E+0	GI irritation
Nitrate	1.60E+0	Methemoglobemia

[a] The blood lead level of 10 ug/dl has been selected as a cutoff for intervention. Lead does not have an RfD because lead does not have a known threshold for the induction of systemic effects (EPA 1990, 15-16-456).

the EPA. An RfD is the highest dose that an individual may receive throughout his lifetime without experiencing an adverse health effect. The more toxic systemic constituents have the lowest RfDs. These constituents are placed in decreasing order of systemic toxicity within each class of chemical (i.e., inorganics and organics).

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APPENDIX G

SAMPLING PROCEDURES FOR MDA-P CLOSURE

APPENDIX G
SAMPLING PROCEDURES

G.1 Procedure for Collection of Rinsate Samples

Rinsate samples will be collected using an open-top stainless steel or polyethylene container or a disposable composite liquid waste sampler (e.g. Coliwasa) or similar equipment. Samples will be collected using the open-top container as follows:

1) Collect rinsate by pouring distilled or deionized water over decontaminated debris.

2) Collect samples for volatile organic compound (VOC) analysis first, by slowly discharging into the sample vials when filling the VOC sample vials. Avoid any agitation that could cause volatilization. Completely fill the vial to eliminate any headspace. This may be achieved by gently pouring the last few drops into the vial so that surface tension holds the water in a convex meniscus. When the cap is applied, some of the overflow may be lost, but the airspace in the bottle should be eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the same procedure. If a second try is required, use a new sample container.

3) To collect composite samples, obtain aliquots from rinsing several pieces of decontaminated debris and combine in a single container. Mix to obtain a uniform composite sample. Then transfer the water from the container to the sample containers. VOC samples should not be composited, due to the potential for VOC loss during the compositing procedure. VOC samples must be collected directly into the VOC sample vials.

4) Ensure that all sample containers are tightly capped. Rinse and dry the sample containers, attach labels and seals, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record.

5) Repeat Steps 1 through 4 until all sample containers for this sample location have been filled.

6) Decontaminate the used sampling equipment. Package and label rags and any other waste material in plastic bags for subsequent disposal.

Rinsate may also be sampled using a Coliwasa or similar equipment. Samples will be collected using the following procedure:

1) Remove the decontaminated sampler from its protective packaging.

2) Open the sampler by pushing the interior rod down to unseat the bottom stopper.

3) Slowly lower the sampler into the liquid at a rate that permits the level of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and will result in a nonrepresentative sample.

4) When the sampler stopper hits the bottom of the liquid container, raise the interior rod to seat the bottom stopper and close the sampler.

5) Slowly withdraw the sampler from the container with one hand and wipe the sampler tube with a disposable cloth in the other hand.

6) Carefully discharge the sample into the appropriate containers by slowly unseating the bottom stopper.

7) Collect the samples for VOC analysis first by slowly discharging into the sample vials when filling the VOC sample vial. Avoid any agitation that could also cause volatilization. Completely fill the vial to eliminate any headspace. This may be achieved by gently pouring the last few drops into the vial so that surface tension holds the water in a convex meniscus. When the cap is applied, some of the overflow may be lost, but

the air space in the bottle should be eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the same procedure. If a second try is required, use a new sample container.

8) Repeat steps 2 through 7 until all sample containers have been filled.

9) Assure that all sample containers are tightly capped. Rinse and dry the sample containers, attach labels and seals to them, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record.

10) Decontaminate the used sampler before collecting the next sample. Package and label rags and any other waste material in plastic bags for subsequent disposal.

G.2 Procedure for Collection of Excavated Soil, Unconsolidated Material, and Tuff Samples

During the excavation of the waste pile, samples of the soil or tuff will be collected from the immediate vicinity of and from within voids of the debris.

A split-spoon sampler will be used with the following procedure:

1) Remove debris material from the sampling site until the top of the soil or pulverized tuff is exposed.

2) Assemble the decontaminated split-spoon sampler.

3) Advance the sampler through the soil or tuff until refusal is reached.

4) Withdraw the sampler from the soil and transfer the sampler to the sample preparation area outside the waste pile but within the exclusion zone. Disassemble the sampler. Split the core lengthwise using a clean stainless steel knife or other appropriate sampling tool.

5) Immediately collect samples for VOC analysis from the bottom 6-in. interval of the core either by slicing vertical segments from the core using a clean stainless steel knife (or other appropriate sampling tool) or by scooping material from the core using a clean stainless steel spoon.

6) Transfer the samples for VOC analysis to appropriate sample containers using a clean stainless steel spoon or other appropriate sampling tool. Tightly pack or fill sample containers as completely as possible to eliminate airspace.

7) Record a description of the underlying soil or tuff in the field log book, including the exact location of the hole and batch number.

8) Collect the remaining samples by obtaining sample material from the remaining interval of the core using a stainless steel spoon or other appropriate sampling tool. If this sample collection technique is not practical, obtain the remaining samples by transferring the bottom 6-in. interval of the core to a decontaminated stainless steel bucket or other appropriate container and mixing until the sample is homogenized. Transfer the samples to appropriate sample containers using a clean stainless steel spoon or other appropriate sampling tool.

9) If additional material is needed to fill sample containers, repeat steps 1 through 8 at a location within the same batch.

10) Ensure that all sample containers are tightly capped. Decontaminate the outside of the containers, attach labels and seals, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record. Place sample containers in plastic bags and place in coolers.

11) Decontaminate the sampler, spoons, knives, pan and other sampling tools before sampling at the next location. Package and label contaminated rags, gloves, and other waste material in double plastic bags or appropriate containers for subsequent disposal.

G.3 Procedure for Collection of Solid Tuff

When necessary, the following procedure will be used for collecting solid tuff samples with a hand-operated electric auger:

1) Remove the decontaminated auger from its protective packaging and attach the drive head.

2) Place a clean sheet of plastic over the tuff and cut a hole for the auger using a clean knife.

3) Drill into the tuff 18 in. at 6-in. intervals using the auger. Allow the cuttings to collect on the plastic sheet. Record in the field log book descriptions of the cuttings from each interval, including the location of the hole and the depth interval.

4) Immediately collect samples for VOC analysis by transferring cuttings from the plastic sheet to appropriate sample containers using a clean stainless steel spoon or other appropriate sample tool. Tightly pack or fill sample containers as completely as possible to eliminate air headspace.

5) Record in the field log book a description of the cuttings including the exact location of the hole and the depth interval.

6) Collect the remaining samples by transferring the sample material to a decontaminated stainless steel bucket or other appropriate container and mixing until the sample is homogenized. Transfer the samples to appropriate sample containers using a clean stainless steel spoon or other appropriate sampling tool.

7) Ensure that all sample containers are tightly capped. Decontaminate the outside of the containers, attach labels and seals, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record. Place sample containers in plastic bags and place in coolers.

8) Decontaminate the auger, spoons, knives, pan, and other sampling tools before sampling at the next location. Package and label contaminated rags, gloves, and other waste material in doubled plastic bags or in appropriate containers for subsequent disposal.

G.4 Procedure for the Collection of Decontamination Sludges

These wastes will be sampled using a thief sampler, sampling trier or scoop, depending on the consistency and quantity of the waste. Samples will be collected using the following procedure:

1) Remove the decontaminated sampler from its protective packaging.

2) Push the sampler down through the waste until the sampler hits the bottom of the container. If a thief sampler is being used, rotate the inner tube to close the sampler. If a trier is being used, rotate the sampler to free it from the waste.

3) Slowly withdraw the sampler from the container with one hand and wipe the outside of the sampler tube with a disposable cloth using the other hand.

4) To collect composite samples, obtain aliquots from the waste containers and combine in a single container. Mix to obtain a uniform composite sample. Then transfer the water from the container to the sample containers. VOC samples should not be composited, due to the potential for VOC loss during the compositing procedure. VOC samples must be collected directly into the VOC sample vials.

5) Open the sampler and immediately collect a sample for VOC analysis. Collect a composite sample for VOC analysis by removing waste from the entire sample profile using a clean stainless steel spoon. After the volatile sample has been collected, transfer the remainder of the sample to a clean stainless steel pan and homogenize it using a stainless steel spoon. Transfer the homogenized sample to appropriate sample containers.

6) Repeat steps 2 through 5 until all sample containers have been filled.

7) Tightly cap the sample containers. Rinse and dry the sample containers, attach labels and seals to them, record sampling information in the field log book and complete the sample analysis request and chain-of-custody record.

8) Decontaminate the sampler, spoon, and pan before collecting the next sample. Package and label rags, gloves, and any other waste material in plastic bags for subsequent disposal.

G.5 Procedure for the Collection of Decontamination Liquids

Decontamination liquid samples will be collected using an open top stainless steel or polyethylene container or a composite liquid waste sampler (e.g. Coliwasa) or similar equipment. samples will be collected using the open top container as follows:

1) Obtain a sample of the decontamination liquid by slowly immersing the open-top sample container and raising it out of the waste. Slowly pour the water into the sample containers.

2) Collect samples for VOC analysis first, by slowly discharging into the sample vials when filling the VOC sample vials. Avoid any agitation that could cause volatilization. Completely fill the vial to eliminate any headspace. This may be achieved by gently pouring the last few drops into the vial so that surface tension holds the water in a convex meniscus. When the cap is applied, some of the overflow may be lost, but the airspace in the bottle should be eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the same procedure. If a second try is required, use a new sample container.

3) To collect composite samples, obtain aliquots from the liquid waste containers and combine in a single bucket. Mix to obtain a uniform composite sample. Then transfer the water from the bucket to the sample containers. VOC samples should not be

composited, due to the potential for VOC loss during the compositing procedure. VOC samples must be collected directly from the individual waste container.

4) Ensure that all sample containers are tightly capped. Rinse and dry the sample containers, attach labels and seals, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record.

5) Repeat Steps 1 and 2 until all sample containers have been filled.

6) Decontaminate the used sampling equipment. Package and label rags and any other waste material in plastic bags for subsequent disposal.

Decontamination liquid may also be sampled using a coliwasa or similar equipment. Samples will be collected using the following procedure:

1) Remove the decontaminated sampler from its protective packaging.

2) Open the sampler by pushing the interior rod down to unseat the bottom stopper.

3) Slowly lower the sampler into the liquid at a rate that permits the level of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and will result in a nonrepresentative sample.

4) When the sampler stopper hits the bottom of the liquid container, raise the interior rod to seat the bottom stopper and close the sampler.

5) Slowly withdraw the sampler from the container with one hand and wipe the sampler tube with a disposable cloth in the other hand.

6) Carefully discharge the sample into the appropriate containers by slowly unseating the bottom stopper.

7) Collect the samples for VOC analysis first by slowly discharging into the sample vials when filling the VOC sample vial. Avoid any agitation that could also cause volatilization. Completely fill the vial to eliminate any headspace. This may be achieved by gently pouring the last few drops into the vial so that surface tension holds the water in a convex meniscus. When the cap is applied, some of the overflow may be lost, but the air space in the bottle should be eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the same procedure. If a second try is required, use a new sample container.

8) Repeat steps 2 through 7 until all sample containers have been filled.

9) Assure that all sample containers are tightly capped. Rinse and dry the sample containers, attach labels and seals to them, record the sample information in the field log book and complete the sample analysis request and chain-of-custody record.

10) Decontaminate the used sampler before collecting the next sample. Package and label rags and any other waste material in plastic bags for subsequent disposal.

APPENDIX I

SITE SPECIFIC STANDARD OPERATING PROCEDURES

Engineering and Sciences Applications (ESA) Division

Weapon Materials Applications (WMA) Group

STANDARD OPERATING PROCEDURE (SOP)

for

SOIL AND WATER SAMPLING OPERATIONS

TA-16 HIGH EXPLOSIVE EXCLUSION AREA

Contents

1.0 SCOPE 2

2.0 LOCATION 2

3.0 DEFINITIONS 2

4.0 HAZARDS AND PRECAUTIONS 3

5.0 TRAINING 4

6.0 USE OF HE SPOT TEST KIT FOR HE CONTAMINATION TESTING 4

7.0 SAMPLING PLAN AND APPROVAL 4

8.0 TRANSPORT AND SHIPMENT OF HE SAMPLES 7

1.0 SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide operational guidelines for personnel taking surface soil samples, subsurface soil samples, and water samples in Engineering Sciences and Applications (ESA) Division, Weapons Material Applications (WMA) Group controlled High Explosive (HE) Exclusion areas specified in Section 2.0. Soil and outfall water at Group ESA-WMA HE exclusion areas have the potential to contain HE in the form of observable pieces, particulate matter in the soil, particulate matter in water, and as a dissolved contaminant in water. This SOP contains the procedures required for both shipment of HE soil/water samples to locations within LANL for analysis and to an off-site location for additional analysis. Group ESA-WMA must approve of all off-site locations to which HE samples are to be shipped as specified in Section 8.0. All personnel entering the HE Corridor area to survey, perform preliminary assessments, collect samples, and/or remediate an area, must complete the training specified in Section 6.0 of this SOP and strictly adhere to the guidelines established in this SOP. A Group ESA-WMA designated Safety Monitor must accompany sampling personnel during all field operations and sampling operations.

2.0 LOCATION

The guidelines shall be followed by all personnel performing field operations and/or taking soil/water samples in Group ESA-WMA controlled locations at TA-8, 11, 16, 28, and 37.

3.0 DEFINITIONS

a. Field Operations: Any activity to be performed in the field, including, but not limited to, visual reconnaissance, RCRA Field Investigations (RFI) sampling, and remedial actions.

b. Hazard Circles: The area in which hazards resulting from explosives firing or other explosive operations are present.

c. HE Spot Test Kit: The "HE spot test kit" is a kit containing collection chemical test developed by DX-16 to detect finely distributed explosives (>100 ppm) in particulate or liquid samples. The HE spot test will detect the presence of all high explosives currently and previously used at TA-16 down to 100 ppm, however, will not quantify the amount of HE present. The HE spot tests are approved only for homogeneous-type samples and cannot be used reliably for heterogeneous-type soil samples.

d. Homogeneous Soil Sample Location: A homogeneous soil sample location is an area that contains explosive materials well dispersed within the desired sample volume with high solubility such that the explosives could be detected by the HE spot test.

e. Heterogeneous Soil Sample Location: A heterogeneous soil sample location is a location that contains randomly dispersed pieces of explosives that are not well

dispersed in a sample volume and cannot be detected reliably using the HE spot test kit. The explosive pieces may be in large chunks or in small pieces, and may be on the surface or buried. These areas constitute a potentially more hazardous situation. The TA-11 Drop Tower area is a heterogeneous type sampling area. If pieces of explosives are present on the surface of the sampling area, the area shall be classified as a heterogeneous area. Samples testing positive with the HE spot test kit or those in which visible pieces of HE are found from heterogeneous areas must be submitted to DX-16 for laboratory analysis.

f. Sampling Area: A specific location defined by the sampling organization at which a specified number of samples will be taken. Examples of a sampling "area" are a 12" by 12" area beneath an outfall pipe, a 6' wide by 100' long segment of a stream bed, or a 300' by 300' area which at one time contained a structure or facility.

4.0 HAZARDS AND PRECAUTIONS

Impact, pinch points, heat, spark, and flame have the potential to initiate explosives. Age and exposure to other substances have the potential to change the sensitivity of explosives. High explosives and components containing high explosives can be present in many colors and exist in many components in a manner that the presence of explosives will not be obvious. Strict guidelines are established for obtaining samples, handling of potentially HE contaminated samples, picking up or removal of any unknown item or component in the HE exclusion areas, and transport of HE contaminated samples within LANL or to an outside location. The following requirements will be strictly enforced for all sampling operations:

a. As a general rule, implements (shovels, troughs, hoes, etc.) used to obtain samples should be made of non-ferrous materials, such as aluminum or plastic. This will reduce the potential of producing a spark during sampling operations. However, it is realized that ferrous implements may be required for some sampling operations, such as deep soil sampling. Operations that require ferrous sampling equipment must be described in the sampling plan as described in Section 7.0 and will be approved on an individual basis. All ferrous and non-ferrous implements used during sample collection must be specifically described in the sampling plan as detailed in Section 7.0.

b. Containers used to store samples shall not have metallic lids that screw onto glass or plastic containers or other type of containment mechanism that allow "pinch points" between metal to metal, metal to glass, or metal to other material. Plastic bottles with plastic screw-on lids are acceptable for sample containment.

c. Heat sources, open flame or spark producing devices are strictly prohibited from entry to the HE corridors sampling areas.

d. Chunks of explosives and any components, materials, or objects found during sampling operations shall not be handled or removed. If the object or component is an explosive,

detonator, or component containing explosives, the sensitivity may be increased from exposure to the weather or mixture with unknown materials at the location. The only items that will be allowed to be removed from the sampling locations are the samples contained in sample containers.

e Existing HE processing operations can pose a hazard for sampling operations. Many of the locations that contain HE contaminated soil are located behind operational facilities. Sampling operations within the existing hazard circles for these facilities will not be permitted during operation of the facility. The time of sampling must be specified in the sampling plan so that the sampling schedule can be worked out with the operating facility Building Managers.

Authorized personnel from the host group governing the sampling location must approve all samples leaving the sample location, whether HE contaminated or not.

5.0 TRAINING

All personnel entering the Group ESA-WMA controlled areas to perform field operations shall complete both the Safety Overview Course and ESA-WMA Site-Specific training. The HE Safety Overview Course is a 1-2 hour briefing on the hazards associated with high explosives and the general rules for working in areas where HE may be present. A test is administered at the conclusion of the HE Safety Overview Course. The site-specific training consists of an additional training course and along with SOP/procedure reading. The site-specific training will be conducted by Group ESA-WMA training personnel. A signature of understanding and abidance is required upon completion of the site-specific training.

It is the responsibility of the FPL (Field Project Leader for Environmental Restoration) or a designee of the FPL to arrange and schedule both the Safety Overview Course and Site Specific training.

6.0 USE OF HE SPOT TEST KIT FOR HE CONTAMINATION TESTING

All personnel performing "HE spot tests" on potentially contaminated soil and/or other samples shall complete the DX-16 training course on the use of the HE spot test field kit. When performing the HE spot test, the sample to be tested must consist of approximately 1 gram. The entire 1 gram sample must be saturated with the test chemicals for a valid test result. "Swiping" of the soil sample for HE contamination testing will not be considered as a valid HE contamination test.

7.0 SAMPLING PLAN AND APPROVAL

A flowchart for the complete process required for sample collection is included as Attachment A. Upon completion of all of the training requirements specified in Section 5.0 and 6.0, the following steps must be followed to collect, analyze, and approve off-site release of collected samples.

a. Submit a "sampling plan" to the host group. The sampling plan must include the exact location, type of sampling (surface, subsurface, or water), depth of sampling if sampling is subsurface, quantity of samples, constituents that sample will be analyzed for, description of equipment or apparatus that will be used to obtain the sample, and date/time at which the sampling will occur. The sampling plan must specifically define the sampling "area" or "areas" (See definition of "area" in Section 3.0) and include the number of samples required in each "area".

b. Group ESA-WMA will review the sampling plan and determine which of the following categories the location falls into: Area generally accepted a free from HE contamination; low to negligible probability of HE contamination area, or area with potential HE contamination. The areas that potentially contain HE contamination will be further divided into "homogenous" or "heterogeneous" contaminated areas. A description of each of the areas and the criteria that the host group will use to determine what category the location falls under is as follows:

1. **Areas Generally Accepted as Free of Explosive Contamination:** If there is substantial historical data, direct knowledge, or if data from an existing or previous sampling program rule out the possibility of potential HE contamination, the host group can declare the location free of HE contamination and host group personnel can authorize the release of samples from the site for further analysis.

2. **Low to Negligible Probability of HE Contamination Area:** These areas are locations not known to have been exposed to explosives, however, have the remote possibility of containing homogeneous or heterogeneous soil mixtures. In conjunction with the requester, the host group or personnel designated by the host group as acceptable to use the HE spot test kit, will perform reconnaissance sampling using the HE spot test kit and visual examination. A visual examination at these areas can rule out the possibility of heterogeneous-type contamination. Negative results for all samples at the location and depths of the final sampling locations will rule out the possibility of homogeneous contamination. Negative results from both the visual examination and the spot test at all locations will allow the samples to be released off -site upon approval from the host group. **If the visual examination by the HE expert results in HE material or any of the HE spot tests are positive, the location must be considered as a potential HE**

contamination area The size of the area will be determined by the HE expert

3 **Potential HE Contamination Area:** These are locations that may contain HE contamination in either a homogeneous or heterogeneous nature These locations include such areas as firing mounds, stream beds and/or drainages from sites with known contamination, and outfalls from HE processing facilities. The host group will determine if the location is a homogeneous or heterogeneous location and the policy for sampling at these locations will be

Homogeneous Area: As defined by Group ESA-WMA, samples from these areas are treated on an individual basis. Samples that test negative using the HE spot test kit are considered non-contaminated and therefore a non-explosive. Such samples can be approved for removal from the sampling site by the host or operating group All samples testing positive for HE using the spot test kit must be further analyzed by either Group DX-16 or the Group ESA-WMA approved mobile field laboratory for quantitative HE analysis Transport of the samples to Group DX-16 must be done as specified in Section 8.1. The mobile field van will be located in the HE exclusion area near the sampling site *If the quantitative analysis determines that the total explosive content is > 5% **or** the spot test indicates positive on the sample after all HE constituents (except TATB) have been extracted and quantified, the sample must be transported to any LANL or off-site location as an explosive as specified in Section 8.2. If the quantitative analysis determines that the total explosive content is < 5% **and** the spot test indicates negative after all HE constituents (except TATB) have been extracted and quantified, the sample can be shipped to a LANL or off-site location as a non-explosive.

* **Note**: At the present time, a laboratory method is not available to quantify TATB explosives in a sample even though the presence of TATB in the sample will show up using the HE spot test. ESA-WMA will require that all samples containing TATB (as determined using the HE spot test on the sample after all other explosives have been extracted and quantified) be handled and shipped as an explosive until a laboratory method for quantitative analysis is available. LANL group DX-16 is currently working on a quantitative analysis method for TATB. This method is expected to be available by February, 1995.

Heterogeneous Area: If the historical data or authorized Group ESA-WMA personnel determine that the location is contaminated in a heterogeneous manner all samples from a specific area must be tested for HE using the HE spot test (See definition of "area" in Section 3.0) If **any** of the samples from the sample "area" (as defined in the sampling plan) test positive for HE or if HE is present on the surface of the sampling area, **all** samples

from the area must considered to be HE contaminated and be submitted to either Group DX-16 or the Group ESA-WMA approved mobile field laboratory for quantitative analysis. The sample must be homogenized before HE constituent analysis can be performed. *If the quantitative analysis determines that the total explosive content is > 5% **or** the spot test indicates positive on the sample after all HE constituents (except TATB) have been extracted and quantified, the sample must be transported as an explosive to any LANL or off-site location as specified in Section 8.2. If the quantitative analysis determines that the total explosive content is < 5% **and** the spot test indicates negative after all HE constituents (except TATB) have been extracted and quantified, the sample can be shipped to a LANL or off-site location as a non-explosive.

For sampling operations that will involve removing or accessing soil at depths greater than 6 inches, an excavation permit from Group HS-3 will be required. The excavation permit can be obtained directly from Group HS-3 upon Group ESA-WMA approval of the sampling plan.

8.0 TRANSPORT AND SHIPMENT OF HE SAMPLES

Soil and water samples that contain a cumulative explosive content of greater than 5% or samples that contain TATB shall be treated as explosives when shipping off site for further analysis. Soil and water samples that contain a cumulative explosive content of 5% or less, and which do not contain TATB, can be treated as a non-explosives when shipping to a LANL or off-site location. LANL Administrative Requirement (AR) 6-6, "Explosives", specifically details the requirements that shall be followed for shipment of explosives both within the LANL and outside of LANL. HE samples (>5% or those which contain TATB) that are shipped to a location outside of LANL can only be shipped to a Group ESA-WMA approved location. Group ESA-WMA technical personnel will ensure that the off-site laboratory will store, handle, and analyze the HE samples in accordance with the DOE EV-6194 Explosive Safety Manual requirements for laboratory operations. A maximum of 500 grams of explosive (cumulative total within soil samples) can be shipped and/or stored at the off-site laboratory at a single time. Sampling personnel will be required to keep ESA-WMA informed of the total quantity of explosives (as determined by quantitative analysis) that will be located at the outside laboratory an any one time. ESA-WMA will request that the outside laboratory have documented disposal methods for HE extracted from the samples for analysis.

Samples that contain 5% or less, and which do not contain TATB, can be shipped to off-site locations as a non-hazardous commercial shipment. A copy of the paperwork for shipment of all samples (both HE and non-HE contaminated) to an off-site organization for analysis must be sent to the CST-9 Sample Control Center.

8.1 TRANSPORT OF EXPLOSIVES SAMPLES TO GROUP DX-16: The transport of HE contaminated and potentially HE contaminated samples to Group DX-16 at TA-9-21 or TA-16-460 shall be done in strict accordance with AR 6-6, "Explosives", and

ESA-WMA (WX-3) SOP 13.1.0, "General Explosives Transportation Procedures". AR 6-6 specifies the general guidelines that are to be followed and WX-3 SOP 13.1.0 defines the specific personnel, vehicles and procedures that will be used in the transport of HE and potentially HE contaminated samples to TA-9-21 or TA-16-460. Sampling personnel are not qualified to transport HE contaminated and potentially HE contaminated samples from the sampling location to TA-9 or TA-21. Because the cost of transporting samples will fall on the organization taking the samples, it is requested that all of the samples from a specific HE exclusion area be transported to Group DX-16 at one time, and upon completion of sampling at the location.

If the mobile field laboratory is used for quantitative analysis, the field laboratory must be located at the HE sampling site. HE samples (>5% or which contain TATB) cannot be transported by the mobile field laboratory when leaving the site.

8.2 SHIPMENT OF EXPLOSIVES SAMPLES TO AN OFF-SITE LOCATION: The transport of HE contaminated samples (>5% or which contain TATB) to an off-site Laboratory or location must be done in strict accordance with LANL Hazardous Materials Transportation Manual and LANL AR 6-6. All explosives shipments to locations outside of LANL shall be arrange by Group MAT-14 as specified in AR 6-6. Sampling personnel are strictly prohibited from transporting or authorizing shipment of HE contaminated samples to a destination or location outside of the Laboratory. The cost of shipping the samples to the outside location will be paid for by the organization requesting the analysis.

REVIEW AND APPROVALS

Prepared by:	E. M. Hyde, ESA-WMA	(Signature)	(Date)
Technical Review by	D. Hemphill, ESA-WMA	(Signature)	(Date)
Technical Review by	Explosive Review Committee	(Signature)	(Date)
Approval	R. D. Taylor, ESA-WMA	(Signature)	(Date)
Approval	L. E. Hatler, ESA-WMA	(Signature)	(Date)
Approval	L. Stretz, ESA-WMA	(Signature)	(Date)
Approval	R. Goldie, ESH-5	(Signature)	(Date)

S-SITE SAFETY REGULATIONS

SAFETY REGULATION NUM:SR0146 JOB NAME: CLEAN-UP AREA "P" BURNING GROUNDS

LANL JOB ORDER: LAB JOB: OTHER:

EACH PERSON FOLLOW THOSE WX-03 SOPS AND SUPPLEMENTAL REQUIREMENTS THAT RELATE TO HIS/HER ACTIVITIES ON THE JOB:

A. ADMINISTRATIVE & SUPERVISORY LIST - REQUIREMENTS LISTED BELOW ARE OF SPECIAL INTEREST TO THOSE WHO MAKE ARRANGEMENTS PRECEDING FIELD ACTIVITIES.

	WX-03 SOP REFERENCES 24	OTHER SOP
SCHEDULING OF ACTIVITIES	III.B	
DEVIATIONS FROM SOPS AND SRS	IV.A.1	
TEMPORARY INCREASED PERSONNEL LIMITS		1.8.0
SAFETY WORK PERMITS		1.5.0
MATERIALS - H.E. COMPATABILITIES	IV.B.1	
VEHICULAR EQUIPMENT CONDITION	IV.C.1	
WORK ZONES NEAR BLOWOUT WALLS	IV.D.2	
DISPOSAL - SCRAP, WASTE, SURPLUS	IV.G.2	
PROTECTIVE APPAREL	IV.H.1	1.0.9.II.A.F
EYE PROTECTIVE DEVICES		1.9.0
FIELD OFFICES	IV.J	

B. FIELD ACTIVITIES LIST-REQUIREMENTS LISTED BELOW ARE EQUALLY IMPORTANT TO ALL PERSONS ENGAGED IN FIELD ACTIVITIES.

POSTED PERSONNEL LIMITS	IV.A.2	
NOTIFICATIONS TO BUILDING SUPERVISOR	IV.A.2	
SMOKING	IV.A.3	1.6.0
FOOD/BEVERAGES IN EXPLOSIVES AREA		1.0.9.VI
SOLVENT USE	IV.B.3	
VEHICULAR TRAFFIC	IV.C.2	
TEMPORARY HAZARDS AREAS	IV.D.1	
LIMITED EGRESS.CONFIRMED SPACES		5.10.0
ELECTRICAL CIRCUIT EXPOSURE	IV.E.3	
EQUIPMENT/MATERIAL REMOVAL, H.E. AREA		1.1.0.III.B.1
WORK ON/WITH CONTAMINATED ARTICLES	IV.G.1	
CONFINING ABRASIVES PARTICLES	IV.G.4	
IN-PROCESS H.E. REMOVAL	IV.I.1	
WORK ZONE BOUNDARY LIMITS	IV.I.3.A	
UNOBSTRUCTED TRAFFIC ROUTES	IV.I.3.B	
WORK ZONE CLEANING	IV.I.4	
WORK ZONE CERTIFICATIONS	IV.I.5.A	
CERTIFYING AGENT SUPERVISION	IV.I.5.B	

C. SUPPLEMENTAL SAFETY REQUIREMENTS: ✓ YES ___ NO

SUBMITTED BY : MCCORMICK
SUBMITTED DATE : 12/06/94
APPROVED BY : STRETZ
APPROVED DATE : 12/06/94

APPLIED SUPPLEMENTAL SAFETY REQUIREMENTS

(IF BLANK, NO REQUIREMENTS WERE APPLIED)
(PRESS RETURN TO CONTINUE)

1. LOCATION OF TRAILER FOR FIELD OFFICE WILL BE ON THE NORTH EAST SIDE OF BURNING PAD 16-387. THE EXISTING TRANSPORTAINER WILL BE RELOCATED TO THE ORIGINAL LOCATION AFTER JOB COMPLETION.

2. THE FIELD OFFICE WILL BE THE PURPOSE OF TAKING BREAKS, LUNCH AND WATER DRINKING. ALL FOOD AND DRINKS MUST BE CONSUMED IN THE OFFICE TRAILER AND NOT IN ANY OTHER LOCATION OUTSIDE.

3. THE FIELD OFFICE MAY BE USED AS A SMOKE BREAK AREA IN ONE SECTION. A LIGHTER SYSTEM FOR THE SMOKE AREA WILL BE FURNISHED. MATCHES ARE NOT ALLOWED IN THE EXCLUSION AREA.

4. FIELD OFFICE WILL BE SUPPLIED WITH CUSTODIAL SERVICE OR THE FIELD OFFICE EMPLOYEES WILL BE REQUIRED TO MAINTAIN CLEANLINESS OF THE AREA.

5. THE USE OF RADIOS OR CELLULAR TELEPHONE WILL BE CLEARED THROUGH THE SAFETY OFFICE FOR ESA-WMA AND OPERATION RULES ISSUED WILL BE FOLLOWED.

6. SAFETY WORK PERMITS AND OTHER PERMITS DEEMED NECESSARY WILL BE ISSUED BY ESA-WMA SAFETY OFFICE AND THE OTHER LANL SAFETY GROUPS.

7. PRIVATE AND COMPANY VEHICLES WILL NOT BE ALLOWED TO ENTER THE HIGH EXPLOSIVE AREA (H.E.) WITHOUT APPROVAL BY ESA-WMA SAFETY OFFICE OR ESA-WMA GROUP OFFICE. A DESIGNATED AREA FOR PARKING OF THESE VEHICLES WILL BE ESTABLISHED BY ESA-WMA SAFETY OFFICE.

8. ANY NECESSARY CHANGES TO THIS SAFETY REGULATION WILL BE DISCUSSED AND ADDED AS REQUIRED.

9. THE SOP's, SAFETY REGULATIONS AND PERMITS MUST BE POSTED IN THE FIELD OFFICE TRAILER.

10. BUILDING 340, SOUTHEAST END, WILL BE USED FOR A SECOND FIELD OFFICE AREA AND TEMPORARY STORAGE FOR MISC. MATERIALS REMOVED FROM BURNING GROUND.

SAFETY REGULATIONS

SOP 04.III: SCHEDULING OF ACTIVITIES

RESPONSIBILITIES

A. OPERATING GROUPS: DEVELOPMENT OF SOP'S FOR THEIR AREAS.

B. WX-12

1. IN SCHEDULING CONTRACTOR ACTIVITIES, ASSURE THAT SAFETY REQUIREMENTS ARE FULLY DETERMINE THROUGH:

   A. EXISTING SOP'S

   B. DEVELOPMENT OF SR'S

2. ADVANCES APPROVAL OF SCHEDULES FOR ROUTINE INSPECTIONS, AND MAINTENANCE, SERVICES.

3. RESOLUTION OF CONFLICTS BETWEEN CONTRACTOR ACTIVITIES AND S-SITE OPERATIONS.

4. IF NECESSARY, EFFICIENT REMOVAL OF EXPLOSIVES.

C. SUPERVISORY ORGANIZATION OF CONTRACTOR PERSONNEL: TELL THEIR PERSONNEL ABOUT SAFETY REQUIREMENTS; SEE THAT THE PERTINENT PROVISIONS OF SOP'S AND SR'S ARE FOLLOWED.

TION WX-03 SOP 1.9.0.IV.C.1 AND D) MAY BE COMBINED AND INCLUDED WITH THIS REQUEST FOR TEMPORARY PERSONNEL LIMITS.

D. A FIVE-PART SPEED LETTER MAY BE USED BY THE REQUESTER. IT SHOULD BE ADDRESSED TO THE WX-03 GROUP LEADER AND MARKED FOR THE PROPER DISTRIBUTION, AS FOLLOWS:

1. REQUESTER (FILE)

2. APPROPRIATE SECTION LEADER(S)

3. APPROPRIATE BUILDING SUPERVISOR(S)

4. WX-03 DEPUTY GROUP LEADER

E. ALL COPIES ARE TO BE SUBMITTED BY THE REQUESTER. APPROVAL WILL BE GRANTED, WITH ANY CONDITIONS OF APPROVAL, ON THE SPEED LETTER. THE COPIES WILL BE DISTRIBUTED BY THE REQUESTER.

SAFETY REGULATIONS

SOP 1.5.0: SAFETY WORK PERMITS

SAFETY WORK PERMITS

I. SCOPE

THIS SOP GOVERNS THE ISSUANCE OF SAFETY WORK PERMITS FOR THE TRANSPORT AND USE OF MATCHES, LIGHTERS, SPARK- OR FLAME-PRODUCING DEVICES, ELECTRIC TOOLS NOT APPROVED FOR OPERATION IN HAZARDOUS LOCATIONS, OR DEVICES WHOSE SURFACE TEMPERATURE WILL EXCEED 228 DEGREES F (109 DEGREES C) WITHIN S-SITE.

II. LOCATION

ALL AREAS AT S-SITE. SEE WX-03 SOP 1.0.0 II

III. DEFINITIONS

A. MAINTENANCE ZONE

A MAINTENANCE ZONE IS ANY LOCATION WITHIN THE EXPLOSIVES AREA WHERE NORMAL MAINTENANCE ACTIVITIES ARE TO BE CONDUCTED.

B. CONSTRUCTION ZONE

A CONSTRUCTION ZONE IS ANY LOCATION WITHIN THE EXPLOSIVES AREA IN WHICH MAJOR CONSTRUCTION OR EXTENSIVE MAINTENANCE WORK IS TO BE DONE, AND IN WHICH AN OPERATING GROUP WILL NOT BE OPERATING. THIS AREA WILL BE THOROUGHLY CLEANED, INSPECTED, AND CERTIFIED BEFORE BEING TURNED OVER TO THE CONTRACTOR FOR SUCH WORK.

C. MAINTENANCE TRUCK

A MAINTENANCE TRUCK IS A VEHICLE THAT HAS WELDING AND BURNING EQUIPMENT PERMANENTLY MOUNTED UPON IT, OR NORMALLY CARRIES ITEMS CONTROLLED BY THIS SOP. SUCH TRUCKS ARE OFTEN USED ONLY AS A MEANS OF TRANSPORTATION TO AND FROM A JOB SITE.

D. HEAT SOURCES

HEAT SOURCES ARE THOSE ITEMS THAT ARE CONTROLLED BY THIS SOP AND ARE USUALLY MATCHES, LIGHTERS, SPARK- OR FLAME-PRODUCING DEVICES, ELECTRIC TOOLS NOT APPROVED FOR OPERATION IN HAZARDOUS LOCATIONS, OR DEVICES WHOSE SURFACE TEMPERATURE WILL EXCEED 228 DEGREES F (109 DEGREES C).

E. SAFETY WORK PERMIT (FORM WX-3-760)

A SAFETY WORK PERMIT IS A PROPERLY SIGNED DOCUMENT THAT GIVES PERMISSION, WITHIN STATED TIME LIMITS FOR A SPECIFIC JOB AND LOCATION, TO TRANSPORT AND USE HEAT SOURCES WITHIN THE CONTROLLED AREAS LISTED BELOW.

IV. CONTROLLED AREAS

A. ADMINISTRATIVE AREA

THE USE OF HEAT SOURCES WITHIN AN AREA THAT IS EQUIPPED WITH SMOKE DETECTORS WILL REQUIRE A SAFETY WORK PERMIT.

B. EXPLOSIVES AREA

A SAFETY WORK PERMIT WILL BE REQUIRED FOR THE TRANSPORT AND USE OF HEAT SOURCES WITHIN THE EXPLOSIVES AREA.

V. TYPES OF SAFETY WORK PERMITS

A. DAILY

A DAILY WORK PERMIT WILL BE ISSUED FOR MAINTENANCE AND CONSTRUCTION ACTIVITIES ON A DAY-TO-DAY BASIS. THIS PERMIT WILL BE GOOD FOR ONLY ONE DAY.

B. EXTENDED TIME

AN EXTENDED TIME PERMIT MAY BY ISSUED FOR A CONSTRUCTION ZONE. THE PERMIT WILL CAREFULLY DESIGNATE THE CONSTRUCTION ZONE AND WILL SPECIFY A FIXED TIME LIMIT.

C. ANNUAL

ANNUAL PERMITS MAY BE ISSUED BY THE WX-12 PLANT AND EQUIPMENT SERVICES SECTION FOR MAINTENANCE TRUCKS WITHIN THE EXPLOSIVES AREA. THE ANNUAL PERMIT WILL AUTHORIZED THE USE OF THE TRUCK WITHIN THE EXPLOSIVES AREA ONLY AS A MEANS OF TRANSPORTATION. THE USE OF THE HEAT SOURCE EQUIPMENT CONTAINED THEREON WILL REQUIRE AN ADDITIONAL SAFETY WORK PERMIT OR A SPECIAL WORK PERMIT (HSE FORM 8-4A). AN ANNUAL PERMIT MAY ALSO BE ISSUED FOR ZONES WITHIN THE EXPLOSIVES AREA THAT ARE NOT USED FOR EXPLOSIVES OPERATIONS AND ARE NOT CONTAMINATED WITH EXPLOSIVES, WHEN HEAT SOURCES ARE REQUIRED FOR ROUTINE OPERATIONS CONDUCTED IN THESE ZONES.

VI. APPROVALS

A. ORIGINATOR

ONE OF THE PERSONS LISTED IN APPENDIX A MUST ISSUE AND SIGN EACH SAFETY WORK PERMIT. HE MUST HAVE AN INTIMATE KNOWLEDGE OF THE WORK TO BE PERFORMED, AND BEFORE HE SIGNS THE PERMIT HE MUST DO THE FOLLOWING THINGS:

1. DETERMINE WHETHER THE USE OF A HEAT SOURCE IS NECESSARY TO ACCOMPLISH THE WORK PROPOSED.

2. ASSURE HIMSELF THAT THE USE OF THE EQUIPMENT WILL NOT CREATE A HAZARD.

3. ASSURE HIMSELF THAT THE CRAFTSMAN IS AWARE OF THE SAFETY PROBLEMS INVOLVED IN USING A HEAT SOURCE IN THE PROPOSED ZONE.

4. DESIGNATE WHAT HEAT SOURCES ARE ALLOWED UNDER THIS PERMIT AND THE WORK ZONE IN WHICH IT MAY BE USED.

5. INDICATE WHAT FURTHER SIGNATURES ARE NEEDED ON THE PERMIT. THE FOLLOWING EXAMPLES ARE TYPICAL:

A. ORIGINATOR ONLY - ANNUAL PERMITS, AND PERMITS FOR ROAD WORK, UTILITY DISTRIBUTION SYSTEMS, OR OTHER WORK AWAY FROM BUILDINGS.

B. ORIGINATOR AND CERTIFYING AGENT - PERMITS FOR CONSTRUCTION ZONES.

C. ORIGINATOR AND LEAD OPERATOR - PERMITS FOR MAINTENANCE ZONES.

D. ORIGINATOR, CERTIFYING AGENT, AND LEAD OPERATOR - PERMITS FOR MAINTENANCE WORK IN OPERATING SECTIONS OF BUILDINGS AND TEST AREAS.

B. AUTHORIZED CERTIFYING AGENT

THE AUTHORIZED CERTIFYING AGENT WILL SIGN PERMITS WHEN REQUESTED BY THE ORIGINATOR. HIS SIGNATURE WILL CONFIRM THAT HE HAS CERTIFIED THE WORK ZONE FREE OF DANGEROUS AMOUNTS OF H.E. AND THAT IT IS SAFE TO USE STATED HEAT SOURCES IN THE AREA SPECIFIED. THE NAMES OF THE AUTHORIZED CERTIFYING AGENTS ARE LISTED IN APPENDIX A.

C. LEAD OPERATOR

THE BUILDING LEAD OPERATOR WILL SIGN ALL PERMITS FOR WORK TO BE DONE WITHIN HIS BUILDING OR IN THE IMMEDIATE VICINITY OF THE BUILDING. HIS SIGNATURE WILL CONFIRM THAT HE IS AWARE THAT THE WORK IS TO BE DONE AND THAT THE USE OF THE HEAT SOURCE WILL NOT ENDANGER PERSONNEL OR PROCESSING OPERATIONS.

VII. ADMINISTRATION PROCEDURE

A. FORMS

EACH ORIGINATOR WILL HAVE A BOOK OF FORMS WHICH ARE ONE-TIME CARBON SNAP-OUT-TYPE, IN TRIPLICATE, NUMBERED, IN BOUND BOOKS WITH WRAP-AROUND COVERS. THE DISTRIBUTION OF THE PERMIT WILL BE AS FOLLOWS:

1. ORIGINAL COPY TO THE CRAFTSMAN WITH VERBAL INSTRUCTIONS FOR OBTAINING THE ADDITIONAL SIGNATURES INDICATED ON THE SAFETY WORK PERMITS.

2. REMAINING COPIES TO KEPT BY THE ORIGINITOR.

B. EXPIRED PERMITS

UPON COMPLETION OF THE WORK, OR EXPIRATION OF THE PERMIT, THE PERMIT WILL BE RETURNED TO THE WX-DIVISION SERVICE AND ACCESS CONTROL OFFICE, BUILDING TA-16-202.

APPENDIX A

A. THE PERSONS LISTED BELOW ARE AUTHORIZED TO ISSUE AND SIGN SAFETY WORK PERMITS FOR USE IN TECHNICAL AREAS 11, 16, 28, AND 37.

T. E. CHANDLER

R. L. HENDERSON
B. G. MCCORMICK
D. J. SHARPLESS
F. J. TAPIE

B. THE PERSONS LISTED BELOW ARE AUTHORIZED CERTIFYING AGENTS.

H. L. KELLER
B. G. MCCORMICK
D. J. SHARPLESS
J. MARTINEZ
F. J. TAPIE

THE TECHNICAL SUPERVISOR, OR ACTING TECHNICAL SUPERVISOR, FOR EACH OF THE BUILDINGS LISTED BELOW MAY ACT AS THE AUTHORIZED CERTIFYING AGENT IN THE SPECIFIC BUILDING FOR WHICH THEY ARE RESPONSIBLE.

BUILDING TA-16-370
BUILDING TA-16-304
BUILDING TA-16-306
BUILDING TA-16-450

C. THOSE PERSONS LISTED IN ITEM A, ABOVE, WHO ISSUE A SPECIFIC SAFETY WORK PERMIT MUST NOT BE THE CERTIFYING AGENT FOR THE PERMIT AND MUST NOT SIGN THE PERMIT AS THE AUTHORIZED CERTIFYING AGENT.

SAFETY REGULATIONS

SOP 24.IV.B.1: MATERIALS - H.E. COMPATABILITIES

REQUIREMENTS

B. COMPATIBLE MATERIALS AND CHEMICALS - ANY QUESTIONS ABOUT THE FOLLOWING SHOULD BE HANDLED THROUGH THE AUTHORIZED CERTIFYING AGENT.

1. MATERIALS OR CHEMICALS NOT ALREADY APPROVED AS COMPATIBLE WITH EXPLOSIVES WILL REQUIRE APPROVAL BY M-1 PRIOR TO THEIR USE.

SAFETY REGULATIONS

SOP 04.IV.C.1: VEHICULAR EQUIPMENT CONDITION

VEHICLES

1. VEHICLES MUST BE IN GOOD OPERATING CONDITION.

SAFETY REGULATIONS

SOP 24.IV.D.2: WORK ZONES NEAR BLOWOUT WALLS
WORK ZONES ON ROOFS

SPECIAL AREAS

2. WHEN CONTRACTOR WORK ZONES OR ACCESS WAYS THERETO MUST BE ESTABLISHED IN AREAS ON THE ROOFS OR BLOWOUT-WALL SIDES OF BUILDINGS OR IN AREAS AWAY FROM ESTABLISHED ROADWAYS, PERMISSION AND ADVANCE PREPARATION FOR THE ACTIVITY WILL BE ARRANGED THROUGH WX-12'S PLANT AND EQUIPMENT SERVICES SECTION.

SAFETY REGULATIONS

SOP 24.IV.3.D DISPOSAL - SCRAP, WASTE, SURPLUS

DISPOSITION OF EQUIPMENT AND MATERIALS

D. CONTRACTOR PERSONNEL WILL DISPOSE OF DEBRIS, SCRAP MATERIALS, WASTE SOLVENTS AND LUBRICANTS, OIL- OR SOLVENT-CONTAMINATED TISSUES AND CLOTHS, AND USED OUTLINED IN CHAPTER 12 OF THE S-SITE SOP MANUAL. SOP 12.3.6 DESCRIBES THE PROCEDURE FOR DUMPING UNCONTAMINATED, UNBURNABLE MATERIAL IN THE S-SITE BURNING GROUND DUMP.

THE WORK ZONE SUPERVISOR OR AN AUTHORIZED CERTIFYING AGENT CAN OFFER ADVICE ABOUT THE PACKAGING OF SCRAP AND CAN ASSIST IN OBTAINING PROPER CONTAINERS.

SAFETY REGULATIONS

SOP 04.IV.H.1: PROTECTIVE APPAREL

PERSONAL PROTECTIVE EQUIPMENT

1. SAFETY FOOTWEAR - APPROVED SAFETY SHOES OR SHOE COVERS WILL BE WORN IN EXPLOSIVES AREAS WHERE THERE IS A POSSIBILITY THAT EXPLOSIVES MAY BE TRANSPORTED ON FOOTWEAR AND/OR WHERE EXPLOSIVES COULD BE INITIATED BY IMPROPERLY CONSTRUCTED FOOTWEAR EXISTS. SAFETY SHOES OR SHOE COVERS CANNOT BE WORN HOME.

   UNLESS CERTIFIED CLEAN OF EXPLOSIVES, APPROVED FOOTWEAR MUST BE WORN IN:

   - EXPLOSIVES OPERATING ZONES--ROOMS, BAYS, CORRIDORS, AND PASSAGEWAYS WHERE EXPLOSIVES ARE PROCESSED, HANDLED, STORED, OR TESTED
   - THE S-SITE BURNING GROUND
   - THE K-SITE TEST AREA EAST OF TA-11-2 AND TA-11-3
   - OTHER ZONES SPECIFICALLY DESIGNATED IN S-SITE SOP'S OR SR'S.

SAFETY REGULATIONS

SOP 1.0.9.II.A F: PROTECTIVE APPAREL

PERSONAL SAFEGUARDS

II. GENERAL RULES FOR PROTECTIVE APPAREL

A. LABORATORY-SUPPLIED APPAREL IS ISSUED AS REQUIRED TO PERSONS WHO WORK IN THE EXPLOSIVES AREA TO PREVENT THE EXPLOSIVES CONTAMINATION OF THEIR PERSONAL APPAREL AND TO AVOID THE TRANSFER OF H.E. FROM THE WORK AREAS TO THE HOME. ISSUED APPAREL MUST BE LEFT AT S-SITE OR ABLE SITE AT THE END OF THE WORKDAY.

B. THE TYPES OF APPAREL ISSUED TO AN EMPLOYEE WILL DEPEND ON HIS JOB ASSIGNMENT AND THE AMOUNT OF EXPOSURE TO HAZARDOUS MATERIALS AND OPERATIONS. THE ITEMS OF APPAREL THAT WILL BE ISSUED TO AN EMPLOYEE WILL BE DETERMINED JOINTLY BY THE GROUP WX-03 SERVICES SECTION AND THE GROUP BY WHICH HE IS EMPLOYED. THE SERVICES SECTION WILL PROVIDE THE GROUPS INVOLVED WITH A LIST OF THE ITEMS AVAILABLE FOR ISSUE.

C. SAFETY SHOES WITH TOE PROTECTION AND NONMETAL FASTENERS MUST BE WORN BY ALL LABORATORY PERSONNEL REGULARLY ASSIGNED TO THE EXPLOSIVES AREA. IN ALL AREAS WHERE H.E. MAY BE PRESENT ON WALKING SURFACES, SHOES WITH EXPOSED METAL ON SOLES OR HEELS ARE PROHIBITED UNLESS THEY ARE PROPERLY COVERED.

D. EYE PROTECTION IS REQUIRED IN MANY OF THE S-SITE OPERATING BUILDINGS AND AREAS. THESE LOCATIONS ARE CALLED OUT IN WX-03 SOP 1.9.0.

E. ALL EMPLOYEES WHO MIGHT REASONALBY BE EXPECTED TO GO INTO THE EXPLOSIVES AREA IN PERFORMANCE OF THEIR DUTIES ARE ISSUED SAFETY SHOES AND SAFETY GLASSES.

F. ALL PERSONS WHO ENTER AN OPERATING BUILDING OR ARE MUST WEAR THE REQUIRED PROTECTIVE APPAREL FOR THE LOCATION (FOOTWEAR AND EYE PROTECTION). THEY MUST ALSO WEAR WHATEVER ADDITIONAL PROTECTIVE APPAREL MAY BE REQUIRED BY THE HAZARDS THAT THEY WILL BE EXPOSED TO WHILE THEY ARE AT THE LOCATION.

SAFETY REGULATIONS

SOP 1.9.0: EYE PROTECTIVE DEVICES

EYE PROTECTION REGULATIONS

I. SCOPE

THESE REGULATIONS DELINEATE THE EYE PROTECTION REQUIREMENTS FOR S-SITE AT LOS ALAMOS, AND ABLE SITE, AREA 27, NTS. IT IS RECOGNIZED THAT OPERATIONS INVOLVE A WIDE RANGE OF EYE HAZARDS, AND IT WOULD BE DIFFICULT AND PROBABLY IMPRACTICAL TO CATEGORIZE THE TYPE OF EYE PROTECTION FOR EACH PROTECTION EQUIPMENT BE WORN IN AREAS IN WHICH EYE HAZARDS ARE KNOWN TO EXIST. SPECIFIC OPERATIONS THAT REQUIRE ADDITIONAL PROTECTION WILL BE SO SPECIFIED IN THE APPROPRIATE SOP.

II. LOCATION

EYE PROTECTION IS REQUIRED IN THE FOLLOWING AREAS:

S-SITE

BUILDING	AREA
TA-11-24	ALL
TA-11-30	ALL
TA-16-193	ROOM 113
TA-16-202	ROOMS 101, 113, 114, AND 114C
TA-16-207	CAGE ON FIRST FLOOR
TA-16-208	ALL
TA-16-222	ROOMS 104 AND 106
TA-16-260	BAYS 3 THROUGH 25, ROOM 103 (CRIB-15) - WHENEVER AN AUTOCOLLIMATOR IS BEING USED IN A BAY, EYE PROTECTION IS NOT REQUIRED, PROVIDED THAT NO OTHER OPERATIONS ARE BEING PERFORMED IN THE BAY.
TA-16-265	ALL
TA-16-267	ALL
TA-16-300	ROOMS 101, 102, AND 103
TA-16-301	ROOM 102
TA-16-302	ROOM 101, 102, AND 103
TA-16-303	ROOM 102
TA-16-304	ROOMS 101, 102, AND 103
TA-16-305	ROOM 102
TA-16-306	ROOMS 102 AND 103
TA-16-307	ROOMS 101 AND 102, CORRIDOR 1
TA-16-340	ROOMS 102 THROUGH 111, 114, 115, AND 116
TA-16-360	UNCRATING AREA
TA-16-370	ROOMS 101, 102, 103, 201, 301, AND 302
TA-16-380	ROOMS 101 THROUGH 104
TA-16-386	ALL
TA-16-387	ALL
TA-16-388	ALL
TA-16-390	WASHDOWN BAY
TA-16-392	ALL

TA-16-394	ALL
TA-16-399	ALL
TA-16-400	ALL
TA-16-401	ALL
TA-16-402	ALL
TA-16-406	ALL
TA-16-410	ROOMS 9 AND 10
TA-16-430	ROOMS 1 THROUGH 6
TA-16-450	OPERATING AREAS
TA-16-460	ROOMS 101, 102, 105 THROUGH 110, 112 THROUGH 115 AND BASEMENT ROOMS 2 AND 3
TA-16-462	ALL
TA-16-477	OPERATING BAY
TA-16-478	OPERATING BAY

III. EYE PROTECTION EQUIPMENT

A. HARDENED GLASS SAFETY GLASSES, PLANO OR PRESCRIPTION

B. HARDENED GLASS GOGGLES

C. PLASTIC MONOGOGGLES

D. PLASTIC FACE SHIELDS

E. OTHER EYE PROTECTION EQUIPMENT SPECIFIED IN WX-03 SOPS APPLICABLE TO A PARTICULAR OPERATION.

IV. GENERAL RULES

A. ALL PERSONNEL WHOSE DUTIES TAKE THEM INTO OPERATIONAL AREAS AT S-SITE AND ABLE SITE WILL BE ISSUED SAFETY GLASSES.

B. ALL PERSONNEL ENTERING DESIGNATED EYE HAZARD AREAS MUST WEAR THE APPROPRIATE EYE PROTECTION FOR THAT AREA, EXCEPT AS PERMITTED IN ITEM C.1, BELOW. BROKEN, LOST, OR MISPLACED GLASSES WILL NOT EXCUSE ANYONE FROM THAT REQUIREMENT. A SUPPLY OF MONOGOGGLES AND PLANO GLASSES IS AVAILABLE IN BUILDING TA-16-209 FOR TEMPORARY USE IN SUCH CASES. MANY OF THE MAJOR OPERATING BUILDINGS ALSO HAVE SMALL SUPPLIES OF MONOGOGGLES AND PLANO GLASSES.

C. TOURS AND VISITORS

1. THE REQUIREMENT FOR WEARING EYE PROTECTION MAY BE WAIVED BY THE WX-03 GROUP LEADER FOR PERSONS WHO ARE INCLUDED IN A GUIDED TOUR OF S-SITE OR ABLE SITE FACILITIES, OR WHO ARE GUIDED VISITORS TO THESE FACILITIES, AND THE GUIDES. THE WAIVER MAY APPLY TO A ZONE, A BUILDING, OR TO ALL BUILDINGS TO BE VISITED.

2. VISITORS OTHER THAN THOSE DESCRIBED IN ITEM C.1, ABOVE, MUST WEAR THE APPROPRIATE EYE PROTECTION IN THE DESIGNATED EYE HAZARD AREAS. IT IS THE RESPONSIBLITIY OF THE PERSON BEING VISITED TO MAKE SURE THAT THE VISITOR IS PROVIDED WITH THE NECESSARY EYE PROTECTION EQUIPMENT.

SAFETY REGULATIONS

SOP 24.IV.J; FIELD OFFICES

FIELD OFFICES

J. FIELD OFFICES

IN ADDITION TO APPLICABLE GENERAL REQUIREMENTS OF THIS SOP, FIELD OFFICES (INCLUDING INTEGRAL OR SEPARATE TOILET FACILITIES AND MATERIALS AND EQUIPMENT STORAGE YARDS) WILL BE LOCATED, USED, AND REMOVED AS FOLLOWS:

1. SITING

A. FIELD OFFICES WILL BE SEPARATED FROM EXPLOSIVES STORAGE OR PROCESSING FACILITIES BY A MINIMUM OF INTRALINE DISTANCE (BARRICADED OR UNBARRICADED, AS APPLICABLE) FOR CLASS 1.1 EXPLOSIVES ITEMS (TABLE 17-5 OF THE ORDNANCE SAFETY MANUEL, AMOR 385-100).

B. FIELD OFFICES MAY BE LOCATED IN A K-SITE HAZARD AREA OR AT THE BURNING GROUND. HOWEVER, WHEN REQUIRED BY THE ZONE SUPERVISOR, THEY WILL BE ABANDONED DURING CERTAIN OPERATIONS INVOLVING EXPLOSIVES. IN SUCH INSTANCES, THE REQUIREMENT DESCRIBED IN J.1.A NEED NOT APPLY.

C. ESTABLISHMENT OF FILED OFFICES OPPOSITE THE BLOWOUT- WALL SIDES OF BUILDINGS WILL BE AVOIDED. EXCEPTIONS:

1) WHEN EXPLOSIVES OPERATIONS SCHEDULES HAVE BEEN ADJUSTED SO THAT THE PRESENCE OF PERSONNEL IN THE FIELD OFFICE WILL NOT COINCIDE WITH THE PRESENCE OF EXPLOSIVES IN THE BUILDING.

2) WHEN THE FIELD OFFICE WILL BE SEPARATED FROM THE BUILDING BY A MINIMUM OF INHABITED-BUILDING DISTANCE (BARRICADED OR UNBARRICADED, AS APPLICABLE) FOR CLASS 1.1 EXPLOSIVES ITEMS (TABLE 17-5 OF THE ORDINANCE SAFETY MANUAL, AMOR 385-100).

D. FIELD OFFICES WILL BE LOCATED OR THE SITE PREPARED SO THAT A FIRE IN THE FILED OFFICE WILL NOT READILY MOVED TO AREAS OR FACILITIES NEARBY.

E. FIELD OFFICES WILL BE LOCATED TO MINIMIZE TRAFFIC CONGESTION ON NEARBY ROADWAYS.

2. ADDITIONAL SAFETY REQUIREMENTS

A. ELECTRIC CIGARETTE LIGHTERS AND ADEQUATE ASHTRAYS WILL BE PROVIDED.

B. COMBUSTIBLE MATERIALS WILL BE MAINTAINED AT MINIMUM

LEVELS REQUIRED BY THE FUNCTIONS OF FIELD OFFICES.

C. APPROPRIATE TYPES AND NUMBERS OF FIRE EXTINGUISHERS WILL BE INSTALLED IN AND NEAR FIELD OFFICES.

D. HEATING EQUIPMENT WILL BE ELECTRIC HEATERS THAT ARE IN GOOD CONDITION AND SAFELY CONNECTED.

E. TEMPORARY OVERHEAD ELECTRIC POWER CONDUCTORS OR CABLES SERVING A FIELD OFFICE ZONE WILL BE INSULATED, EXCEPT GROUNDED CONDUCTORS, WHICH MAY BE UNINSULATED. THEY WILL BE INSTALLED TO HAVE THE FOLLOWING CLEARANCES:

OVER ESTABLISHED ROADWAYS LIKELY TO BE USED DURING THE EXISTENCE OF THE INSTALLATION	18 FT.
OVER ROOFS OF STRUCTURES THAT MAY BY READILY WALKED ON	8 FT.
OVER WALKWAYS OR ANY POINT ON THE GROUND LIKELY TO BE USED BY PEDESTRIANS	10 FT.

3. REMOVAL

A. FIELD OFFICES WILL BE REMOVED PROMPTLY AFTER ACTIVITIES REQUIREING THEIR USE ARE COMPLETED.

B. ABANDONED FIELD OFFICE ZONES WILL BE CLEANED OF DEBRIS AND SURPLUS MATERIALS AND WILL BE RESTORED TO THEIR PREVIOUS CONDITION OR A CONDITION APPROVED BY THE WX-12 PLANT AND EQUIPMENT SERVICES SECTION.

SAFETY REGULATIONS

SOP 24.IV.A.2: POSTED PERSONNEL LIMITS & NOTIFICATIONS TO BUILDING SUPERVISOR

REQUIREMENTS

A. GENERAL

2. POSTED PERSONNEL LIMITS WILL BE OBSERVED. ON ENTERING AND LEAVING THE POSTED ZONE DURING OPERATING HOURS, CONTRACTOR PERSONNEL WILL NOTIFY THE SUPERVISOR RESPONSIBLE FOR ENFORCEMENT OF PERSONNEL LIMITS.

SAFETY REGULATIONS

SOP 24.IV.A.2: POSTED PERSONNEL LIMITS & NOTIFICATIONS TO BUILDING SUPERVISOR

REQUIREMENTS

A. GENERAL

2. POSTED PERSONNEL LIMITS WILL BE OBSERVED. ON ENTERING AND LEAVING THE POSTED ZONE DURING OPERATING HOURS, CONTRACTOR PERSONNEL WILL NOTIFY THE SUPERVISOR RESPONSIBLE FOR ENFORCEMENT OF PERSONNEL LIMITS.

SAFETY REGULATIONS

SOP 04.IV.A.3: SMOKING

REQUIREMENTS

A. GENERAL

3. SMOKING REGULATIONS WILL BE OBSERVED. ANY PERSON MAY BE SUBJECTED TO AN UNANNOUNCED CHECK FOR PROHIBITIED ITEMS: MATCHES, LIGHTERS, AND OTHER FLAME-PRODUCING MATERIALS.

SAFETY REGULATIONS

SOP 1.6.0: SMOKING

SMOKING REGULATIONS

I. SCOPE

THIS SOP GOVERNS SMOKING WITHIN THE CONFINES OF THE ARE DESIGNATED AS S-SITE ANDNTS AREA 27.

II. LOCATION

A. ALL S-SITE AREAS, SEE SOP 1.0.0.II.

B. AREA 27, ABLE SITE, NTS (SEE TABLE II)

III. DEFINITIONS

A. FIELD OFFICES

A FIELD OFFICE IS A BUILDING OR SHELTER THAT IS SET UP TEMPORARILY FOR SOME JOBS BY THE PAN-AM COMPANY OR OTHER CONTRACTORS TO HOUSE THE FIELD HEADQUARTERS FOR A MODIFICATION OR MAINTENANCE JOB. THE FIELD OFFICE WILL BE LOCATED AT LEAST INTRALINE DISTANCE FROM EXPLOSIVES OPERATIONS AND STORAGE.

B. CONSTRUCTION AREA

A CONSTRUCTION ARE IS ANY PART OF THE EXPLOSIVES AREA IN WHICH MAJOR CONSTRUCTION WORK IS TO BE DONE, AND IN WHICH NO OPERATIONS ARE BEING CONDUCTED. EXTENSIVE REPAIRS OR MODIFICATIONS TO A BUILDING WILL NOT NORMALLY BE CONSIDERED MAJOR CONSTRUCTION.

IV. SMOKING

A. ADMINISTRATIVE AREA

SMOKING IS GENERALLY ALLOWED IN THE ADMINISTRATIVE AREA; HOWEVER, SMOKING IS PROHIBITED IN THE FOLLOWING AREAS:

1. BUILDING TA-16-200, ROOMS 112, 212, AND 312 - VAULTS
   ROOM B-12 - DATA PROCESSING MACHINES
   ROOM 308A - NC DRAFTING MACHINE

2. BUILDING TA-16-206, PAINT STORAGE BUILDING

3. BUILDING TA-16-208, SOLVENT STORAGE BUILDING

4. ANY S-SITE ZONE THAT IS POSTED "NO SMOKING"

B. EXPLOSIVES AREA

SMOKING IS NOT PERMITTED INSIDE OR OUTSIDE BUILDINGS IN THE EXPLOSIVES AREA, OR IN VEHICLES TRAVELING IN THESE AREAS, EXCEPT

IN THE LOCATIONS SPECIFIED IN TABLE I AND II OF THIS SOP.

7. MATCHES, LIGHTERS, AND OTHER FLAME-PRODUCING MATERIALS

A. LOCATIONS IN THE EXPLOSIVES AREA WHERE SMOKING IS PERMITTED ARE EQUIPPED WITH INSTALLED LIGHTERS.

B. THE POSSESSION OF MATCHES, LIGHTERS, AND OTHER FLAME-PRODUCING MATERIALS IN THE EXPLOSIVES AREA IS PROHIBITED, EXCEPT AS ALLOWED BY A SAFETY WORK PERMIT OR SPECIFICALLY PROVIDED FOR IN OTHER SOPS. ITEMS THAT ARE BEING TRANSPORTED BY A PERSON IN THE EXPLOSIVES AREA ARE CONSIDERED TO BE IN HIS POSSESSION.

C. ANY PERSON IN THE EXPLOSIVES AREA MAY BE SUBJECTED TO UNANNOUNCED CHECKS FOR THESE PROHIBITED ITEMS.

D. ANY PERSON WHO DISCOVERS, AFTER ENTERING THE EXPLOSIVES AREA, THAT HE HAS INADVERTENTLY CARRIED FLAME-PRODUCING MATERIALS INTO THE AREA, SHALL IMMEDIATELY LEAVE THE AREA AND DISPOSE OF THESE MATERIALS BEFORE RE-ENTERING.

SAFETY REGULATIONS

SOP 1.0.9.VI: FOOD BEVERAGES IN EXPLOSIVES AREA

VI. CONSUMPTION OF FOODS AND BEVERAGES IN THE EXPLOSIVES AREA

A. BECAUSE OF THE EXPLOSIVES HEALTH HAZARDS MENTIONED IN WX-03 SOP 1.1.0.II.B AND THE CHEMICAL HEALTH HAZARDS MENTIONED IN WX-03 SOP 1.2.0, THE CONSUMPTION OF FOODS AND BEVERAGES IN THE EXPLOSIVES AREA IS PROHIBITED, EXCEPT AS ALLOWED BY VI.B AND C, BELOW.

B. MEALS MAY NOT BE CONSUMED IN THE EXPLOSIVES AREA EXCEPT BY PROTECTIVE FORCE PERSONNEL IN STATIONS 561 AND 565 AND BY CONSTRUCTION PERSONNEL IN FIELD OFFICES.

C. LABORATORY-SUPPLIED BEVERAGES ARE PROVIDED FOR THE COFFEE BREAK AT MOST OF THE LOCATIONS MENTIONED IN ITEM VI.A, ABOVE. PERSONALLY PROVIDED BEVERAGES (NONALCOHOLIC) AND SNACKS MAY ALSO BE CONSUMED IN THESE LOCATIONS. PERSONAL DISHES OR UTENSILS ARE NOT TO BE TAKEN INTO THE EXPLOSIVES AREA. EXCEPTIONS ARE THE PERSONAL BEVERAGE CONTAINERS THAT MUST BE USED IN THE LOCATIONS MENTIONED ABOVE.

D. ELECTRICAL HEATING DEVICES FOR LIQUIDS ARE PERMISSIBLE IN THE COFFEE ROOMS.

SAFETY REGULATIONS

SOP 04.IV.B.01 SOLVENT USE

REQUIREMENTS

1. ONLY M-01 APPROVED SOLVENTS MAY BE USED.

SAFETY REGULATIONS

SOP 04.IV.C.2: VEHICULAR TRAFFIC

VEHICLES

2. NOTICE, CAUTION, AND DANGER SIGNS WILL BE NEEDED. VEHICLES NORMALLY WILL BE CONFINED TO PAVED OR UNPAVED ROADWAYS.

SAFETY REGULATIONS

SOP 24.IV.D.1: TEMPORARY HAZARD AREAS

SPECIAL AREAS

1. SIGNS, GATES, AND BARRIERS DESIGNATING AREAS THAT ARE HAZARDOUS DURING TESTS AND CERTAIN PROCESSING AND DISPOSED OPERATIONS MUST BE OBEYED.

SAFETY REGULATIONS

SOP 5.10.0: LIMITED EGRESS/CONFINED SPACES

I. SCOPE

THIS SOP DEFINES THOSE LOCATIONS IN THE PRESSING OPERATIONS AT BUILDING TA-16-430 THAT ARE IDENTIFIED AS CLASS A LIMITED EGRESS/CONFINED SPACE (LE/CS) AREAS. IT ALSO DETAILS THE PROCEDURES THAT MUST BE FOLLOWED WHEN WORKING IN THESE LE/CS AREAS.

II. LOCATION

BUILDING TA-16-430

A. NO. 3-H PRESS PIT, BAY 101
B. 500-TON ELMES PRESS PIT, BAY 102
C. 500-TON ELMES PRESS PIT, BAY 104
D. 1000-TON ELMES PRESS PIT, BAY 105

A SIGN THAT IDENTIFIES EACH OF THESE PITS AS LE/CS AREAS IN PROMINENTLY DISPLAYED ABOVE THE ENTRANCE TO THE PITS.

III. LIMITS

A. PERSONNEL

SEE GROUP WX-03 5.2.0

B. EXPLOSIVES

NO EXPLOSIVES ARE ALLOWED IN THE PITS.

IV. PROTECTIVE APPAREL

SEE WX-03 SOP 5.1.0

V. EQUIPMENT

A. HAND TOOLS AS REQUIRED.

B. POWER TOOLS AS REQUIRED, SUBJECT TO THE REQUIREMENTS OF GROUP WX-03 SOP 5.1.1.

VI. CLEANLINESS OF WORK AREAS

FLUID LEAKS IN THE HYDRAULIC SYSTEMS LOCATED IN THE PITS ARE NOT UNUSUAL. WITH THE EXCEPTION OF THE 1000-TON ELMES PRESS LOCATED IN BAY 105 AND THE 20-TON PELLET PRESS LOCATED IN BAY 101, THE HYDRAULIC FLUID USED IN ALL THE PRESSES IS A WATER-BASED LIQUID THAT IS NON-FLAMMABLE. THE HYDRAULIC FLUID USED IN THE 1000-TON ELMES PRESS AND THE 20-TON PELLET PRESS IS A PETROLEUM OIL. BOTH FLUIDS CAN MAKE THE FLOORS DANGEROUSLY SLIPPERY. SLIPPERY FLOORS CONSTITUTE THE MOST LIKELY PHYSICAL HAZARD TO BE ENCOUNTERED IN THE PIT.

ACCUMULATIONS OF FLUID ON THE FLOOR MUST BE CLEANED UP ON A REGULAR BASIS. MOPPING UP THE FLUID WITH RAGS IS THE RECOMMENDED METHODS OF CLEANING; HOWEVER, INERT ABSORPTION AGENTS, SUCH AS DORB-ALL, MAY BE USED. THESE HAVE THE ADVANTAGE OF PROVIDING SURER FOOTING WHEN SPREAD ON THE FLOOR. DORB-ALL MUST NOT BE ALLOWED TO ACCUMULATE IN LAYERS ON THE PIT FLOORS, BUT MUST BE CLEANED UP AT THE EARLIEST CONVENIENT TIME AFTER USE.

PITS SHALL NOT BE USED AS STORAGE AREAS. RAGS, SOLVENTS, TOOS, ETC. USED IN THE PERFORMANCE OF MAINTENANCE OR OPERATION ADJUSTMENTS, SHALL BE REMOVED ON COMPLETION OF EACH JOB.

IN THE INSTANCE OF THE BAY 101 PIT, SPECIAL TOOLING AND MATERIALS INTENDED FOR USE IN THE OPERATIONS OF THE NO. 3-H PRESS ARE AN EXCEPTION TO THE ABOVE RULE. WHEN NOT IN USE, THIS TOOLING SHALL BE HUNG ON WALL BRACKETS PROVIDED FOR THAT PURPOSE.

VII. PROCEDURES

A. IRRESPECTIVE OF ORGANIZATIONAL AFFILIATION PERSONNEL WHO ENTER LE/CS AREAS TO PERFORM EQUIPMENT CHECKS, ADJUSTMENTS, OR MAINTENANCE MUST BE COMPLETELY FAMILIAR WITH THIS SOP AND OTHER WX-00 SOPS CALLED OUT HEREIN.

B. ACCESS TO THE LE/CS AREAS IS BY A TRAP DOOR IN THE FLOOR BEHIND THE PRESSES OR, IN THE CASE OF BAY 101, A FLIGHT OF STEPS. LIGHTS AND THE FRESH-AIR BLOWER LOCATED IN THE PIT MUST BE TURNED ON BEFORE PROCEEDING WITH ANY JOB. IF THE LIGHTS AND BLOWER CANNOT BE TURNED ON, REPORT THE MALFUNCTION TO THE TEC SUPERVISOR IMMEDIATELY.

C. NOT MORE THAN ONE PINT OF ANY SOLVENT (OTHER THAN WATER) MAY BE TAKEN INTO AN LE/CS AREA. VERBAL PERMISSION FROM THE TECH SUPERVISOR MUST BE OBTAINED BEFORE ANY SOLVENT CAN BE USED IN ANY LE/CS AREA.

D. PERSONNEL WANTING TO ENTER ANY LE/CS AREA MUST NOTIFY THE TECH SUPERVISOR AND OBTAIN HIS CONCURRENCE BEFORE PROCEEDING.

E. MAJOR, MAINTENANCE OPERATIONS INVOLVING DISASSEMBLY OF HYDRAULIC SYSTEMS TO THE POINT THAT CLEANING OPERATIONS WILL REQUIRE THE USE OF LARGE AMOUNT SO SOLVENTS SHALL BE DONE UNDER SPECIAL WORK PERMITS IN ACCORDANCE WITH LANL ADMINISTRATIVE REQUIREMENT 6.1.

SAFETY REGULATIONS

SOP 04.IV.E.0: ELECTRICAL CIRCUIT EXPOSURE

SPECIAL EQUIPMENT PRECAUTIONS

0. ENERGIZED ELECTRICAL CIRCUITS WILL NOT BE EXPOSED IN THE PRESENCE OF SIGNIFICANT AMOUNTS OF EXPLOSIVES.

SAFETY REGULATIONS

SOP 04.IV.3.1: CONTAMINATED EQUIPMENT TRANSFER
WORK ON/WITH CONTAMINATED ARTICLES

DISPOSITION OF EQUIPMENT AND MATERIALS

1. EQUIPMENT KNOWN OR SUSPECTED TO BE CONTAMINATED WITH EXPLOSIVES WILL NOT BE TRANSFERRED, STORED, REMOVED FROM THE EXPLOSIVES AREA, OR PREPARED FOR MAINTENANCE EXCEPT IN ACCORDANCE WITH REQUIREMENTS OF CHAPTER 27 OF THE S-SITE SOP MANUAL. IN INSTANCES OF DOUBT ABOUT CONTAMINATION, AN AUTHORIZED CERTIFYING AGENT MUST BE CONTACTED. HIS DECISIONS AND ADVICE WILL BE FOLLOWED.

SAFETY REGULATIONS

SOP 1.1.0.III.B.2: EQUIPMENT/MATERIAL REMOVAL, EXPLOSIVES AREA

B. ADMINISTRATIVE AREA

2. ALL EQUIPMENT AND NONEXPLOSIVE MATERIALS REMOVED FROM THE EXPLOSIVES AREA AND BROUGHT INTO THE ADMINISTRATIVE AREA, OR TAKEN OFF-SITE THROUGH THE GATES AT SECURITY STATIONS 560 OR BUILDING TA-16-220, MUST BE CERTIFIED CLEAN OF EXPLOSIVES BY AN S-SITE CERTIFYING AGENT; EXCEPTIONS ARE NOTED IN ITEM B.1. EXPLOSIVES TRANSPORTATION VEHICLES MUST BE CERTIFIED CLEAN BEFORE THEY ARE SENT OFF-SITE FOR MAINTENANCE OR REPAIRS OR ARE RELEASED TO ANOTHER ORGANIZATION; HOWEVER, ROUTINE SERVICING MAY BE PERFORMED AT THE BUILDING TA-16-195 GARAGE WITHOUT THIS CERTIFICATION.

SAFETY REGULATIONS

SOP 24.IV.3.1: CONTAMINATED EQUIPMENT TRANSFER
WORK ON/WITH CONTAMINATED ARTICLES

DISPOSITION OF EQUIPMENT AND MATERIALS

1. EQUIPMENT KNOWN OR SUSPECTED TO BE CONTAMINATED WITH EXPLOSIVES WILL NOT BE TRANSFERRED, STORED, REMOVED FROM THE EXPLOSIVES AREA, OR PREPARED FOR MAINTENANCE EXCEPT IN ACCORDANCE WITH REQUIREMENTS OF CHAPTER 27 OF THE S-SITE SOP MANUAL. IN INSTANCES OF DOUBT ABOUT CONTAMINATION, AN AUTHORIZED CERTIFYING AGENT MUST BE CONTACTED. HIS DECISIONS AND ADVICE WILL BE FOLLOWED.

SAFETY REGULATIONS

SOP 04.IV.3.4: CONFINING ABRASIVES PARTICLES

DISPOSITION OF EQUIPMENT AND MATERIALS

4. EFFECTIVE WAYS FOR CONFINING ABRASIVE PARTICLES, SUCH AS THOSE FROM CONCRETE SHIPPING, GRINDING, OR FILING, AND ACCIDENTAL GLASS BREAKAGE, TO WORK ZONES MUST BE DEVISED AND EMPLOYED.

SAFETY REGULATIONS

SOP 04.IV.I.1: IN-PROCESS H.E. REMOVAL

PREPARATION OF WORK ZONES

CONTRACTOR WORK ZONES AND THE ACCESS WAYS THERETO IN BUILDINGS AND OUTDOOR AREAS WHERE EXPLOSIVES ARE PROCESSED, HANDLED, STORED, TESTED, OR DESTROYED, AND IN OUTDOOR AREAS WHERE EXPLOSIVES-BEARING EFFLUENT WATER IS OR HAS BEEN PRESENT ARE TO BE PREPARED AS FOLLOWS:

1. OPERATING PERSONNEL WILL REMOVE IN-PROCESS OR STORED EXPLOSIVES FROM WORK ZONES EXCEPT FOR ACTIVITIES THAT DO NOT REQUIRE THEIR REMOVAL. THIS WILL PREVENT THE INITIATION OF SUCH EXPLOSIVES THROUGH CONTRACTOR ACTIVITIES.

SAFETY REGULATIONS

SOP 04.IV.I.D.A: WORK ZONE BOUNDARY LIMITS

DETERMINATION OF CONTRACTOR WORK ZONES

A. A WORK ZONE COMPRISES ALL OF A BAY, ROOM, BUILDING CORRIDOR, PASSAGEWAY, OR A DEFINED OUTDOOR AREA. WHEN THIS IS NOT PRACTICAL OR REQUIRED FOR EXPLOSIVES SAFETY AND/OR CONDUCTING CONTRACTOR ACTIVITIES, A DIFFERENT DEFINITION CAN BE ESTABLISHED BY AN AUTHORIZED CERTIFYING AGENT.

SAFETY REGULATIONS

SOP 24.IV.I.3.B: UNOBSTRUCTED TRAFFIC ROUTES

DETERMINATION OF CONTRACTOR WORK ZONES

B. WORK ZONES WILL BE ESTABLISHED AND ACTIVITIES CONDUCTED SO THAT EMERGENCY EXITS, ACCESS WAYS TO EMERGENCY EXITS, AND ROUTES OF NORMAL OPERATIONAL TRAFFIC REMAIN OPEN.

SAFETY REGULATIONS

SOP 24.IV.I.4: WORK ZONE CLEANING

PREPARATION OF WORK ZONES

4. CLEANING OR DECONTAMINATION - CLEANING OR DECONTAMINATION WILL BE PERFORMED BY TRAINED OPERATING PERSONNEL.

SAFETY REGULATIONS

SOP 24.IV.I.5.A: WORK ZONE CERTIFICATIONS

PREPARATION OF WORK ZONES

5. CERTIFICATIONS - INSPECTIONS TO CERTIFY WORK ZONES WILL BE PROVIDED BY AUTHORIZED CERTIFYING AGENTS. THIS WILL ASSURE THAT HAZARDOUS QUANTITIES OF CONTAMINATING EXPLOSIVES ARE NOT PRESENT.

   A. DETAILS OF THE PLANNED ACTIVITY MUST BE GIVEN IN ADVANCE OF THE AUTHORIZED CERTIFYING AGENT. HE WILL INSPECT THE WORK ZONE (STRUCTURES, EQUIPMENT, AND/OR TERRAIN AS NECESSARY). IF PROPERLY CLEAN FOR THE PARTICULAR ACTIVITY, HE WILL CERTIFY THE ZONE CLEAN.

SAFETY REGULATIONS

SOP 04.IV.I.5.B: CERTIFYING AGENT SUPERVISION

PREPERATION OF WORK ZONES

B. THE AUTHORIZED CERTIFYING AGENT MAY OBSERVE OR DIRECT PHASES OF AN ACTIVITY IN ORDER TO DETECT HIDDEN CONTAMINATING EXPLOSIVES. IF SIGNIFICANT ACCUMULATIONS ARE FOUND, HE WILL SUSPEND THE ACTIVITY UNTIL FURTHER CLEANING AND RECERTIFICATION ARE DONE.

APPENDIX J

SITE GEOLOGY AND HYDROLOGY OF TECHNICAL AREA 16, AREA P (EXTRACTED FROM BROWN ET AL., 1987)

Appendix D: Geology and In-Situ Moisture Content of Technical Area 16 Area P.

Fred Brown

(extracted from Brown et al., 1987)

I. REGIONAL GEOLOGY

The regional geology of Los Alamos has been previously reported in detail (i.e., Smith and Bailey, 1966; Purtymun, 1974; Gardner and Goff, 1986). In summary, Los Alamos National Laboratory is located on the eastern flank of the Jemez Mountains, an area dominated by volcanic deposits associated with the formation and collapse of the Valle and Toledo Calderas. Eruptive activity culminated with the deposition of a large volume (about 400 km^3) of Quaternary Bandelier Tuff, a rhyolitic tuff ranging in thickness from 30 to 1000 ft. The Bandelier Tuff is composed of a series of ashfall and ashflow tuffs (ignimbrites) unconformably resting on Chino Mesa Basalt and Puye Conglomerate of the Santa Fe Group. Depth to the main aquifer in the vicinity of Area P is about 1230 ft (Purtymun, 1984). See Figure D1.

Deposits of Bandelier Tuff form broad plateaus that encircle the Jemez Mountains and dip gently away from the Valle

Caldera. The plateau on the eastern side of the Jemez Mountains, the Pajarito Plateau, consists of a series of east to southeast trending mesas separated by deeply incised canyons. The Bandelier Tuff itself consists of upper (Tshirege) and lower (Otowi) members, each containing a prominent ashfall bed at the base. Generally, the upper (Tshirege) member is the more densely welded of the two, and welding tends to increase with proximity to caldera sources (Bailey et al. 1969; Gardner et al., 1986).

The Bandelier Tuff dips 2 to 5 degrees towards the east. Four fault zones have been recognized in the Pajarito Plateau: the Pajarito, Water Canyon, Guaje Mt., and Rendija Canyon Fault Zones (Dransfield and Gardner, 1985). The Water Canyon Fault Zone, which extends through TA-16, trends roughly north to northeast, with about 30 to 100 ft of down-to-the-east displacement. Approximately 10 to 15 ft of displacement can be seen in the subsurface adjacent to Area-P, with little-or-no surface expression apparent.

II. GEOLOGY OF AREA P

Area P lies near the eastern margin of the Jemez Mountains, in the saddle of a short east-west trending mesa. The Water Canyon Fault Zone cuts through the tuff approximately 500 ft to the east. To the north the Canon de Valle has cut through the fault scarp, draining an area on the west of the Sierra

de los Valles flanks. To the south is a small unnamed canyon containing intermittent discharge from local outfalls. The main technical centers of TA-16 are located west of Area P (See Figure D2).

The mesa is capped by approximately 800 ft of Bandelier Tuff (Purtymun, 1968). Five distinct units, composed of groups of ashflows, have been recognized in the Tshirege Member of the Bandelier Tuff (Griggs, 1964; Smith and Bailey, 1966), of which two units were encountered during drilling operations at Area P (Brown, 1987). In addition, scattered outcrops of El Cajete Pumice occur in the area.

In order to establish the subsurface geology of Area P a series of 17 boreholes (numbered P-0 through P-16) was drilled in the summer of 1987. Drilling was done with a CME-55 rotary drilling rig and four-inch conventional auger. Continuous auger cuttings were retrieved for moisture analysis, and one set of continuous core was recovered using six-inch hollow stem auger and split spoon core barrels.

Borehole logging of lithology was done on the basis of four characteristics: (1) color (Goddard et al., 1984), (2) degree of welding, (3) shape and abundance of pumice lapilli, and (4) distribution of lithic fragments. Four distinct types of welding were recognized during drilling operations:

1. Non-welded: high porosity, low cohesion of glassy fragments and crumbly texture. In core samples this can be recognized by disaggregation and little or no flattening of pumice lapilli.

2. Moderately welded: less porosity, moderate cohesion, brittle texture and slight deformation of glassy fragments. In core samples this texture crumbles easily in the hand and contains some noticeably flattened pumice lapilli.

3. Welded: low porosity, good cohesion, brittle texture and noticeable deformation of glassy fragments. This texture normally requires a hammer to break, and the majority of pumice fragments are noticeably flattened.

4. Densely welded: texture noticeably impedes or hinders drilling; little or no penetration; poor core recovery.

Two major lithologic units have been recognized at Area P (person. comm., W. Purtymun, 1987). Unit 3, the uppermost unit encountered during drilling operations, consists of four individual ashflows that appear to have cooled as a single unit. These ashflows are herein designated as Subunits 3a, 3b, 3c and 3d (bottom to top). Unit 3 rests conformably above Unit 2, the lowermost unit encountered. In

the vicinity of Area P dip is negligible, and the units are essentially horizontal and of uniform thickness.

Subunit 3a consists of a welded dark yellowish brown tuff, with rare pumice lapilli (slightly flattened), and abundant pebble sized red porphyritic latite and grey rhyolite lithic fragments. The contact between Subunit 3a and Unit 2 tends to be densely welded. East of the Water Canyon Fault this unit appears to be non-welded.

Subunit 3b consists of a welded pale yellowish brown tuff, with common grey and red pumice lapilli, (noticeably flattened), and rare pebble sized rhyolite lithic fragments. This unit weathers to a dark brown, and contains abundant clayey pumice lapilli to the north-west.

Subunit 3c consists of a moderately welded brownish grey to yellowish brown tuff, with common grey pumice lapilli (noticeably flattened), and rare pebble sized rhyolite lithic fragments. Clay filled vertical fractures are common throughout this subunit. The contact between 3c and 3d tends to be densely welded.

Subunit 3d outcrops along the higher rim of the saddle, and consists of a moderately welded yellowish brown tuff, with rare pebble sized rhyolite lithic fragments and common

grey pumice lapilli. Subunit 3d is overlain by scattered deposits of El Cajete Pumice.

Locally, Unit 2 consists of a welded to densely welded tuff, light grey to pinkish grey in color, with common pumice lapilli and pebble sized rhyolite fragments. Due to dense welding the drill bit was only able to penetrate the upper 5 to 10 ft of Unit 2. See Figure D3.

III. IN-SITU MOISTURE CONTENT

Hydrologic characteristics of tuff depend primarily on the degree of welding, with porosity and hydraulic conductivity decreasing as the degree of welding increases. At Los Alamos, saturated hydraulic conductivity for a moderately welded tuff ranges from 0.1 to 1.7 ft/day, and for a welded tuff ranges from 0.009 to 0.26 ft/day (Abeele et al., 1981). Samples of tuff recovered during drilling operations at Area P were not saturated.

Gravimetric moisture determinations were conducted to obtain a direct measurement of in-situ water content of the tuff. Samples were taken from drill cuttings every 5 or 10 ft, and moisture determinations were made by weighing samples immediately after collection and after oven-drying 24 hrs at 105 degrees C.

Although gravimetric moisture determinations are relatively easy to perform, care must be taken to insure that the heat produced by drilling does not bias the samples collected. In the few cases where drill cuttings were noticeably warm to the touch, or water vapor was noticed coming from the borehole, samples were not collected for analysis. Care was also taken to maintain the drying oven at 105 degrees C to ensure that no structural water was driven off.

Table D1 provides a summary of gravimetric data collected for Unit 3, and indicates a low overall moisture content for Area P. Although a range of 1.9 to 24.7% is considered low, this value slightly exceeds the gravimetric moisture content determined for technical areas further to the east (5-11% for TA-33, Abrahams 1963; 2-20% for TA-54; Kearl et al., 1986). This increase may be due to increased rainfall at TA-16 caused by orographic effects adjacent to the Jemez Mountains.

Unit	Mean (%)	STD	Range (%)
3d	5.2	3.6	2.2-17.7
3c	6.1	3.5	1.9-24.7
3b	5.7	2.1	2.3-11.4
3a	3.8	1.4	2.3-5.8
Total Unit	5.8	3.0	1.9-24.7

Table D1: Average Gravimetric Moisture Content. STD = Standard Deviation.

The energy relationship with moisture content for the Tshirege Member of the Bandelier Tuff was worked out for volumetric moisture content by Abrahams (1963). Volumetric values can be converted to gravimetric values by using the average bulk density of the tuff. Repeated neutron and gamma probe calibration runs have established an average bulk density for the Tshirege Member of 1.4 g/cm^3. In addition, the density of ten random samples was obtained after drying by weighing crushed tuff of a known volume. Average density for the ten samples was 1.47 g/cm^3, with a standard deviation of 0.12.

TA-16 Area P lies in the vadose zone of the Bandelier Tuff, a zone defined by Everett et al. (1984) as existing beneath the topsoil and above the water table, in which moisture in pore spaces coexists with air or in which geological materials are unsaturated. Based on the results of Abrahams (1963), saturation of the Tshirege Member of the Bandelier Tuff, and thus groundwater, occurs when gravimetric moisture content is about 29%. When moisture content is below 7% there is no movement of water; between 7 to 21% moisture is redistributed by diffusion; between 21 to 29% moisture distribution is by gravity and capillarity, and above 29% movement is by gravity drainage (Figure D4). From Table D1 it can be seen that the primary mechanism for moisture

distribution at Area P is diffusion. There is no evidence for the existence of groundwater at Area P.

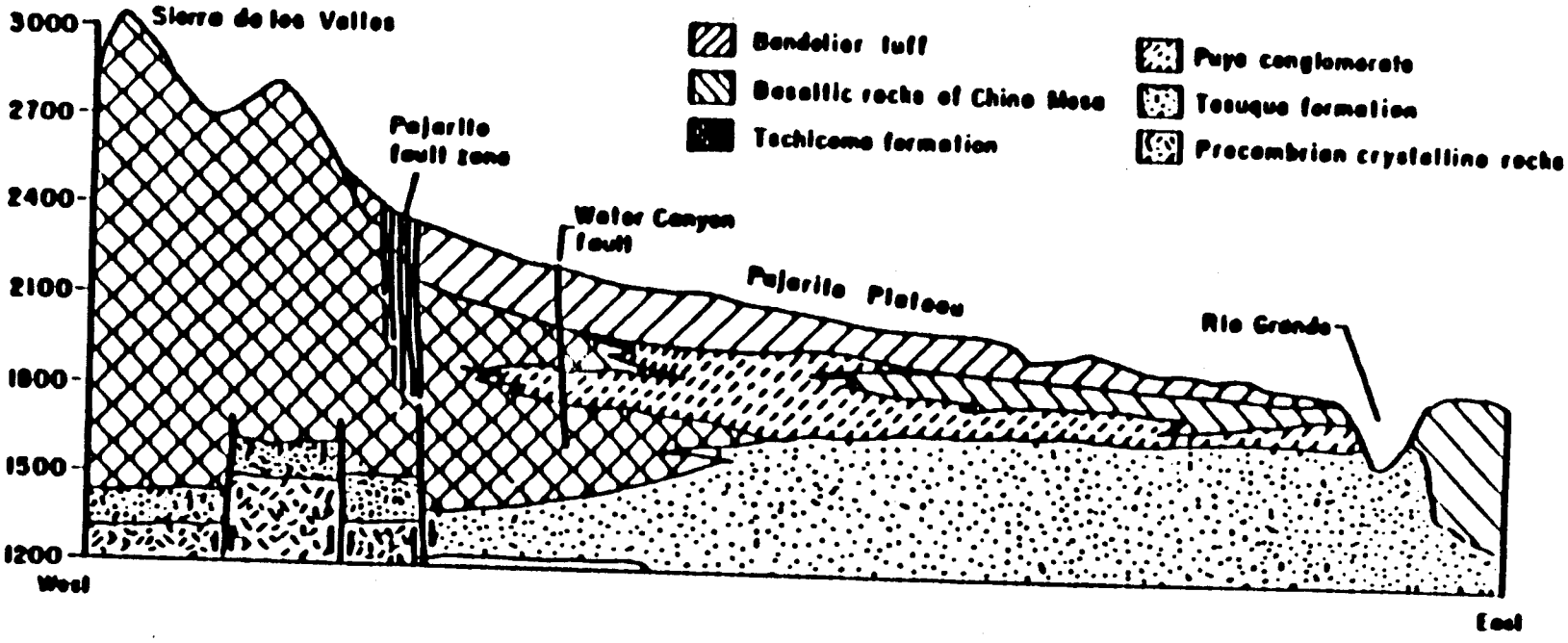


Figure D1. Geologic cross section through the Pajarito Plateau.

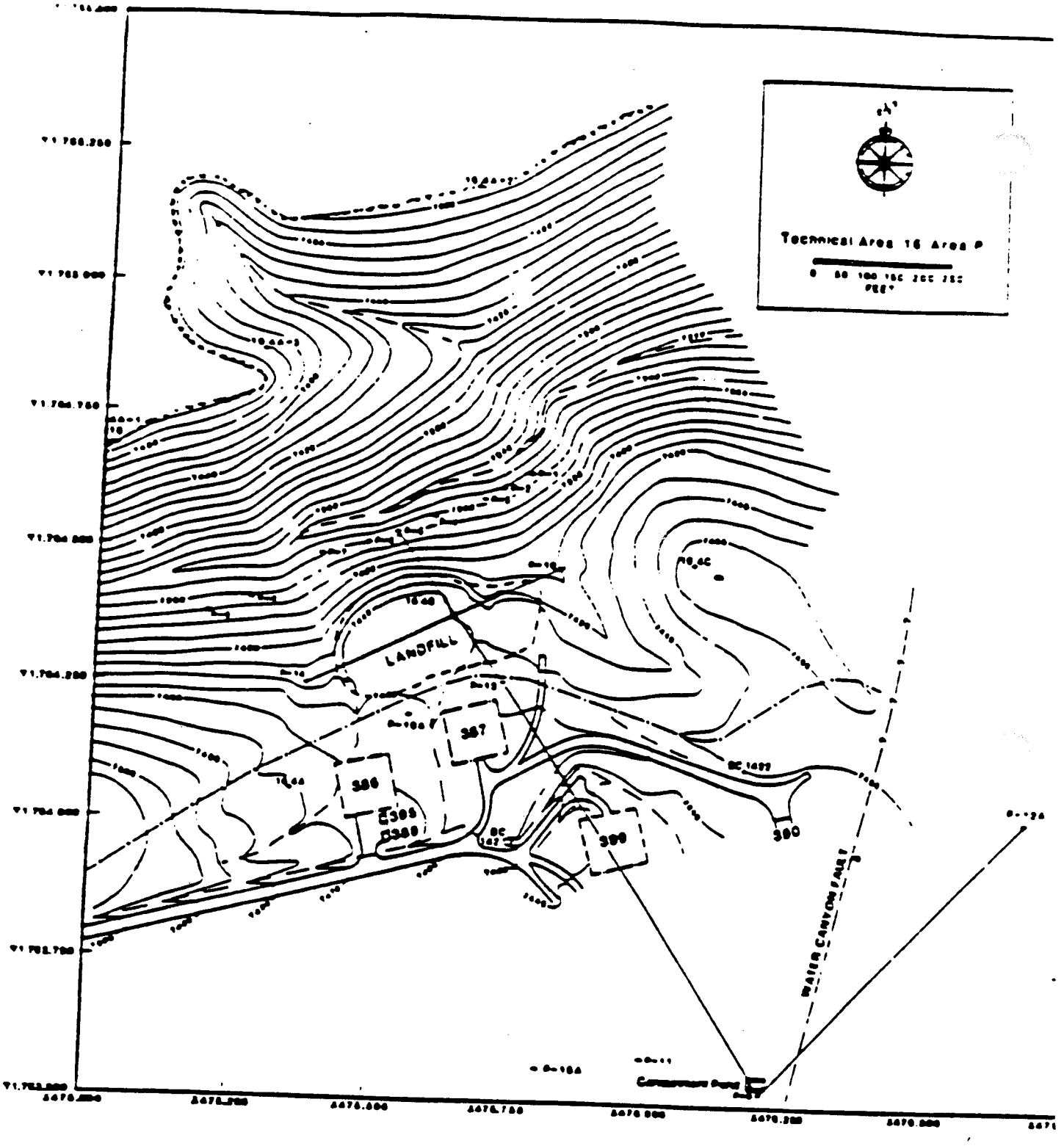
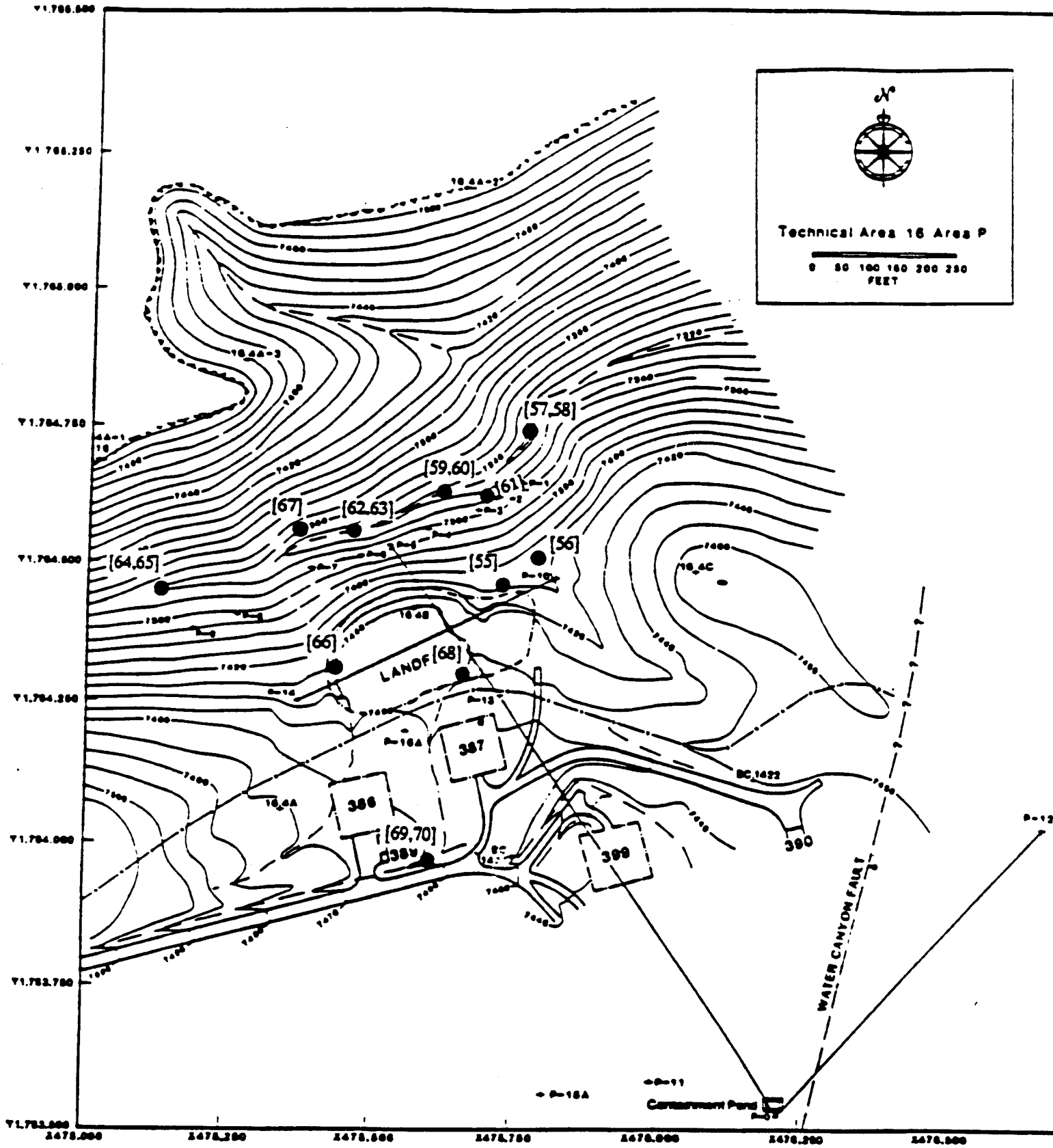


Figure D2. Site map of Technical Area 16 Area P. Boreholes are numbered P-0 through P-16A, and marked with crosses.


Technical Area 16 Area P
0 50 100 150 200 250
FEET
[57,58]
[59,60]
[61]
[67]
[62,63]
[64,65]
[55]
[56]
[66]
LANDF
[68]
387
386
[69,70]
389
390
WATER CANYON FAULT
Containment Pond

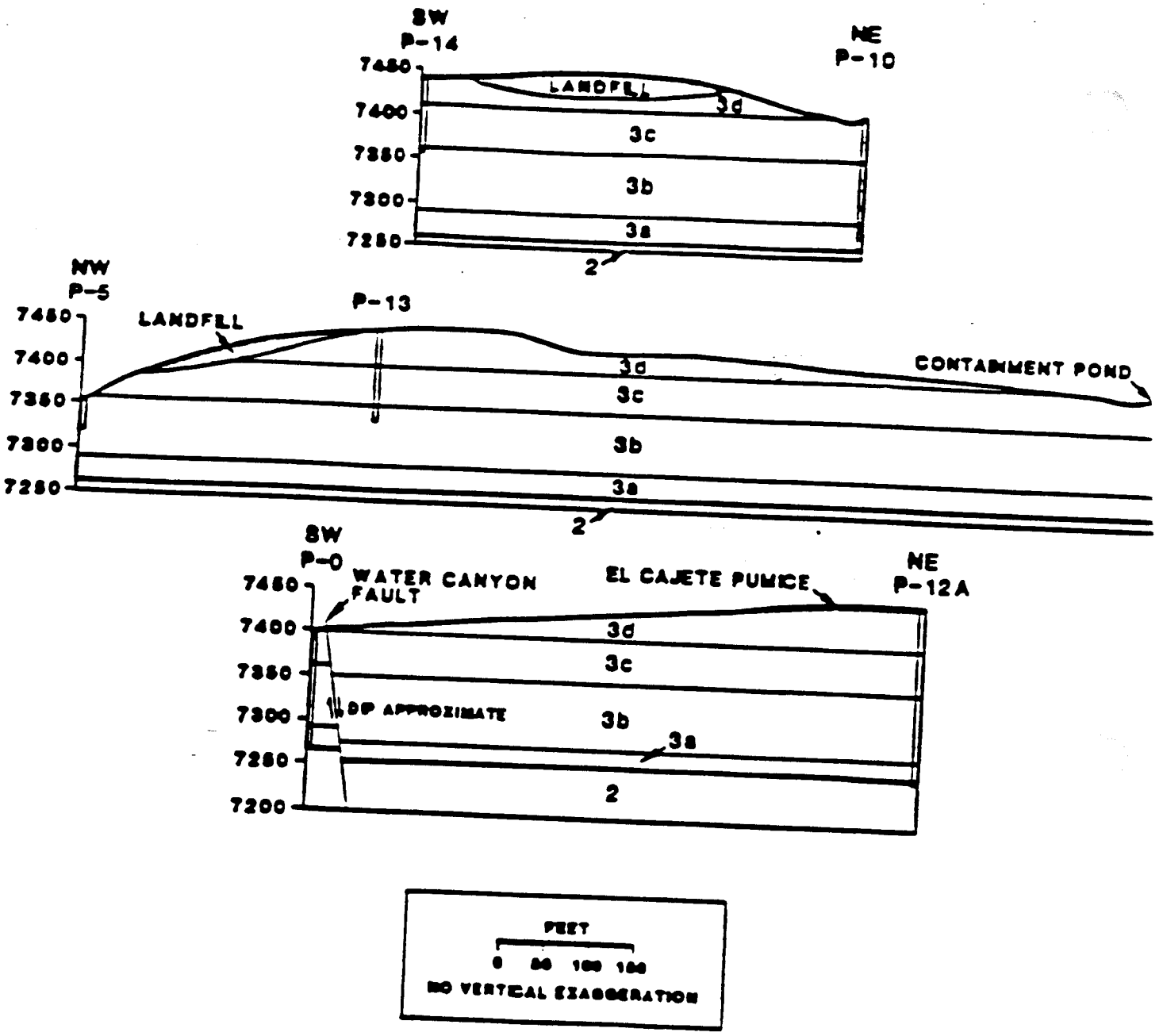


Figure D3. Geologic cross sections through Area P. Section lines are shown in Figure D2.

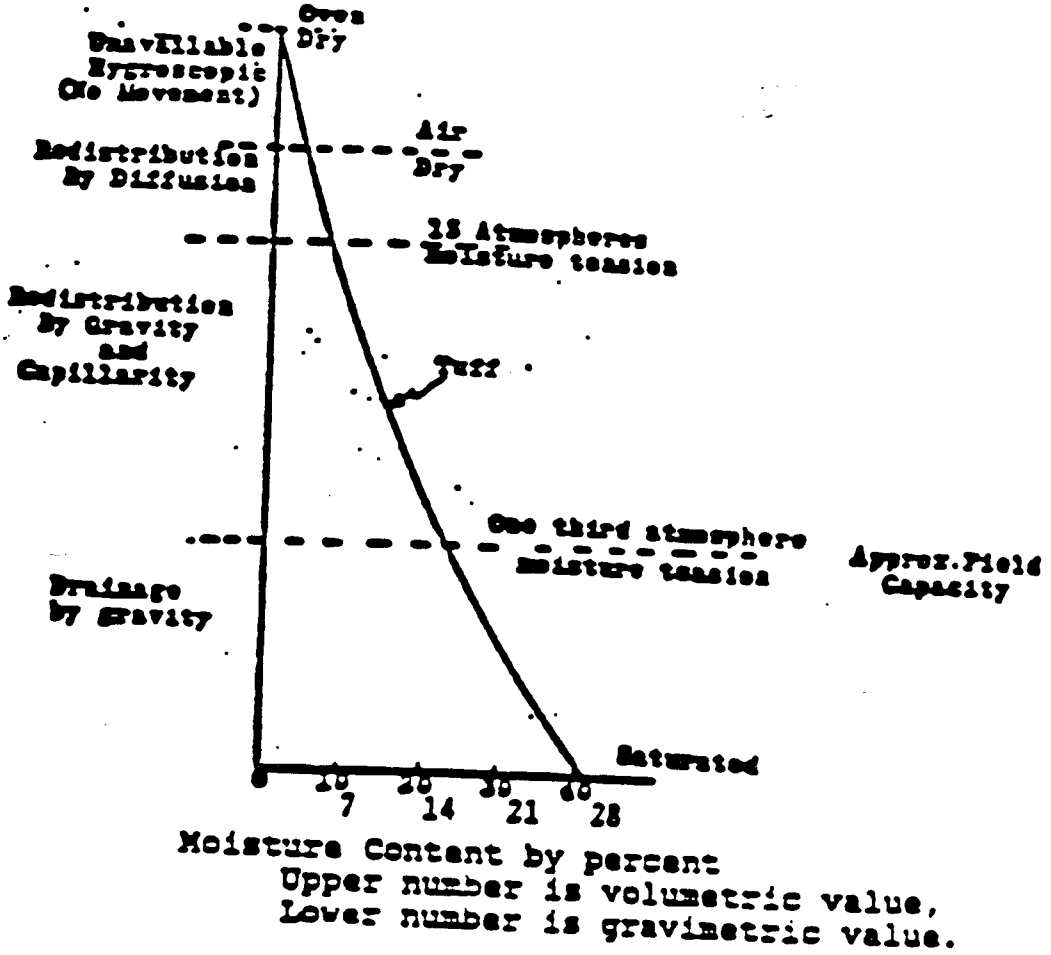
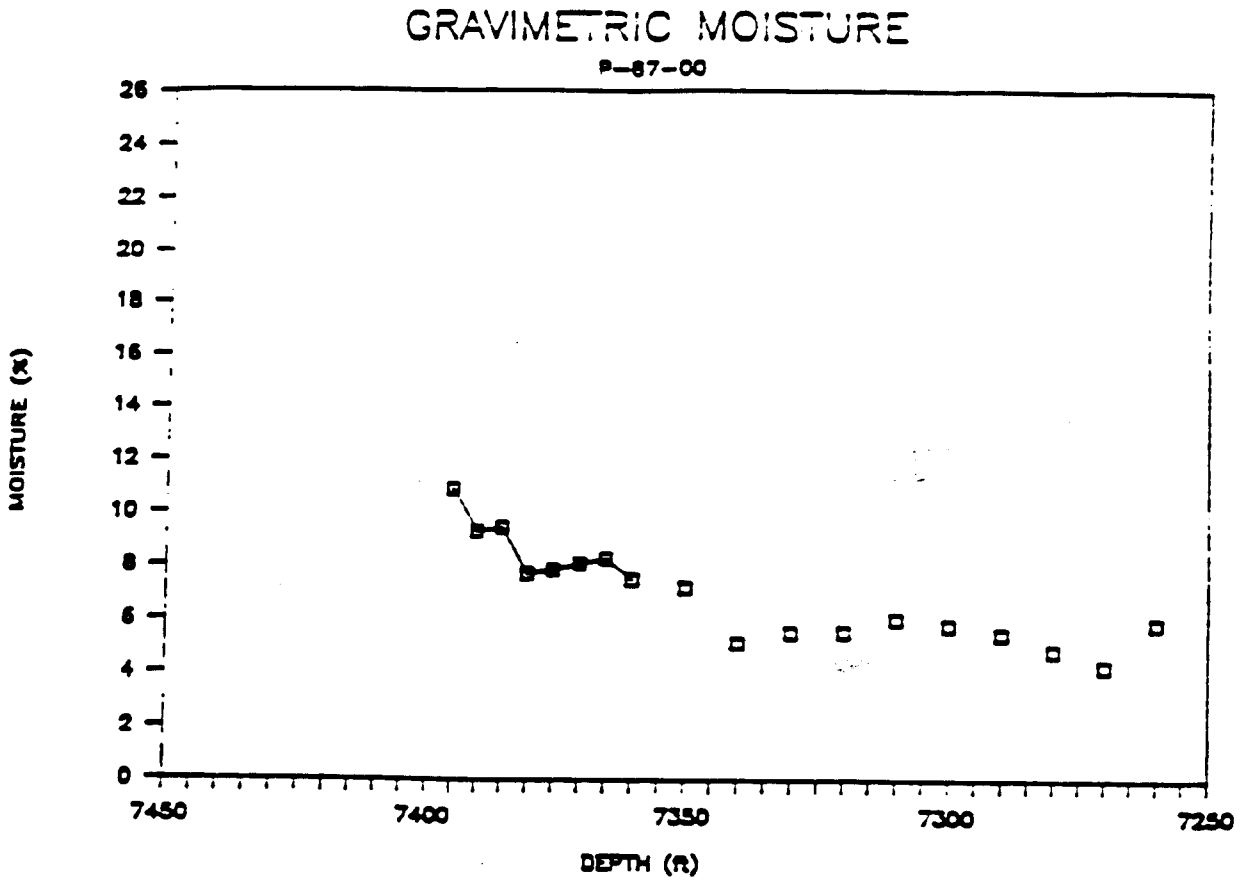


Figure D4. Energy relationship with moisture content of Bandelier Tuff (modified from Abrahams, 1963).


GRAVIMETRIC MOISTURE
P-87-00
MOISTURE (%)
DEPTH (ft)
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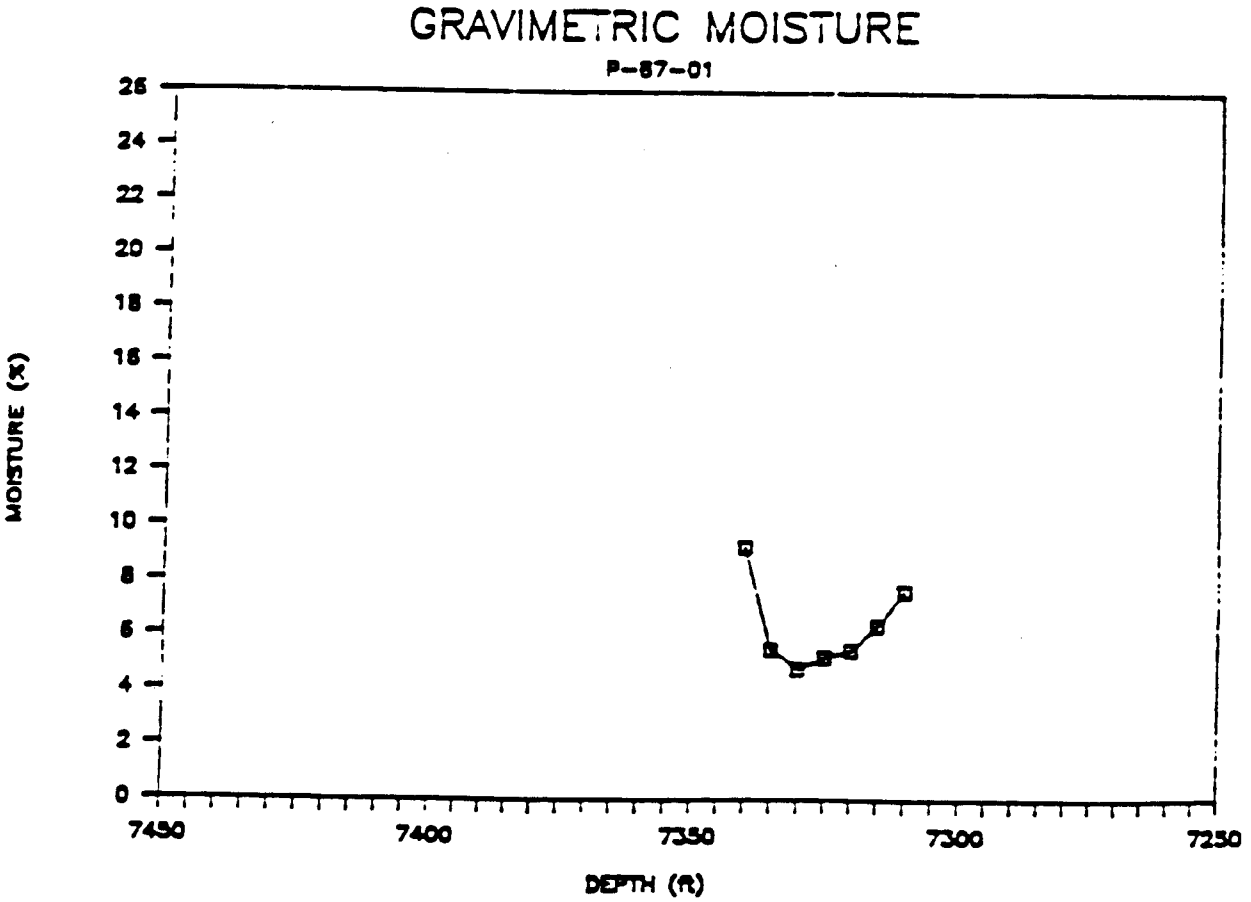
2
4
6
8
10
12
14
16
18
20
22
24
26
7450
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-01
MOISTURE (%)
DEPTH (ft)
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12
14
16
18
20
22
24
26
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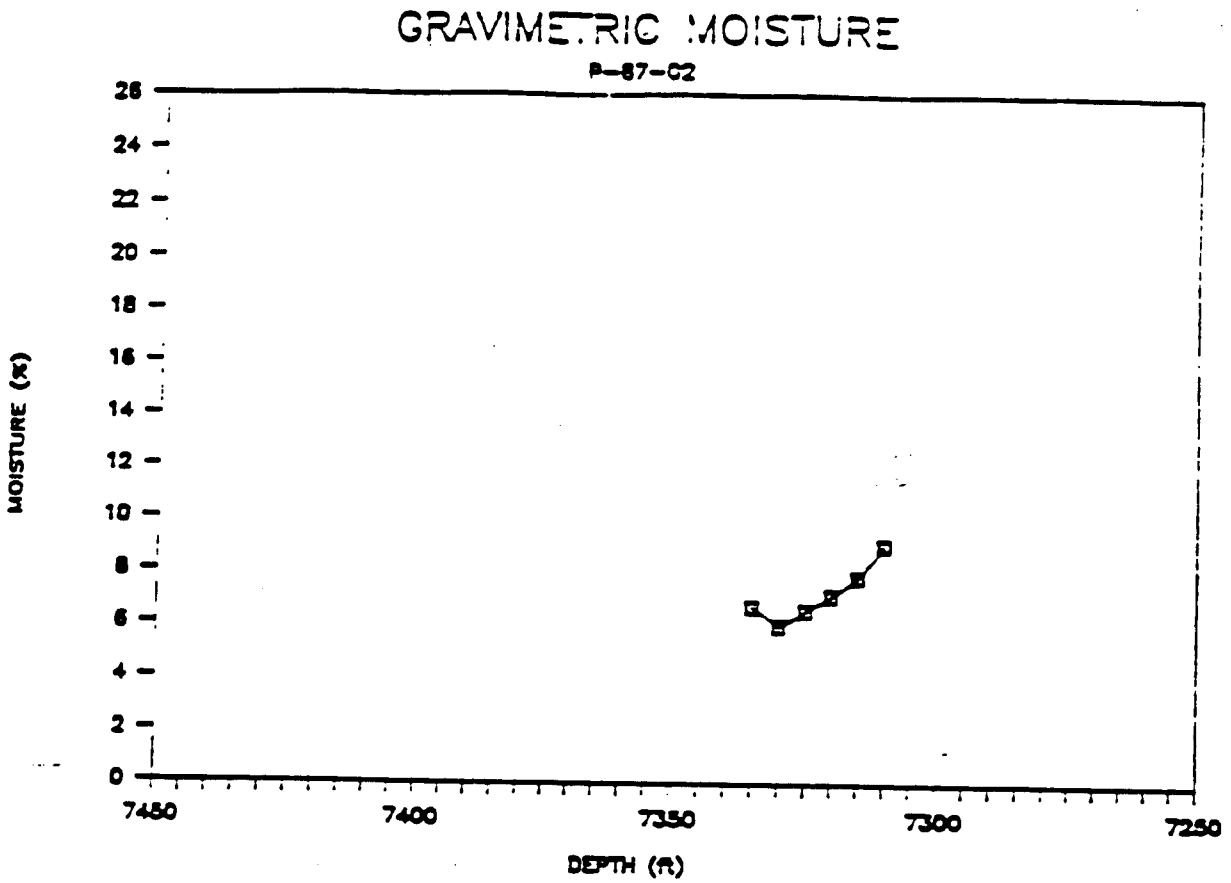
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-02
MOISTURE (%)
DEPTH (ft)
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12
14
16
18
20
22
24
26
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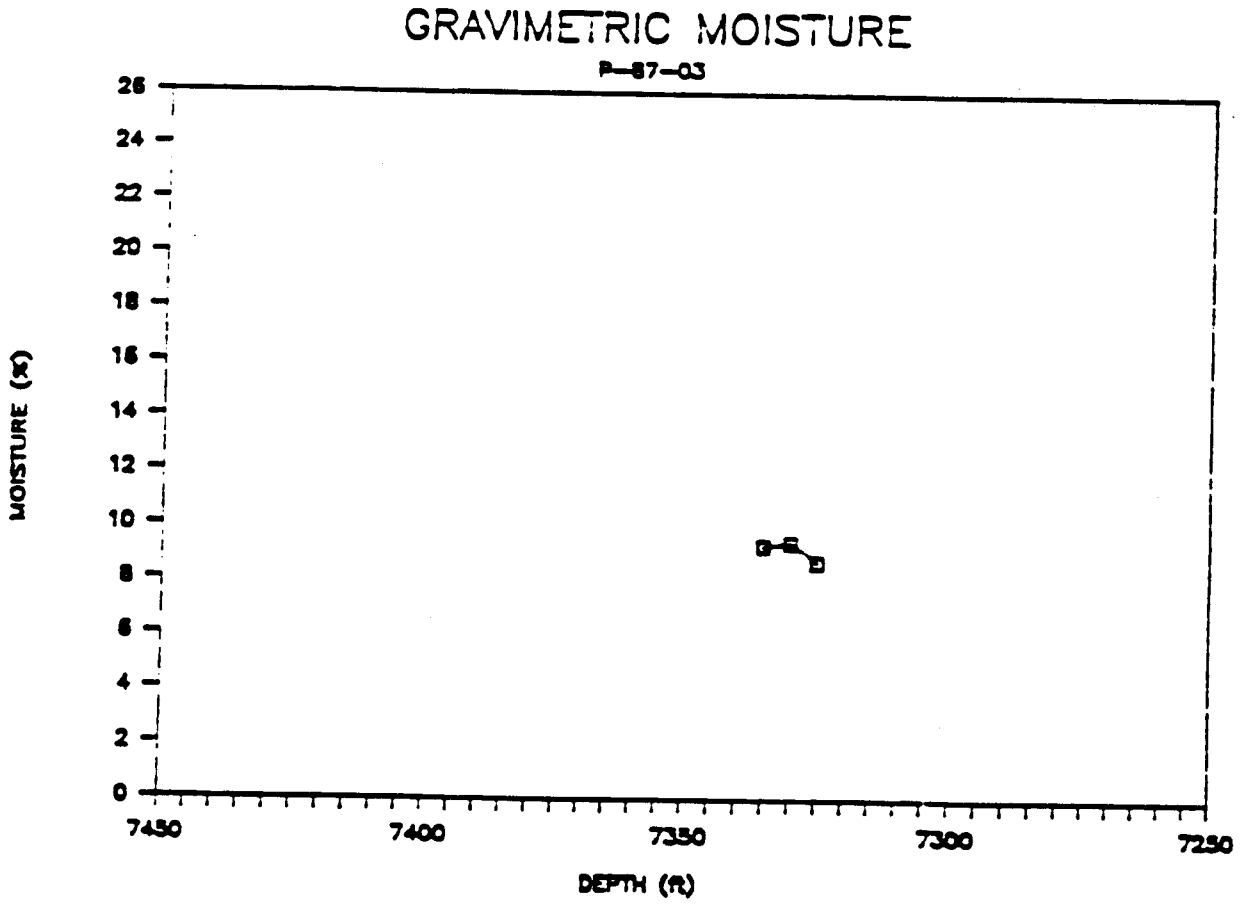
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-03
MOISTURE (%)
DEPTH (ft)
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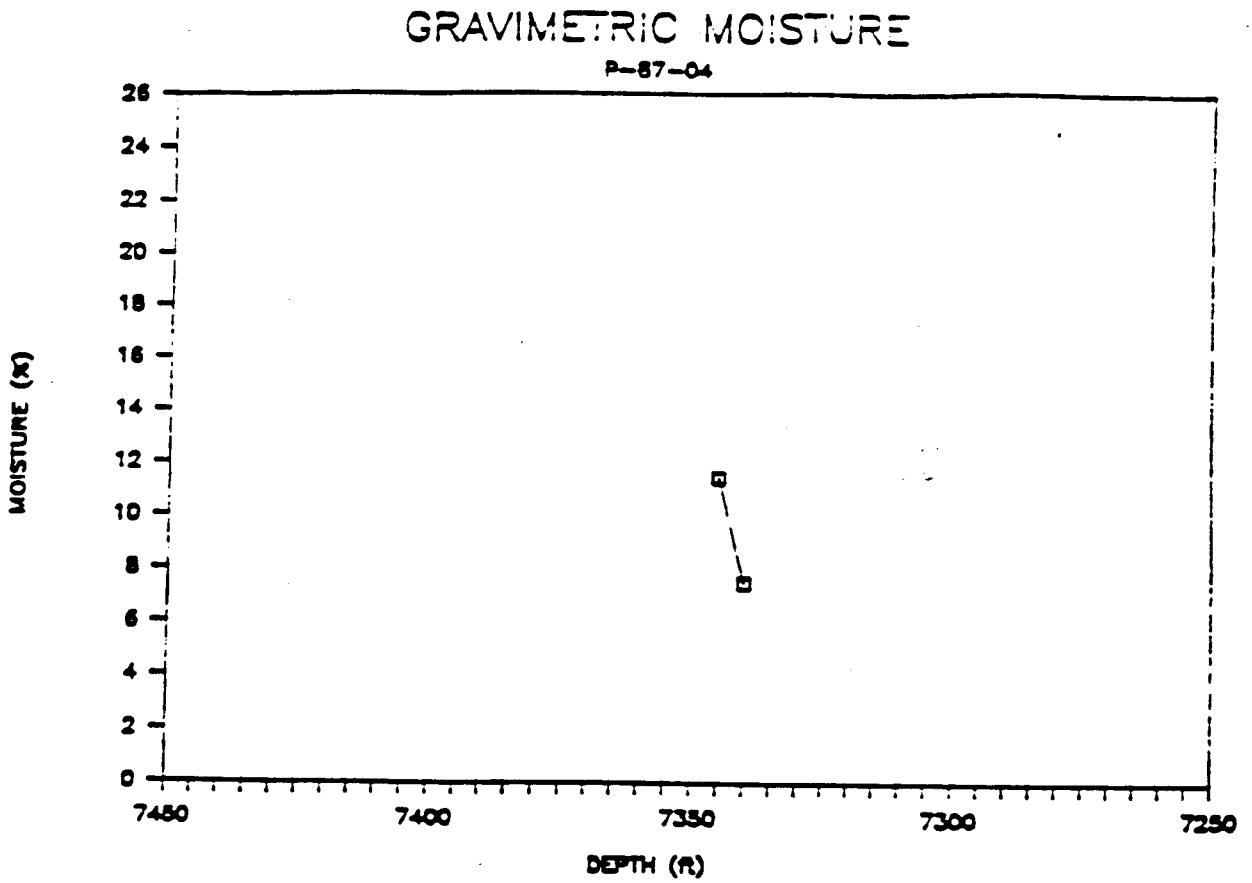
10
12
14
16
18
20
22
24
26
7450
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-04
MOISTURE (%)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
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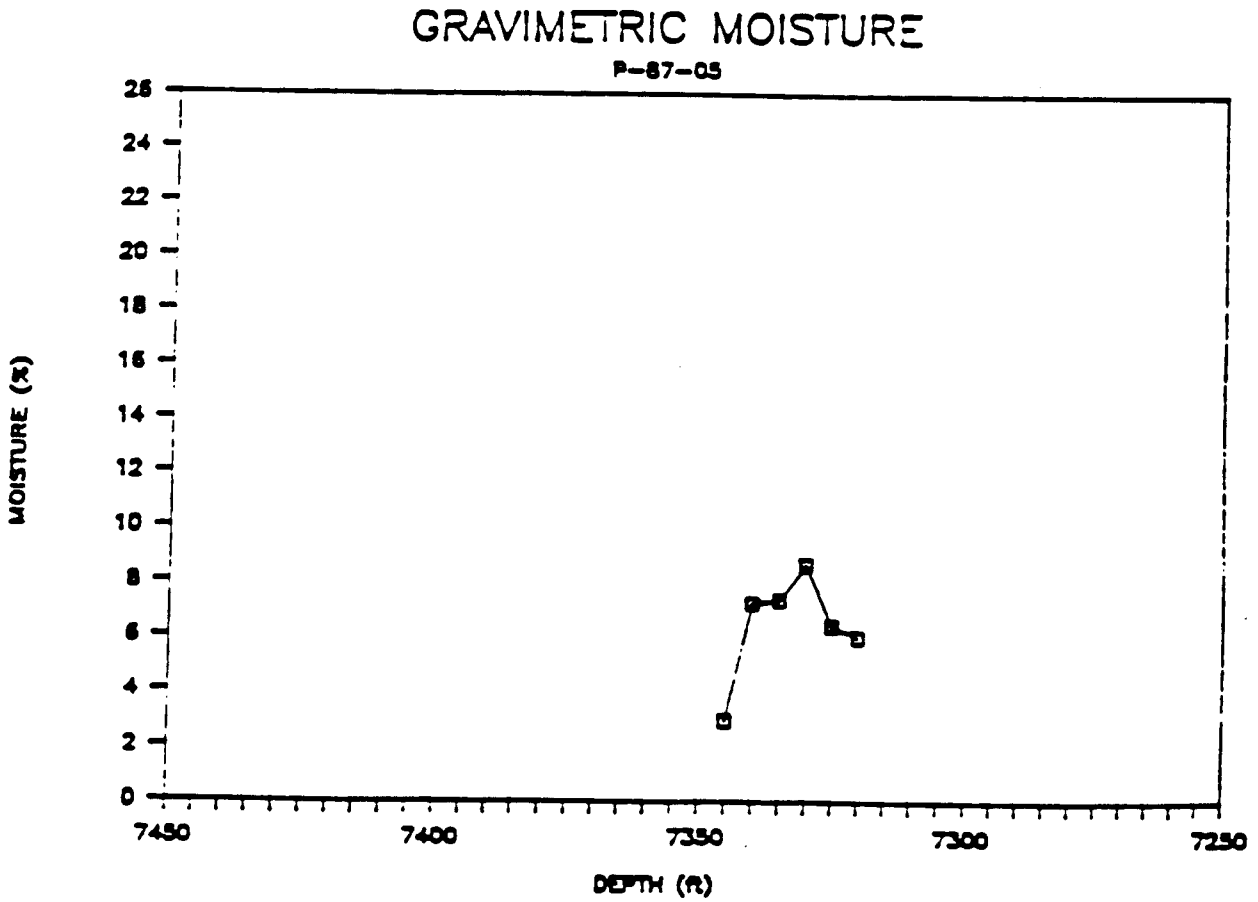
7400
7350
7300
7250
DEPTH (ft)


GRAVIMETRIC MOISTURE
P-87-05
MOISTURE (%)
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24
22
20
18
16
14
12
10
8
6
4
2
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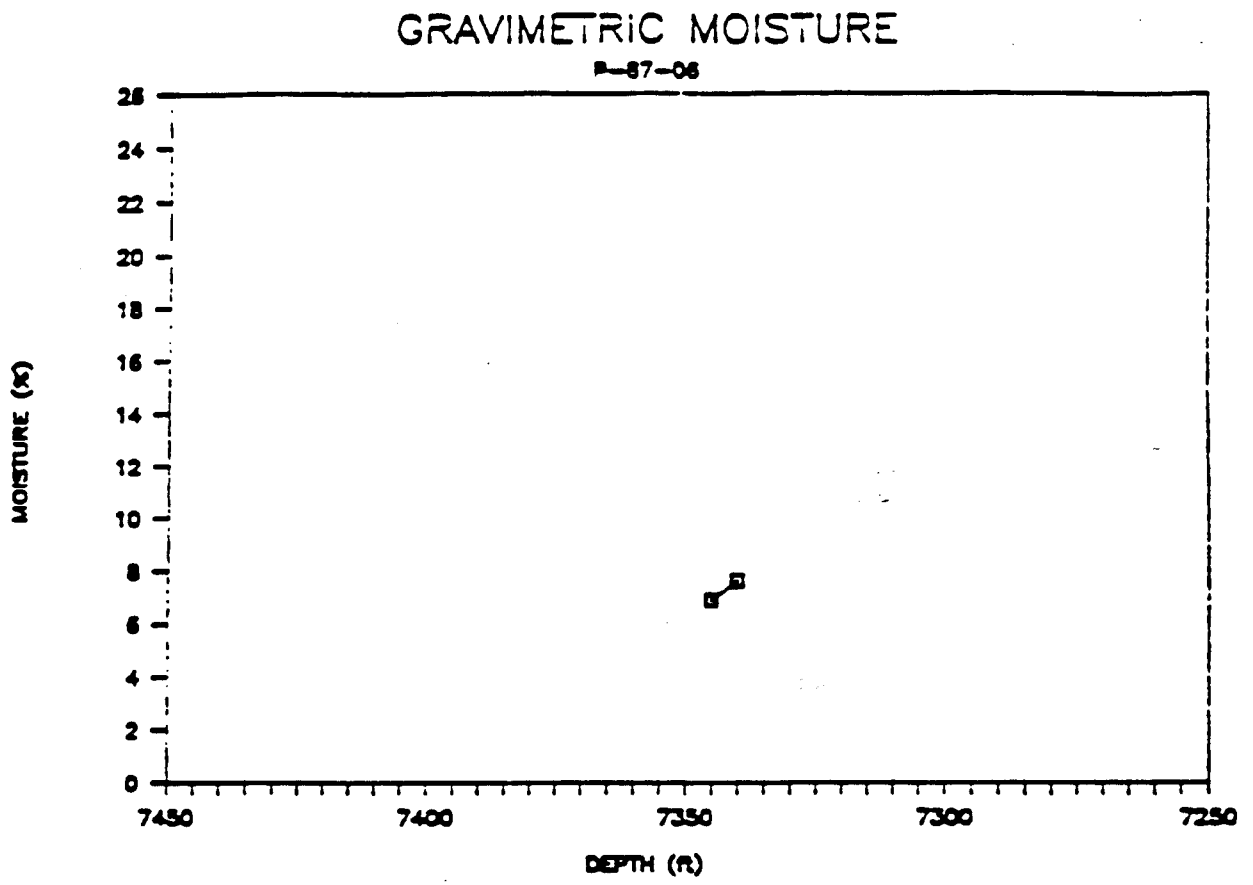
7400
7350
7300
7250
DEPTH (ft)


GRAVIMETRIC MOISTURE
P-87-06
MOISTURE (%)
DEPTH (ft)
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4
6
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10
12
14
16
18
20
22
24
26
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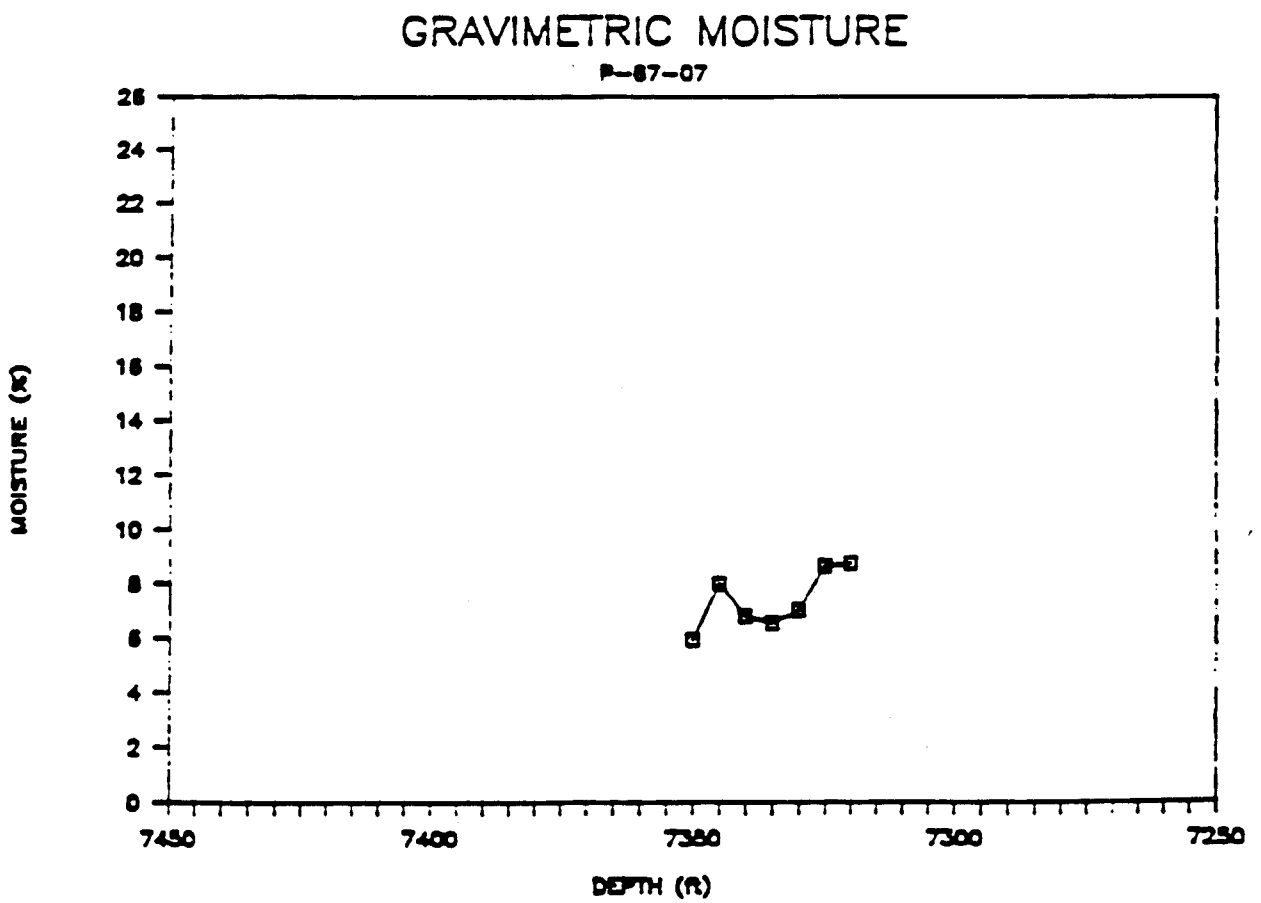
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-07
MOISTURE (%)
DEPTH (ft)
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6
8
10
12
14
16
18
20
22
24
26
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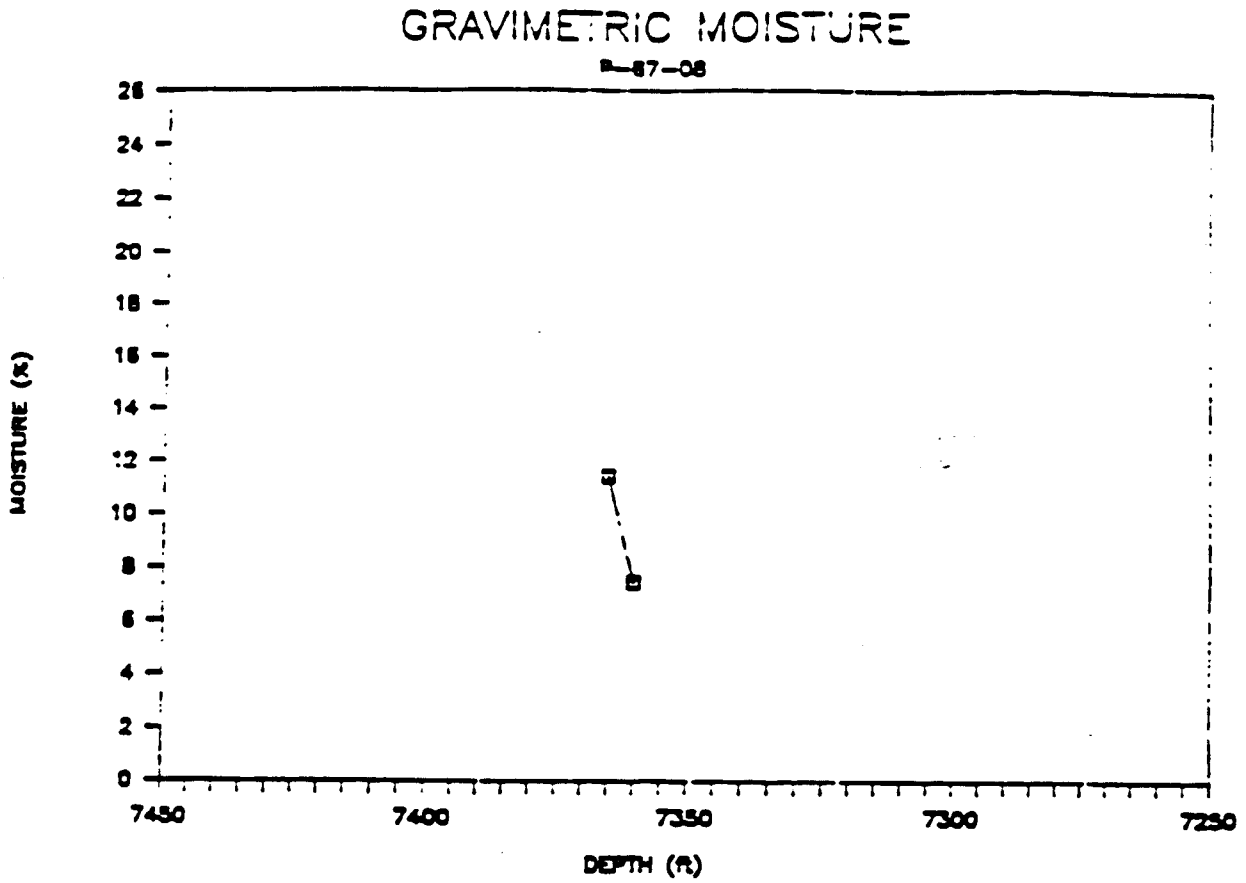
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-08
MOISTURE (%)
DEPTH (ft)
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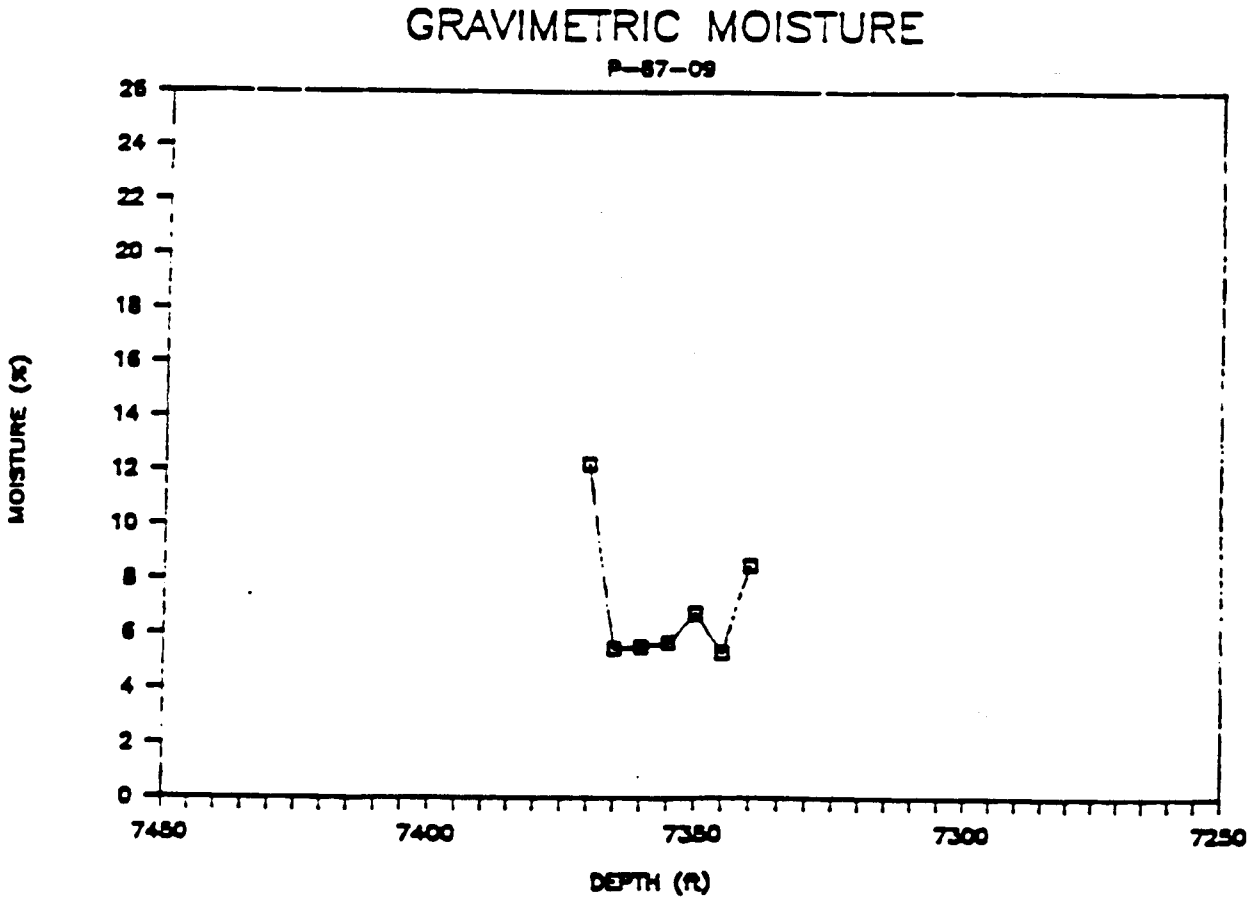
6
8
10
12
14
16
18
20
22
24
26
7450
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-09
MOISTURE (%)
DEPTH (ft)
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6
8
10
12
14
16
18
20
22
24
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7450
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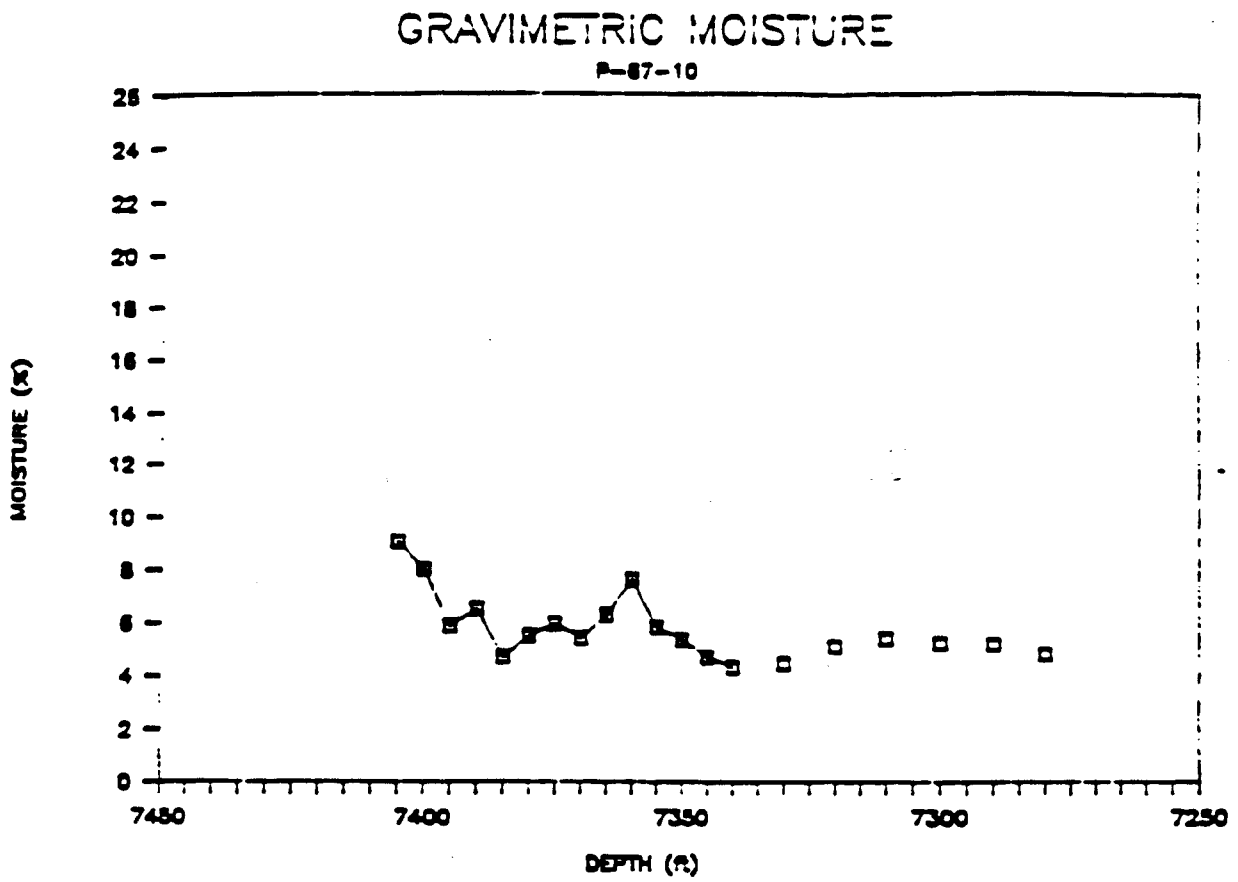
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-10
MOISTURE (%)
DEPTH (ft)
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12
14
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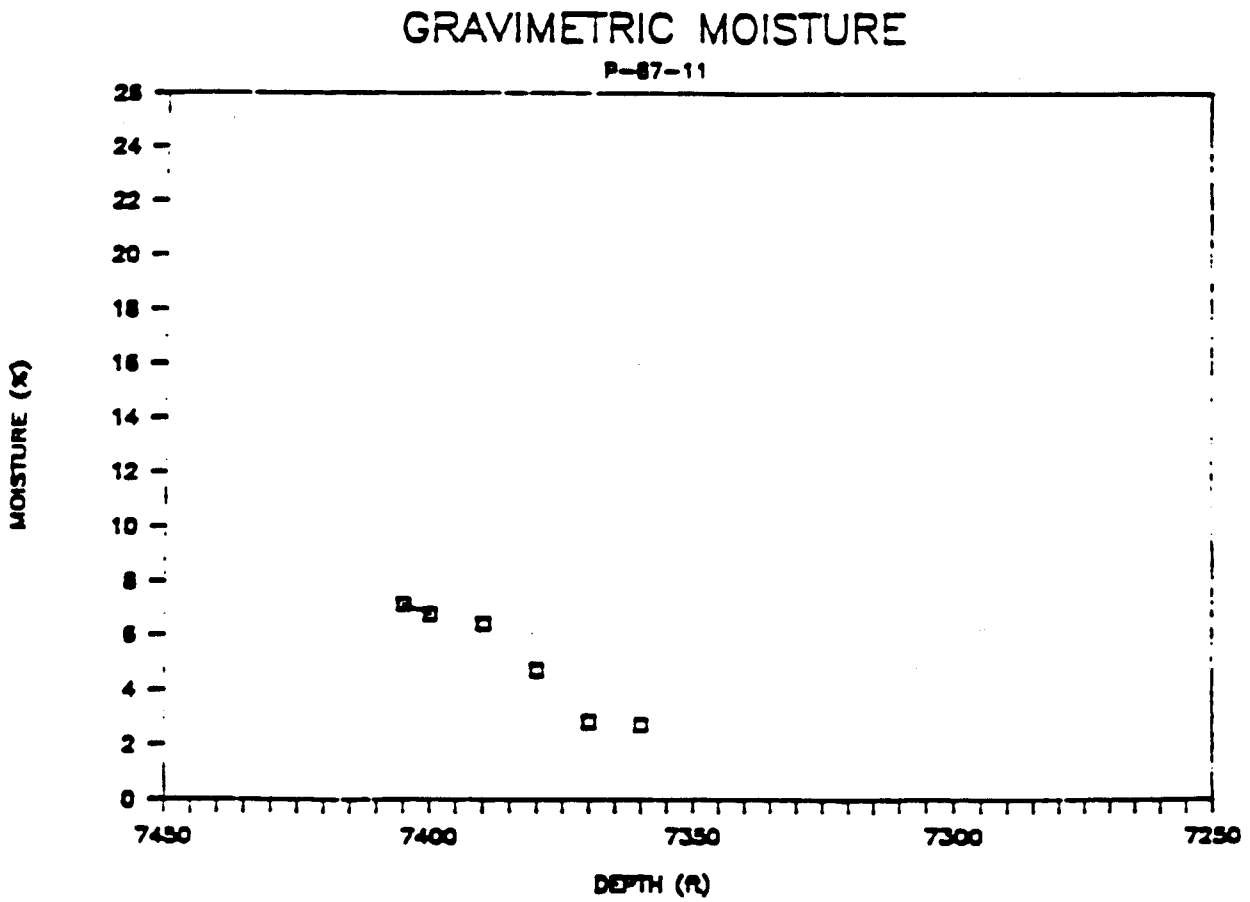
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-11
MOISTURE (%)
DEPTH (ft)
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10
12
14
16
18
20
22
24
26
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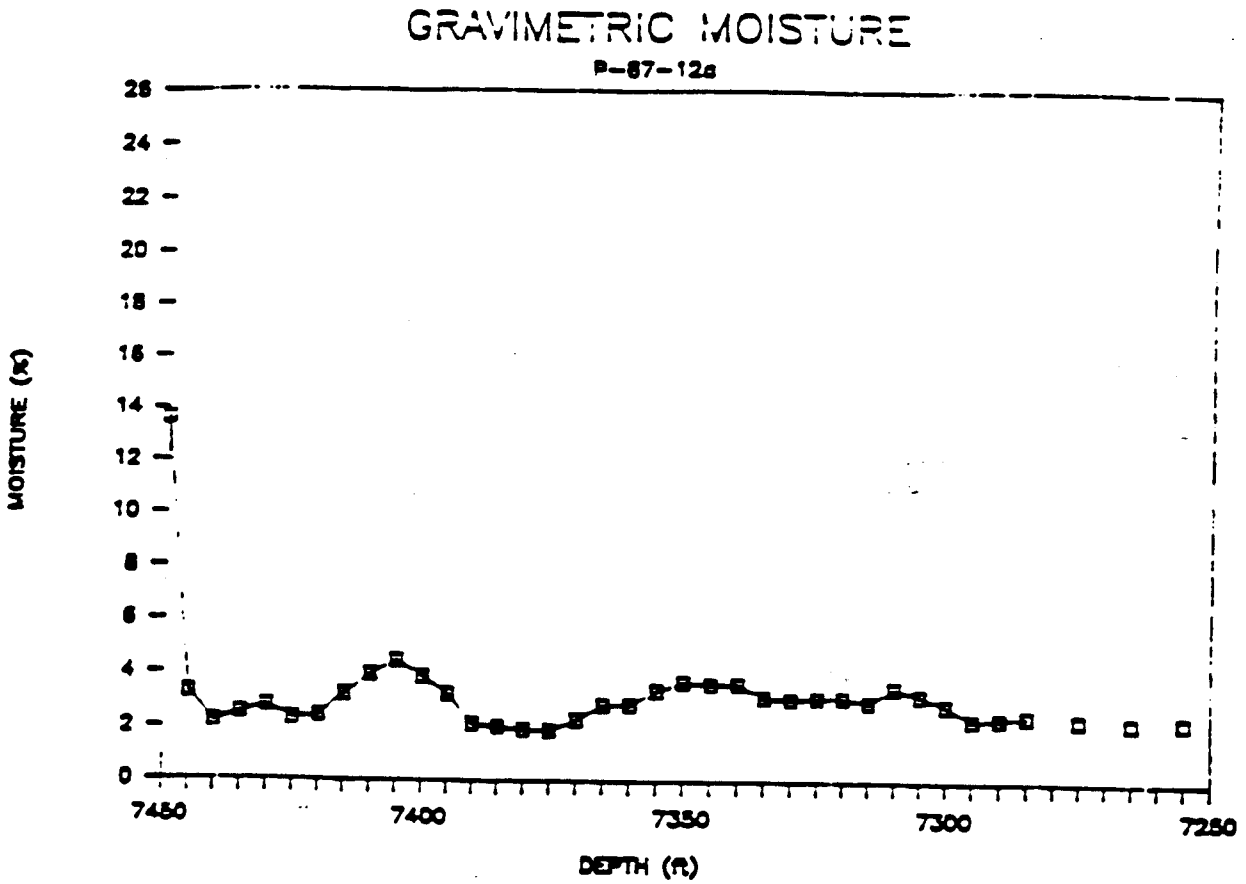
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-12a
MOISTURE (%)
DEPTH (ft)
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12
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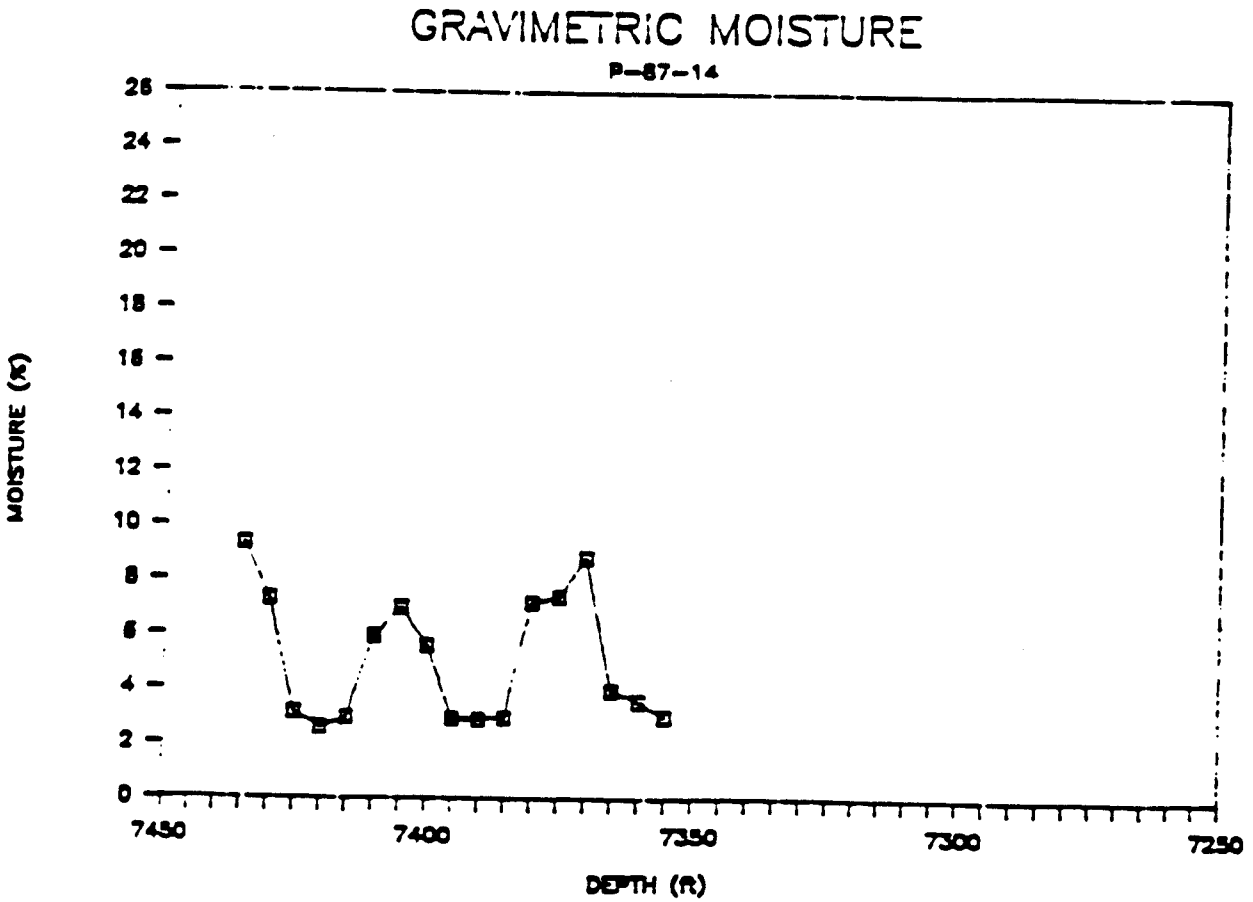
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-14
MOISTURE (%)
DEPTH (ft)
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10
12
14
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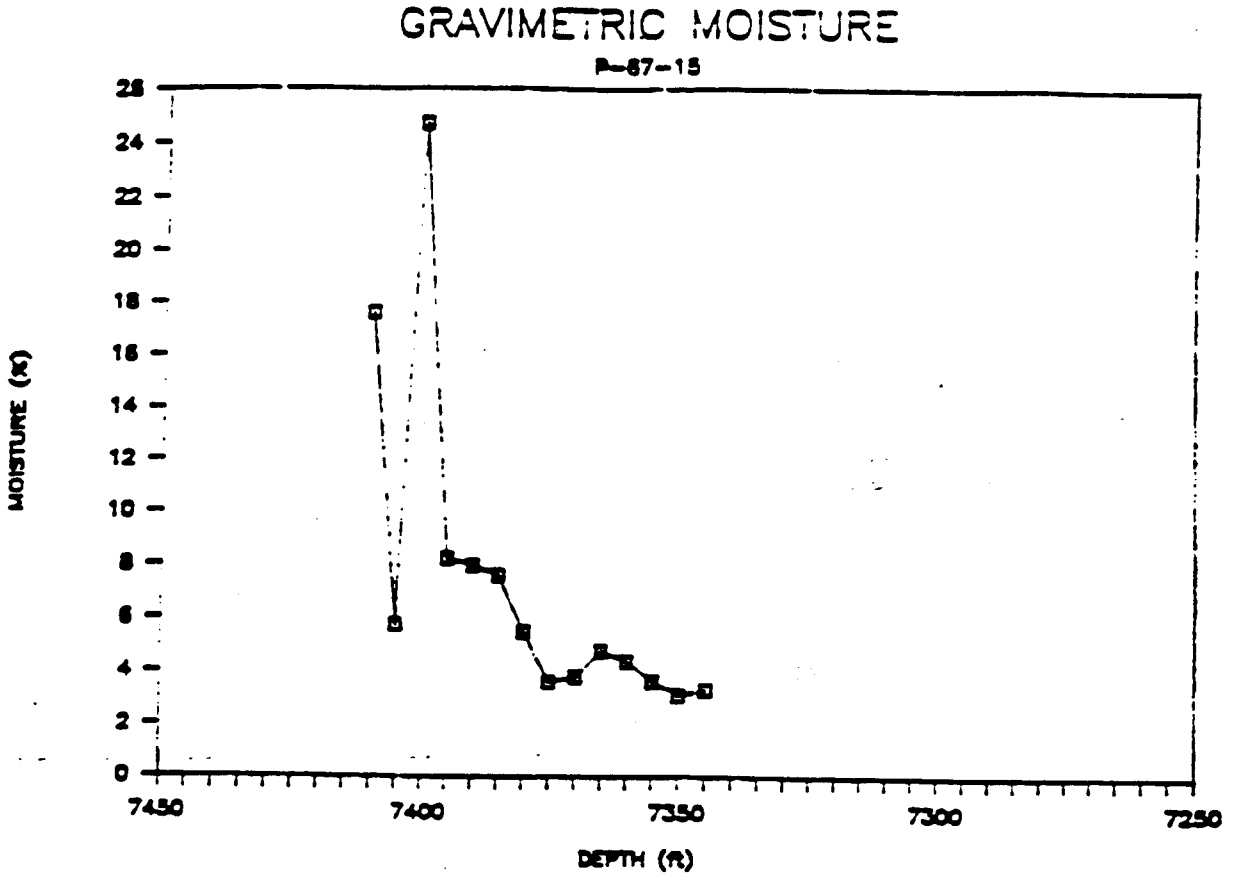
7400
7350
7300
7250


GRAVIMETRIC MOISTURE
P-87-15
MOISTURE (%)
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24
22
20
18
16
14
12
10
8
6
4
2
0
7450
7400
7350
7300
7250
DEPTH (ft)

TABLE D-2
DATA FROM DRILLING CORES RECOVERED AT WELL P-16A

RESULTS OF HEAVY METALS ANALYSES:

EPA EXTRACT CONCENTRATIONS (in milligrams/liter)

	CORE DEPTHS (in feet)					UNCERTANITY
PARAMETER	10	50	55	60	81	(mg/l)
Arsenic	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	<0.05	0.07	0.09	0.09	<0.05	<0.05
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

VOLUMETRIC MOISTURE CONTENT OF CORE LOGS RECOVERED FROM WELL P-16A

Depth	% Moisture
0.5 ft	5.6 %
5.5 ft	16.0 %
10.5 ft	10.1 %
15.5 ft	13.8 %
20.5 ft	13.1 %

AVERAGE GRAVIMETRIC MOISTURE CONTENT (%) FROM FIFTEEN DIFFERENT CORE LOGS AT TA-16 AREA P LANDFILL

GEOLOGIC UNIT	MEAN MOISTURE (%)	STD	RANGE (%)
3 d	5.2	3.6	2.2 - 17.7
3 c	6.1	3.5	1.9 - 24.7
3 b	5.7	2.1	2.3 - 11.4
3 a	3.8	1.4	2.3 - 5.8
Total for Unit	5.8	3.0	1.9 - 24.7

Notes: (1) See Figure D-3 for Geologic Unit Cross Section
(2) STD = standard deviation.

TABLE D-3
TARGET VOLATILE AND SEMI-VOLATILE ORGANIC COMPOUND
INDENTIFICATION LIST FOR WELL P-16 CORE SAMPLES

Compound Name	CAS Number
Acetone	67641
Benzene	71432
Bromodichloromethane	75274
Bromoform	75252
Bromomethane (methyl bromide)	74839
2-Butanone (methyl ethyl ketone)	78933
Carbon Disulfide	75150
Carbon Tetrachloride	56235
Chlorobenzene	108907
Chloroethane	75003
Chloroform	67663
Chloromethane (methyl chloride)	74873
1,2-Dichlorobenzene	95501
1,3-Dichlorobenzene	541731
1,4-Dichlorobenzene	106467
1,1-Dichloroethane (ethylidene dichloride)	75343
1,2-Dichloroethane	107062
1,2-Dichloroethene	540590
1,1-Dichloroethylene	75354
1,2-Dichloropropane (propylene dichloride)	78875
cis-1,3-Dichloropropene	10061015
trans-1,3-Dichloropropene	10061026
Ethyl Benzene	100414
Naphthalene	91023
Methylene Chloride	75092
4-Methyl-2-Pentanone	108101
Styrene	100425
1,1,2,2-Tetrachloroethane	79345
Tetrachloroethene	127184
Toluene	108883
1,1,2-Trichloroethane	79005
1,1,1-Trichloroethane (methyl chloroform)	71556
Trichloroethene	79016
Trichloroflouromethane	75694
Vinyl Acetate	108054
Vinyl Chloride (chloroethene)	75014
Xylenes	133027

NOTE: All of the above compounds were at concentrations below GC/MS detection limits. Sample date was 9-10-87.

TABLE D-4. RECONNAISSANCE WATER QUALITY AND SEDIMENT SAMPLING
LOS ALAMOS NATIONAL LABORATORY - TA-16 AREA P LANDFILL
SEE ATTACHED MAP FOR SAMPLE LOCATIONS

STATION ID : TA-16 AREA P - CANON DE VALLE
SAMPLE TYPE: SURFACE WATER SAMPLES - CANON DE VALLE
SAMPLE DATE: DECEMBER 7, 1987
LABORATORY : LANL HSE-9 LABORATORY (ANALYSES ON 12-15-87)

PARAMETER CONCENTRATION ===> (all units in mg/l)

SAMPLE NO.	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
57	< 0.05	3.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
59	< 0.05	3.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
63	< 0.05	3.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
64	< 0.05	3.30	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
70	< 0.05	.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
UNCERTAINITY	0.05	0.05	0.01	0.05	0.05	0.001	0.01	0.05

SAMPLE NO.	SAMPLE DESCRIPTION ==>
57	DOWNSTREAM SURFACE WATER SAMPLE
59	SURFACE WATER NORTH OF LANDFILL
63	SURFACE WATER NORTH OF LANDFILL
64	UPSTREAM SURFACE WATER SAMPLE
70	SNOWMELT IN INFLOW DRAINAGE CHANNEL

TABLE D-4. RECONNAISSANCE WATER QUALITY AND SEDIMENT SAMPLING
LOS ALAMOS NATIONAL LABORATORY - TA-16 AREA P LANDFILL
SEE ATTACHED MAP FOR SAMPLE LOCATIONS

STATION ID : TA-16 AREA P - CANON DE VALLE
SAMPLE TYPE: STREAM SEDIMENTS & SOIL SAMPLES - EPA WATER EXTRACT
SAMPLE DATE: DECEMBER 7, 1987
LABORATORY : LANL HSE-9 LABORATORY (ANALYSES ON 12-15-87)

	PARAMETER CONCENTRATION ===> (all units in mg/l)							
SAMPLE NO.	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
55	< 0.05	.60	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
56	< 0.05	.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
58	< 0.05	.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
60	< 0.05	2.70	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
61	< 0.05	.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
62	< 0.05	2.10	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
65	< 0.05	2.70	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
66	< 0.05	.50	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
67	< 0.05	.90	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
68	< 0.05	2.70	< 0.01	< 0.05	.13	< 0.001	< 0.01	< 0.05
69	< 0.05	1.30	< 0.01	< 0.05	< 0.05	< 0.001	< 0.01	< 0.05
UNCERTAINITY	0.05	0.05	0.01	0.05	0.05	0.001	0.01	0.05

SAMPLE NO.	SAMPLE DESCRIPTION ==>
55	LANDFILL EROSION SOIL SEDIMENTS
56	BACKGROUND EROSION SOIL SEDIMENTS
58	DOWNSTREAM SURFACE CHANNEL SEDIMENTS
60	SURFACE CHANNEL SEDIMENTS NORTH OF LANDFILL
61	SURFACE CHANNEL SEDIMENTS NORTH OF LANDFILL
62	SURFACE CHANNEL SEDIMENTS NORTH OF LANDFILL
65	UPSTREAM SURFACE CHANNEL SEDIMENTS (NORTHWEST)
66	DRAINAGE CHANNEL SEDIMENTS WEST OF LANDFILL
67	DRAINAGE CHANNEL SEDIMENTS AT CANON DE VALLE
68	DRAINAGE CHANNEL SEDIMENTS SOUTH OF LANDFILL
69	INFLOW DRAINAGE CHANNEL SEDIMENTS

WELL COMPLETION DIAGRAM

P-87-00
(ALUMINUM)

```
                 T|  |<--------- 0
                 T|  | TOP SOIL
                 T|  |<--------- 3
                 T|  |
                 T|  | TUFF (3c)
                 T|  |
                 T|  |<--------- 40
                 T|  |
                 T|  |
                 T|  | TUFF (3b)
                 T|  |
                 T|  |
                 T|  |
                 T|  |<--------- 110
120 --------->T|  |
                |X| TUFF (3a)
                |X|
                 - <--------- 135
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-00
GEOLOGIST: Fred Brown
DATE DRILLED: 21 JULY 1987
ELEVATION: 72[illegible] ft
LOCATION: 476[illegible]5,1763523
TOTAL DEPTH: 135 ft
DISPOSITION: Aluminum Casing

DEPTH	DESCRIPTION
0-3	Fill/Top Soil (sandy loam)
3-40	Unit 3c. Light brownish grey tuff Moderately welded Rare rhyolite lithic fragments Common grey pumice lapilli
40	Contact is strongly welded
40-110	Unit 3b. Pale yellowish brown tuff Moderately welded Rare rhyolite fragments Abundant grey pumice lapilli Fracture noted at 45 ft
110	Contact is strongly welded
110-135	Unit 3a. Dark yellowish brown tuff Welded Abundant rhyolite/latite lithic fragments Rare pumice lapilli
135	Unit 2. Densely welded tuff halts drilling

WELL COMPLETION DIAGRAM

P-87-01
(PVC)

```
                C|  |<---------- 0
                C|  | TOP SOIL
                C|  |<---------- 4
                C|  |
13 ---------->C|  |
                B|  |
15 ---------->B|  |
                S|=|
                S|=|
                S|=| TUFF (3b)
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                  - <---------- 35
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-01
GEOLOGIST: Fred Brown
DATE DRILLED: 29 JULY 1987
ELEVATION: 7344 ft
LOCATION: 475756,1764645
TOTAL DEPTH: 35 ft
DISPOSITION: PVC Casing

DEPTH	DESCRIPTION
0-4	Top Soil (sandy loam)
5-10	Unit 3b. Dark yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli
10-35	Unit 3b. Pale yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli

BOREHOLE: P-87-02
GEOLOGIST: Fred Brown
DATE DRILLED: 23 JULY 1987
ELEVATION: 7341 ft
LOCATION: 475708, 1764617
TOTAL DEPTH: 10 ft
DISPOSITION: Filled In

DEPTH	DESCRIPTION
0-3	Top Soil (sandy loam)
3-10	Unit 3b. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-03
(TEFLON)

```
                C|  |<---------- 0
1 ---------->C|  |
                B|  |  TOP SOIL
2 ---------->B|  |
                S|=|
                S|=|
                S|=|<---------- 3
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|  TUFF (3b)
                S|=|
                S|=|
7 ---------->S|=|
                |X|
                |X|
                 - <---------- 9
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-03
GEOLOGIST: Fred Brown
DATE DRILLED: 23 JULY 1987
ELEVATION: 7342 ft
LOCATION: 475676, 1764596
TOTAL DEPTH: 9 ft
DISPOSITION: Teflon Casing

DEPTH	DESCRIPTION
0-3	Top Soil, boulders and cobbles
3-9	Unit 3b. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-04
(TEFLON)

```
                C|  |<---------- 0
1 ---------->C|  |
                B|  | TOP SOIL
3 ---------->B|  |
                S|=|
                S|=|
                S|=|<---------- 4
                S|=|
                S|=|
                S|=|
                S|=|
                S|=| TUFF (3b)
                S|=|
                S|=|
8 ---------->S|=|
                |X|
                |X|
                 - <---------- 10
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-04
GEOLOGIST: Fred Brown
DATE DRILLED: 28 JULY 1987
ELEVATION: 7348 ft
LOCATION: 475588, 1764562
TOTAL DEPTH: 10 ft
DISPOSITION: Teflon Casing

DEPTH	DESCRIPTION
0-4	Top Soil (sandy loam)
4-10	Unit 3b. Dark yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-05
(PVC)

```
                C|  |<---------- 0
                C|  | TOP SOIL
                C|  |<---------- 3
                C|  |
13 ---------->C|  |
                B|  |
15 ---------->B|  |
                S|=|
                S|=|
                S|=| TUFF (3b)
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                  - <---------- 35
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-05
GEOLOGIST: Fred Brown
DATE DRILLED: 29 JULY 1987
ELEVATION: 7353 ft
LOCATION: 475520, 1764532
TOTAL DEPTH: 35 ft
DISPOSITION: PVC Casing

DEPTH	DESCRIPTION
0-3	Top Soil (sandy loam)
3-15	Unit 3b. Dark yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli
15-35	Unit 3b. Orange pink tuff Moderately welded Rare rhyolite lithic fragments Rare grey pumice lapilli

WELL COMPLETION DIAGRAM

P-87-06
(TEFLON)

```
                C|  |<---------- 0
1 ---------->C|  |
                B|  |
2 ---------->B|  | TOP SOIL
               S|=|
               S|=|
               S|=|<---------- 4
               S|=|
               S|=|
               S|=|
               S|=|
               S|=| TUFF (3b)
               S|=|
               S|=|
7 ---------->S|=|
                |X|
                |X|
                 - <---------- 10
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-06
GEOLOGIST: Fred Brown
DATE DRILLED: 28 JULY 1987
ELEVATION: 7352 ft
LOCATION: 475467, 1764514
TOTAL DEPTH: 10 ft
DISPOSITION: Teflon Casing

DEPTH	DESCRIPTION
0-4	Top Soil (sandy loam)
4-10	Unit 3b. Pale yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-07
(PVC)

```
                C|  |<--------- 0
                C|  | TOP SOIL
                C|  |<--------- 2
                C|  |
13 --------->C|  |
                B|  |
15 --------->B|  |
                S|=|
                S|=|
                S|=| TUFF (3b)
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                  - <--------- 35
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-07
GEOLOGIST: Fred Brown
DATE DRILLED: 29 JULY 1987
ELEVATION: 7356
LOCATION: 475381, 1764491
TOTAL DEPTH: 35 ft
DISPOSITION: PVC Casing

DEPTH	DESCRIPTION
0-2	Top Soil (sandy loam)
2-5	Unit 3b. Pale yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli
5-6	Weathered dark reddish brown clay
6-35	Unit 3b. Pale yellowish brown tuff Moderately welded Common rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-08
(TEFLON)

```
                C|  |<--------- 0
1 --------->C|  |
                B|  | TOP SOIL
2 --------->B|  |
                S|=|
                S|=|
                S|=|<---------- 3
                S|=|
                S|=|
                S|=|
                S|=|
                S|=| TUFF (3c)
                S|=|
                S|=|
7 --------->S|=|
                 |X|
                 |X|
                  - <--------- 10
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-08
GEOLOGIST: Fred Brown
DATE DRILLED: 28 JULY 1987
ELEVATION: 7370 ft
LOCATION: 475257, 1764405
TOTAL DEPTH: 10 ft
DISPOSITION: Teflon Casing

DEPTH	DESCRIPTION
0-3	Top Soil (sandy loam)
3-10	Unit 3c. Dark yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-09
(PVC)

```
                C|  |<--------- 0
                C|  | TOP SOIL
                C|  |<--------- 3
                C|  |
13 ---------->C|  | TUFF (3c)
                B|  |
15 ---------->B|  |<---------- 15
                S|=|
                S|=|
                S|=|
                S|=|
                S|=| TUFF (3b)
                S|=|
                S|=|
                S|=|
                S|=|
                S|=|
                  - <---------- 35
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-09
GEOLOGIST: Fred Brown
DATE DRILLED: 29 JULY 1987
ELEVATION: 7376 ft
LOCATION: 475183, 1764381
TOTAL DEPTH: 35 ft
DISPOSITION: PVC Casing

DEPTH	DESCRIPTION
0-3	Top Soil (sandy loam)
3-15	Unit 3c. Moderate brown tuff Moderately welded Rare rhyolite lithic fragments Common grey pumice lapilli
15-33	Unit 3b. Greyish brown tuff Welded Abundant rhyolite/latite lithic fragments Common red-brown pumice lapilli
33-35	Unit 3b. Pale brown tuff and clay Moderately welded Rare rhyolite lithic fragments Abundant clayey pumice lapilli

WELL COMPLETION DIAGRAM

P-87-10
(UNCASED)

```
<---------- 0
 TOP SOIL
<---------- 3

 TUFF (3c)

<---------- 50

 TUFF (3b)

<---------- 120

 TUFF (3a)

<---------- 150
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-11
GEOLOGIST: Fred Brown
DATE DRILLED: 27 AUGUST 1987
ELEVATION: 7409 ft
LOCATION: 475991, 1763584
TOTAL DEPTH: 70 ft
DISPOSITION: Uncased

DEPTH	DESCRIPTION
0-2	Top Soil (sandy loam)
2-35	Unit 3c. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Common red pumice lapilli
35-45	Unit 3c. Pale yellowish brown tuff Slightly welded Rare rhyolite lithic fragments Rare pumice lapilli
45-50	Unit 3c. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli
50-70	Unit 3b. Pale yellowish brown tuff Densely welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-12A
(ALUMINUM)

```
                 T|  |<--------- 0
                 T|  | TOP SOIL
                 T|  |<--------- 3
                 T|  | TUFF (3d)
                 T|  |
                 T|  |<--------- 50
                 T|  |
                 T|  | TUFF (3C)
                 T|  |
                 T|  |<--------- 102
                 T|  |
171 ---------->T|  | TUFF (3b)
                |X|
                |X|<--------- 173
                |X| TUFF (3a)
                |X|<--------- 195
                |X| TUFF (2)
                 - <--------- 200
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-12A
GEOLOGIST: Fred Brown
DATE DRILLED: 26 August 1987
ELEVATION: 7448 ft
LOCATION: 476664, 1764036
TOTAL DEPTH: 200 ft
DISPOSITION: Aluminum Casing

DEPTH	DESCRIPTION
0-1	El Cajete Pumice
1-3	Pumice/Top Soil (sandy loam)
3-5	Clay
5-50	Unit 3d. Greyish pink tuff Slightly welded Rare rhyolite lithic fragments Rare pumice lapilli
50	Contact moderately welded Abundant brown pumice lapilli
50-102	Unit 3c. Light brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli
102	Contact moderately welded Abundant rhyolite/latite lithic fragments Common grey pumice lapilli
102-173	Unit 3b. Pale yellowish brown tuff Slightly welded Rare rhyolite lithic fragments Common reddish pumice lapilli
173	Contact slightly welded Abundant rhyolite lithic fragments Rare pumice lapilli
173-195	Unit 3a. Pale yellowish brown tuff Non-welded Abundant rhyolite/latite lithic fragments Rare pumice lapilli
195-200	Unit 2. Dark yellowish brown tuff Densely welded Abundant rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-13
(ALUMINUM)

```
                 T|  |<---------- 0
                 T|  |
                 T|  |
                 T|  |  TUFF (3d)
                 T|  |
                 T|  |
                 T|  |<---------- 38
                 T|  |
                 T|  |
                 T|  |  TUFF (3c)
                 T|  |
                 T|  |
                 T|  |<---------- 84
92 ---------->T|  |
                |X|  TUFF (3b)
                |X|
                |X|
                 -  <---------- 103
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-86-13
GEOLOGIST: William Purtymun
DATE DRILLED: 3 OCTOBER 1986
ELEVATION: 7445 ft
LOCATION: 475720, 1764264
TOTAL DEPTH: 103 ft
DISPOSITION: Aluminum Casing

DEPTH	DESCRIPTION
0-38	Unit 3d. Light brown tuff Moderately welded Rare rhyolite/latite lithic fragments Rare pumice lapilli
38	Contact strongly welded Common rhyolite/latite lithic fragments
38-84	Unit 3c. Grey tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli
84-103	Unit 3b. Light grey tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-14
(ALUMINUM)

```
                 T|  |<--------- 0
                 T|  | TOP SOIL
                 T|  |<--------- 4
                 T|  |
                 T|  | TUFF (3d)
                 T|  |
                 T|  |<--------- 30
                 T|  |
                 T|  |
                 T|  |
                 T|  | TUFF (3c)
                 T|  |
                 T|  |
                 T|  |
79 ---------->T|  |<--------- 75
                 |X| TUFF (3b)
                 |X|
                  - <--------- 85
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-14
GEOLOGIST: Fred Brown
DATE DRILLED: 28 AUGUST 1987
ELEVATION: 7437 ft
LOCATION: 475365, 1764251
TOTAL DEPTH: 85 ft
DISPOSITION: Aluminum Casing

DEPTH	DESCRIPTION
0-4	Fill/Top Soil (sandy loam)
4-30	Unit 3d. Pale yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Common grey pumice lapilli
30	Contact is strongly welded Abundant rhyolite lithic fragments Common grey pumice lapilli
30-35	Unit 3c. Pale yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli
35-75	Unit 3c. Dark yellowish brown tuff and clay Welded Rare rhyolite lithic fragments Abundant clayey pumice lapilli
75-85	Unit 3b. Pale yellowish brown pumice Densely welded Rare rhyolite lithic fragments Common grey pumice lapilli

BOREHOLE: P-87-15
GEOLOGIST: Fred Brown
DATE DRILLED: 27 AUGUST 1987
ELEVATION: 7413 ft
LOCATION: 475803, 1763520
TOTAL DEPTH: 70 ft
DISPOSITION: Uncased

DEPTH	DESCRIPTION
0-1	El Cajete Pumice
1-3	Pumice/Top Soil (sandy loam)
3-4	Dark yellowish brown clay
4-40	Unit 3c. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Common red-grey pumice lapilli
40-50	Unit 3c. Pale yellowish brown tuff Slightly welded Rare rhyolite lithic fragments Rare pumice lapilli
50-55	Unit 3c. Dark yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Common red-grey pumice lapilli
55-70	Unit 3b. Dark yellowish brown tuff Densely welded Rare rhyolite lithic fragments Rare pumice lapilli

WELL COMPLETION DIAGRAM

P-87-16A
(ALUMINUM)

```
                T|  |<--------- 0
                T|  | TOP SOIL
                T|  |<--------- 7
                T|  |
                T|  | TUFF (3d)
                T|  |
                T|  |
                T|  |<-------- 42
                T|  |
                T|  |
                T|  | TUFF (3c)
                T|  |
                T|  |
                T|  |<--------- 87
8 --------->T|  |
              |X| TUFF (3b)
              |X|
               - <--------- 105
```

SCREEN	=
CAVED-IN	X
BACKFILLED TUFF	T
CEMENT	C
BENTONITE	B
SILICA SAND	S

(NOT TO SCALE)

BOREHOLE: P-87-16A
GEOLOGIST: Fred Brown
DATE DRILLED: 4 SEPTEMBER 1987
ELEVATION: 7452 ft
LOCATION: 475550, 1764200
TOTAL DEPTH: 105 ft
DISPOSITION: Aluminum Casing

DEPTH	DESCRIPTION
0-5	Fill/Dark Brown Clay
5-7	Top Soil (sandy loam)
7-15	Unit 3d. Pale yellowish brown tuff Slightly welded Rare rhyolite lithic fragments Rare pumice lapilli Vertical fracture at 9-12 ft
15-26	Unit 3d. Greyish orange pink tuff Moderately welded Rare rhyolite lithic fragments Oxidation halo surrounds rhyolite lithic fragments Rare brown pumice lapilli Vertical fracture 19-22 ft
26-31	Extensive clay-filled vertical fractures
31-42	Unit 3d. Greyish orange pink tuff Moderately welded Common oxidized rhyolite lithic fragments Common grey pumice lapilli
42-46	Unit 3c. Pale red tuff Welded Common oxidized rhyolite lithic fragments Common grey pumice lapilli Clay-filled vertical fracture (width to .5 in)
46-50	Unit 3c. Pale yellowish brown tuff Welded Common oxidized rhyolite lithic fragments Common grey pumice lapilli
50-60	Densly welded, no core recovered
60-68	Unit 3c. Greyish red tuff Welded Rare rhyolite lithic fragments Common large (to 2 in) pumice lapilli

68-74	Unit 3c. Pale brown tuff Moderately welded Rare rhyolite lithic fragments Rare clayey pumice lapilli
74-81	Unit 3c. Pale yellowish brown tuff Moderately welded Rare rhyolite lithic fragments Rare pumice lapilli Clay-filled vertical fracture (width to .75 in)
81-87	Unit 3c. Pale yellowish brown tuff Welded Rare rhyolite lithic fragments Rare pumice lapilli
87-105	Unit 3b. Densly welded, no core recovered

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