Volume I

TA-21 Operable Unit RFI Work Plan for Environmental Restoration

May 1991

A Department of Energy environmental clean-up program

Los Alamos
NATIONAL LABORATORY

LAUR-91-962

Table of Contents

APPENDICES

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS USED IN THE TA-21 OU RFI WORK PLAN

ADS	Activity data sheet
AEC	US Atomic Energy Commission
ALARA	As low as reasonably achievable
ASTM	American Society of Testing Materials
BTX	Benzene, toluene, o-xylene, m-xylene
CA	Corrective activities
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMP	Corrugated metal pipe
CMS	Corrective measures study
COLIWASA	COmposite LIquid WAste SAmpler
CY	Calendar Year
D&D	Decontamination and decommissioning
DCG	DOE-derived concentraton guide
DOE/AL	US Department of Energy Albuquerque Operations Office
DOE/HQ	US Department of Energy Headquarters
DOE/LAAO	US Department of Energy Los Alamos Area Office
DOT	Department of Transportation
DP Site	D Prime, where D was D Building in the Former TA-1 (now part of the current townsite)
DP East	Eastern part of TA-21
DP West	Western part of TA-21
DQO	Data quality objectives
EA	Environmental assessment
EES-1	Geology and Geochemistry Group
EIS	Environmental impact statement
EP toxicity	Extraction Procedure Toxicity
EPA	US Environmental Protection Agency
ER	Environmental restoration
ES&H	Environment, safety, and health
ESG	Environmental Surveillance Group
FID	Flame ionization detector
FIMAD	Facility for Information Management, Analysis, and Display
FSP	Field Sampling Plan
FY	Fiscal year
FYP	Five Year Plan
GIS	Geographical Information System
GM	Geiger-Mueller
H&S	Health and Safety
HPIC	High pressure ion chamber
HSE	Health, Safety, and Environment (Division)
HSE-7	Waste Management Group
HSE-13	Environmental Restoration Group
HSWA	Hazardous and Solid Waste Act Amendments

ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
INC	Isotope and Nuclear Chemistry (Division)
INC-4	Isotope and Structural Chemistry Group
IRM	Interim remedial measure
IWP	Installation Work Plan
K_d	Distribution coefficient
LANL	Los Alamos National Laboratory; the Laboratory
LAMPF	Los Alamos Meson Physics Facility
LASL	Los Alamos Scientific Laboratory (LANL before 1979)
MCL	Maximum concentration level
MDA	Material Disposal Area
MDL	Minimum detection limit
MST-3	Tritium Science and Technology Group
NaI detector	Sodium Iodide detector
NEPA	National Environmental Policy Act
NFA	No further action
NIST	National Institute of Standards and Technology
NMED	New Mexico Environmental Division
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OUPL	Operable unit project leader
PCB	Polychlorinated biphenyl
PID	Photoionization detector
PL	Project leader
PM	Program Manager (ER)
PMP	Program Management Plan
QAPjP	Quality assurance project plan
QA	Quality assurance
QP	Quality administrative procedure
QPP	Quality Program Plan
QPPL	Quality Program Project Leader
RA.	Remedial action
RD	Remedial design
RFA	RCRA facility assessment
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RI	Remedial investigation
RMP	Records management plan
RPF	Records Processing Facility
RWS	Raw waste storage
SARA	Superfund Amendment Reauthorization Act
SOP	Standard operating procedure
SSP	Site-specific plan
STP	Sewage Treatment Plant
SWMU	Solid waste management unit
TA	Technical area
TAL	Target analyte list
TCLP	Toxicity Characteristic Leaching Procedure
TLD	Thermoluninescent dosimeter
TLV	Threshold limit value
TRU	Transuranic (waste)

TSTA	Tritium Systems Test Assembly
UC	University of California
USC	United States Code
USGS	US Geological Survey
UST	Underground storage tanks
VCP	Vitrified clay pipe
VOA	Volatile organic analyses
WBS	Work Breakdown Structure
WIN	Waste Information Network

RADIONUCLIDES[a]

^{227}Ac	Actinium-227
^{241}Am	Americium-241
^{137}Cs	Cesium-137
^{238}Pu, $^{239/240}Pu$	Plutonium
^{210}Po	Polonium
^{226}Ra	Radium-226
^{90}Sr	Strontium-90
^{232}Th	Thorium-232
^{3}H	Tritium
^{234}U, ^{235}U, ^{238}U	Uranium

[a]Numbers refer to specific isotopes of these radionuclides.

- Mesa Top Characterization
- Surface Units
- Outfalls and Associated Septic Systems
- MDAs
- Subsurface Units
- SWMUs to be Coordinated with D&D
- Areas of Concern
- Units Proposed for No Further Investigation

1.2.3 Analytical Strategy

Radiological contamination is a general characteristic of TA-21 and a primary focus of SWMU-specific investigations. For most SWMUs, the release of any hazardous constituents would have been associated with the release of radioactive materials. Field instrument surveys and field screening of samples, using instruments such as gross gamma detectors and organic vapor analyzers, can be used to identify gross contamination and to serve as Level I/II data. Field laboratory analyses can be used to provide rapid Level II data to help guide field operations and to support field decisions. An analytical laboratory will be used to provide Level III/IV data for verification of field data. The full suite of analytes for analytical laboratory analysis typically includes

- gamma spectrometry,
- tritium,
- total uranium,
- isotopic plutonium,
- strontium-90,
- volatile organic compounds (by Method SW 8240),
- semivolatile organic compounds (by Method SW 8270), and
- the RCRA-regulated metals (by Method 6010).

1.2.4 Scope of the Efforts

The RFI field work described herein is expected to require five years for completion. During the initial investigation, 7,858 linear ft of drilling will be required, and a total of 3,409 samples will be collected (2,171 samples will be collected for chemical characterization, 2,168 for radiological, and 502 for geohydrological). For the subsequent investigations, it is estimated that 7,950 linear ft of drilling will be required and a total of 2,316 samples will be collected. A summary of the scope of the investigations is given in Table 1.2-I, organized by the section of the work plan where the investigation is described. Figure 1.2-1 shows the schedule for the planned investigations.

1.3 Reports

Reports generated in the implementation of this work plan will be made available for review by the public at the Environmental Restoration Community Reading Room in downtown Los Alamos (2101 Trinity Drive). The Reading Room is open to the public from 9 a.m. to 4 p.m. on Laboratory business days.

1.3.1 Periodic Reports

The HSWA permit specifies certain periodic reports, including monthly programmatic status reports and quarterly technical progress reports. The execution of the TA-21 RFI will provide data for these reports.

1.3.2 Technical Memoranda/Work Plan Modifications

Because of the large number of SWMUs addressed in this work plan and the time required for completion of RFI field work, some interim reports will be generated and submitted as appropriate portions of the effort are completed. These technical memoranda will serve both as partial RFI Phase I reports summarizing the results of initial site characterization activities and as partial RFI Phase II work plans describing the follow-on activities being planned (including any modifications to field sampling plans suggested by initial findings). These technical memoranda/work plan modifications will be submitted for work conducted on individual SWMUs or aggregates of SWMUs. A summary of planned submission dates is given in Table 1.3-1.

TABLE 1.2-I SUMMARY OF SCOPE OF RFI INVESTIGATIONS.

Chapter/Section	Initial Investigations					Subsequent Investigations				
	Feet Drilled	Samples Collected	Chemical Analysis	Radiological Analysis	Geohydrological Analysis	Feet Drilled	Samples Collected	Chemical Analysis	Radiological Analysis	Geohydrological Analysis
12 Mesa Top										
12.4 Mesa Top Soil		230	230	230						
12.5 Mesa Top Boreholes	2875	593	43	43	184	1350	270			84
12.6 Water Sampling		25	25	25		400	160	160	160	
13 Surface Soil Contamination										
13.2 Surface Soil/Filter Blds	37.5	375	261	261			112	112	112	
14 Surface Units										
14.2 PCB Ctr. Stg Area		63	22	22		65	26	9	9	
14.3 Above Ground Tanks	10	12	7	6						
14.4 Active Ctr Stg Areas		8	8	8						
14.5 DP Tank Farm	100	42	22	20						
14.6 Inactive Ctr Stg Areas		8	8	8		15	12	3	3	
14 7 Surface Disposal Areas	270	324	62	62		30	36	6	6	
14.8 Sewage Treatment plant	30	59	20	20						
15 Outfalls										
15.2 Undetermined Locations	60	66	66	66						
15.3 Outfalls With Septic Tanks	100	47	47	47						
15.4 Direct Discharge Outfalls		35	35	35						
15.6 Septic Tanks	80	16	16	16						
15.7 Drainage South of TA-21-155		6	6	6						
15.8 Drainage North of TA-21-155	20	31	31	31						
15.9 Special Cases	30	23	23	23						
15.10 NPDES Discharge Systems		30	30	30						
16 Material Disposal Areas										
16.1 MDA Drainages		45	45	45						
16.2 MDA B	1030	326	312	312	93	375	105	100	105	
16.3 MDA T	650	238	238	238	67	2590	653	549	549	
16.4 TA-21-35	175	48	16	16		180	52	13	13	
16.5 TA-21-257	70	69	24	24		100	46	14	14	
16.6 MDA U	250	130	130	130	37	450	150	150	150	
16.7 MDA V	500	145	138	138	59	1225	320	295	295	
16.8 MDA A	615	209	200	200	62		130	130	130	
17 Subsurface Units										
17.2 Underground Seepage Pit	45	12	6	6		400	80	36	36	
17.3 Waste Treatment Laboratory	30	16	7	7		50	20	5	5	
17 4 Acid Lines and Sumps	200	40	24	24		720	144	42	42	
17.6 Acid Pit	10	4	2	2						
18 D&D Coordination Units										
18.8 Acid Waste Sumps	480	96	48	48						
18.9 South Side PU Complex	190	38	19	19						
Total	7857	3409	2171	2168	502	7950	2316	1624	1629	84

FIGURE 1.2-1. TA-21 OU RFI SCHEDULE

Chapter and Section	Start Date	Duratn (Days)	End Date
12 INITIAL INVESTIGATION	15/Oct/91	467	20/Aug/93
12.3 GEOMORPHOLOGY	15/Oct/91	158	29/May/92
12.4 SURFACE SOIL CHARACT.	16/Dec/91	168	12/Aug/92
12.4 ROUND 2 SURFACE SOIL CHAR	15/Mar/93	113	20/Aug/93
12.5 VADOSE ZONE CHARACT.	25/Mar/92	258	2/Apr/93
12.6 YEAR 1: SPRING SAMPLING	15/Oct/91	287	3/Dec/92
12 SUBSEQUENT INVESTIGATIONS	20/Nov/92	997	8/Nov/96
12.5 VADOSE ZONE CHARACT.	20/Jul/94	186	17/Apr/95
12.6 YEAR 2: WATER SAMPLING	20/Nov/92	997	8/Nov/96
12.6 YEAR 3-5: WATER SAMPLING	29/Nov/93	742	8/Nov/96
13 INITIAL INVESTIGATION	12/Mar/92	387	22/Sep/93
13.2 AIRBORNE EMISSIONS	12/Mar/92	147	7/Oct/92
13.2 ROUND 2 AIRBORNE EMISSION	15/Jan/93	174	22/Sep/93
13 SUBSEQUENT INVESTIGATIONS	10/Jan/94	141	29/Jul/94
13.2 AIRBORNE EMISSIONS	10/Jan/94	141	29/Jul/94
14 INITIAL INVESTIGATION	10/Mar/94	106	8/Aug/94
14.2 PCB CTR STORAGE	24/Mar/94	59	15/Jun/94
14.3 ABOVE GROUND TANKS	31/Mar/94	61	24/Jun/94
14.4 ACTIVE CTR STORAGE	5/Apr/94	47	9/Jun/94
14.5 DP TANK FARM	5/Apr/94	68	11/Jul/94
14.6 INACTIVE CTR STORAGE	11/Apr/94	46	14/Jun/94
14.7 SURFACE DISP AREAS	10/Mar/94	106	8/Aug/94
14.8 SEWAGE TREATMENT PLANT	22/Apr/94	71	2/Aug/94
14 SUBSEQUENT INVESTIGATIONS	8/May/95	108	10/Oct/95
14.2 PCB CTR STORAGE	8/May/95	107	6/Oct/95
14.6 INACTIVE CTR STORAGE	13/Jul/95	56	29/Sep/95
14.7 SURFACE DISPOSAL AREAS	17/Jul/95	60	10/Oct/95
15 INITIAL INVESTIGATION	20/Apr/94	126	18/Oct/94
15.2 UNKNOWN LOCATIONS	20/Apr/94	85	18/Aug/94
15.3 SEPTIC SYSTEM	29/Apr/94	77	17/Aug/94
15.4 DIRECT DISCHARGE	11/May/94	56	29/Jul/94
15.5 DRNG S TA-21-3	17/May/94	61	11/Aug/94
15.6 SEPTIC TANKS	16/May/94	64	15/Aug/94
15.7 S TA-21-155	23/May/94	45	26/Jul/94
15.8 N TA-21-155	23/May/94	69	29/Aug/94
15.9 SPECIAL CASES	25/May/94	65	25/Aug/94
15.10 NPDES	31/May/94	98	18/Oct/94

Timeline: 91 Oct 1 · 92 Jan 2, Mar 2, Jun 1, Aug 3, Oct 1 · 93 Jan 4, Apr 1, Jun 1, Sep 1, Nov 1 · 94 Feb 1, May 2, Jul 1, Sep 1 · 95 Dec 1, Mar 1, May 1, Aug 1, Oct 2 · 96 Jan 2, Apr 1, Jun 3, Aug 1, Nov 1 · 97 Jan 2

FIGURE 1.2-1. TA-21 OU RFI SCHEDULE (CONTINUED)

Chapter and Section	Start Date	Duratn (Days)	End Date
16 INITIAL INVESTIGATION	25/Sep/92	725	16/Aug/95
16.1 MDA GENERAL	26/Apr/93	78	13/Aug/93
16.2 MDA B	14/Sep/93	483	16/Aug/95
16.3 MDA T	21/Sep/93	355	22/Feb/95
16.4 BLDG TA21-35	11/May/93	66	12/Aug/93
16.5 BLDG TA21-257	19/May/93	137	3/Dec/93
16.6 MDA U	1/Sep/93	288	25/Oct/94
16.7 MDA V	25/Sep/92	302	9/Dec/93
16.8 MDA A	20/Aug/93	304	4/Nov/94
16.X MDA'S SURFACE STUDY	14/Jan/94	187	11/Oct/94
16 SUBSEQUENT INVESTIGATIONS	20/Jul/94	596	3/Dec/96
16.2 MDA B	9/Aug/94	571	15/Nov/96
16.3 MDA T	9/Aug/94	582	3/Dec/96
16.4 BLDG TA21-35	20/Jul/94	49	27/Sep/94
16.5 BLDG TA21-257	27/Jul/94	42	23/Sep/94
16.6 MDA U	3/Aug/94	342	13/Dec/95
16.7 MDA V	28/Jul/94	444	3/May/96
16.8 MDA A	1/Aug/94	437	26/Apr/96
17 INITIAL INVESTIGATION	2/Jun/94	76	19/Sep/94
17.2 SEEPAGE PITS	2/Jun/94	60	25/Aug/94
17.3 WASTE TRT LAB	6/Jun/94	62	31/Aug/94
17.4 DRY WELLS	9/Jun/94	64	8/Sep/94
17.5 ACID WST SUMPS	15/Jun/94	67	19/Sep/94
17.6 ACID PIT	22/Jun/94	56	9/Sep/94
17 SUBSEQUENT INVESTIGATION	20/Jul/95	268	12/Aug/96
17.2 SEEPAGE PITS	20/Jul/95	76	6/Nov/95
17.3 WASTE TRT LAB	3/Aug/95	59	26/Oct/95
17.5 ACID WST SUMPS	7/Aug/95	256	12/Aug/96
18 INTITIAL INVESTIGATION	15/Jun/94	270	10/Jul/95
18.8 ACID WASTE SUMPS	15/Jun/94	91	24/Oct/94
18.9 EQUIP ROOM SUMPS	13/Jul/94	249	10/Jul/95

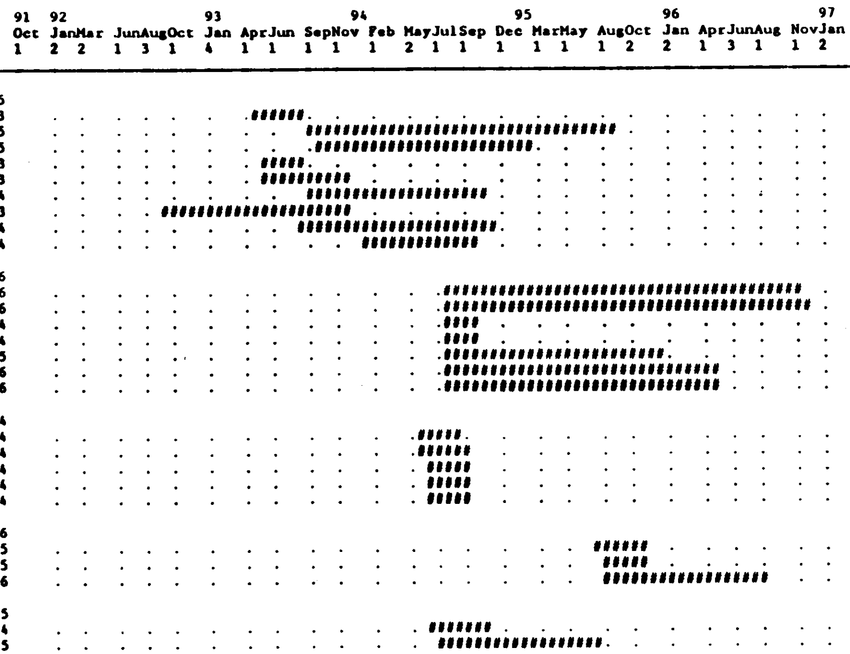


TABLE 1.3-I REPORTS PLANNED FOR THE TA-21 OU RFI

Report Type and Subject	Draft Date	Final Date
Quarterly Technical Progress Reports		
Summary of Technical Activities/Data		15 Feb, Yearly 15 May, Yearly 15 Aug, Yearly 15 Nov, Yearly
Technical Memoranda/Work Plan Modifications		
1. Subsurface Investigations Mesa Top and MDA V (Initial)[a]	20 Sep 93	10 Dec 93
2. Surface Investigations Mesa Top and MDAs (Initial)	22 Jul 94	12 Oct 94
3. Surface/Subsurface Investigations MDAs Surface (Subsequent)[b] All Non-MDA Units (Initial)	20 Apr 95	11 Jul 95
4. Subsurface Investigations MDA A, MDA B (Initial)	30 May 95	17 Aug 95
5. Surface/Subsurface Investigations Non-MDA Units (Subsequent)	3 May 96	24 Jul 96
6. Subsurface Investigations MDA T, MDA U, MDA V (Initial and Subsequent)	12 Sep 96	4 Dec 96
7. Subsurface Investigations MDA A, MDA B (if needed)	27 Aug 96	18 Nov 96
RFI Report		
Final RFI Report	11 Dec 96	28 May 97

[a] Initial: Report of results from the planned initial investigation.

[b] Subsequent: Report of results from subsequent investigations, if any.

1. EXECUTIVE SUMMARY

TA-21 RFI Work Plan

1.1 Introduction

1.1.1 Purpose

The primary purpose of this document is to satisfy the regulatory requirements of Module VIII of the Los Alamos National Laboratory's (the Laboratory's) Resource Conservation and Recovery Act (RCRA) Part B operating permit. Module VIII of the permit which was issued by the Environmental Protection Agency (EPA), addresses Hazardous and Solid Waste Act Amendments (HSWA) requirements. At the Laboratory, these permit requirements are addressed by the Department of Energy's (DOE) Environmental Restoration (ER) Program. This document meets schedule requirements for May 23, 1991, to address a percentage of the Laboratory's solid waste management units (SWMUs; i.e., potential release sites) in a RCRA Facility Investigation (RFI) work plan. The second purpose of this document is to serve as a field sampling plan for personnel who will implement the RFI.

1.1.2 Installation Work Plan

The HSWA Module required that the Laboratory prepare an installation-wide work plan to describe the Laboratory-wide system for accomplishing all RFI/Corrective Measures Study (CMS) work. This requirement was satisfied by a Laboratory-wide Installation Work Plan (IWP) submitted to EPA on November 19, 1990. The IWP identifies the Laboratory's SWMUs and their aggregation into 24 operable units (OUs) and presents the Laboratory's overall management and technical approach for meeting the requirements of the HSWA Module. The TA-21 OU is the first OU through the process. This work plan, as with all OU work plans, is tiered to the IWP. Relevant information in the IWP is incorporated into this plan by reference.

The IWP and this work plan address radioactive materials and other hazardous substances not subject to RCRA. It is understood that language in this work plan pertaining to subjects outside the scope of RCRA is not enforceable under the RCRA Part B operating permit.

1.1.3 Background

The Laboratory's Technical Area (TA)-21, also known as "DP Site," is located on the northern edge of the laboratory, at an elevation of 7,140 ft. It is centrally located on the Pajarito Plateau, roughly midway between the flanks of the Jemez Mountains on the west and the White Rock Canyon of the Rio Grande to the east. It is sited on the Bandelier Tuff, which is approximately 800 ft of volcanic ash deposits, the bedrock throughout the OU. Groundwater lies at a depth of approximately 1,150 ft.

TA-21 centers on DP Mesa immediately east-southeast of the Los Alamos townsite. The TA-21 OU encompasses TA-21 and the areas extending to the stream channels in the canyons on either side of the mesa, DP Canyon to the north, and Los Alamos Canyon to the south. Figure 1.1-1 shows the location and extent of the TA-21 OU, which is approximately 311 acres in size and includes some 112 SWMUs. TA-21 has been used for both chemical research and plutonium metal production from 1945 to 1978. Subsequently, offices and other activities have occupied the facilities. Because the major industrial activity was related to plutonium production, the major waste disposal activities were plutonium-related as well. The SWMUs fall into four conceptual categories as follows:

- deep liquid releases, such as seepage pits and absorption beds into which plutonium- bearing liquids were discharged in large quantities;
- near-surface liquid releases, such as surface discharges from septic systems that may have contained industrial liquid wastes;
- subsurface solid waste disposal sites, such as Material Disposal Areas (MDAs), where contaminated industrial materials, stabilized process residues, and other solid or hazardous wastes were buried; and
- surface contamination areas, where limited quantities of contaminants were released at or to the land surface, such as stack release fallout and surface spills.

1.1.4 Contaminants and Pathways of Concern

Principal contaminants of concern are radiological in nature because of the dominant industrial activity that occurred at TA-21. Known contaminants are plutonium, tritium, uranium, volatile organic compounds (at a limited number of sites), and PCBs (at one site). However, knowledge of contaminants, in general, is limited because historical sampling was principally for radioactive constituents. Hazardous constituents are likely to be present at TA-21 because of plutonium processing. Thus, relatively broad-spectrum analyses are contemplated for selected samples

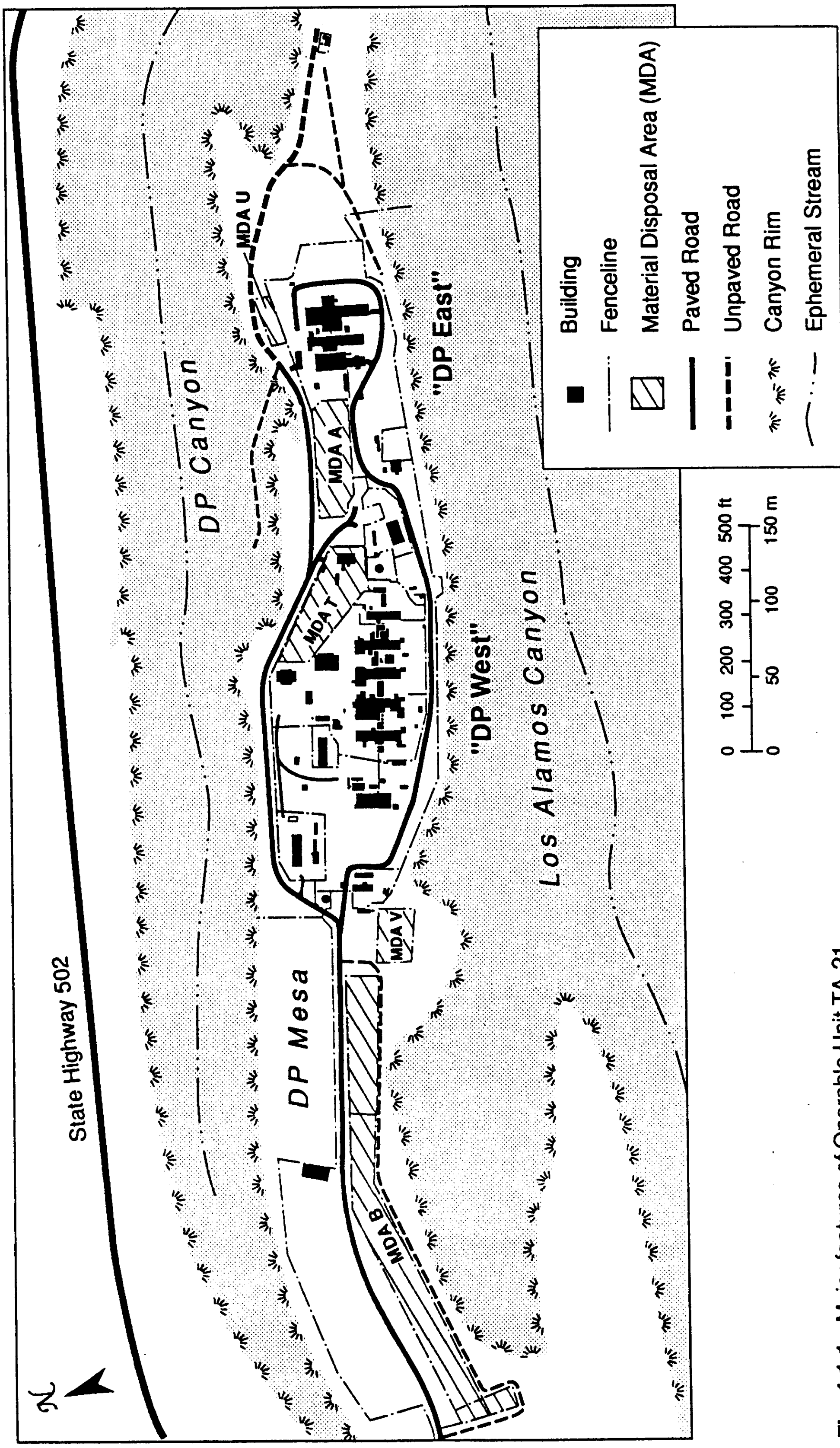


Fig. 1.1-1 Major features of Operable Unit TA-21.

across the TA-21 OU.

Under the current land use patterns in the vicinity of the TA-21 OU, no pathways or receptors are of concern. However, if land use patterns change in the future (i.e., loss of institutional control), the following primary exposure pathways of concern would be

- surface run-off and sediment transport and
- erosion and surface exposure.

Both unsaturated zone transport (in both the liquid and vapor phase) and the groundwater pathway are not of direct concern, based on the great depth and no known pathway to the main aquifer system.

1.2. Method of Approach

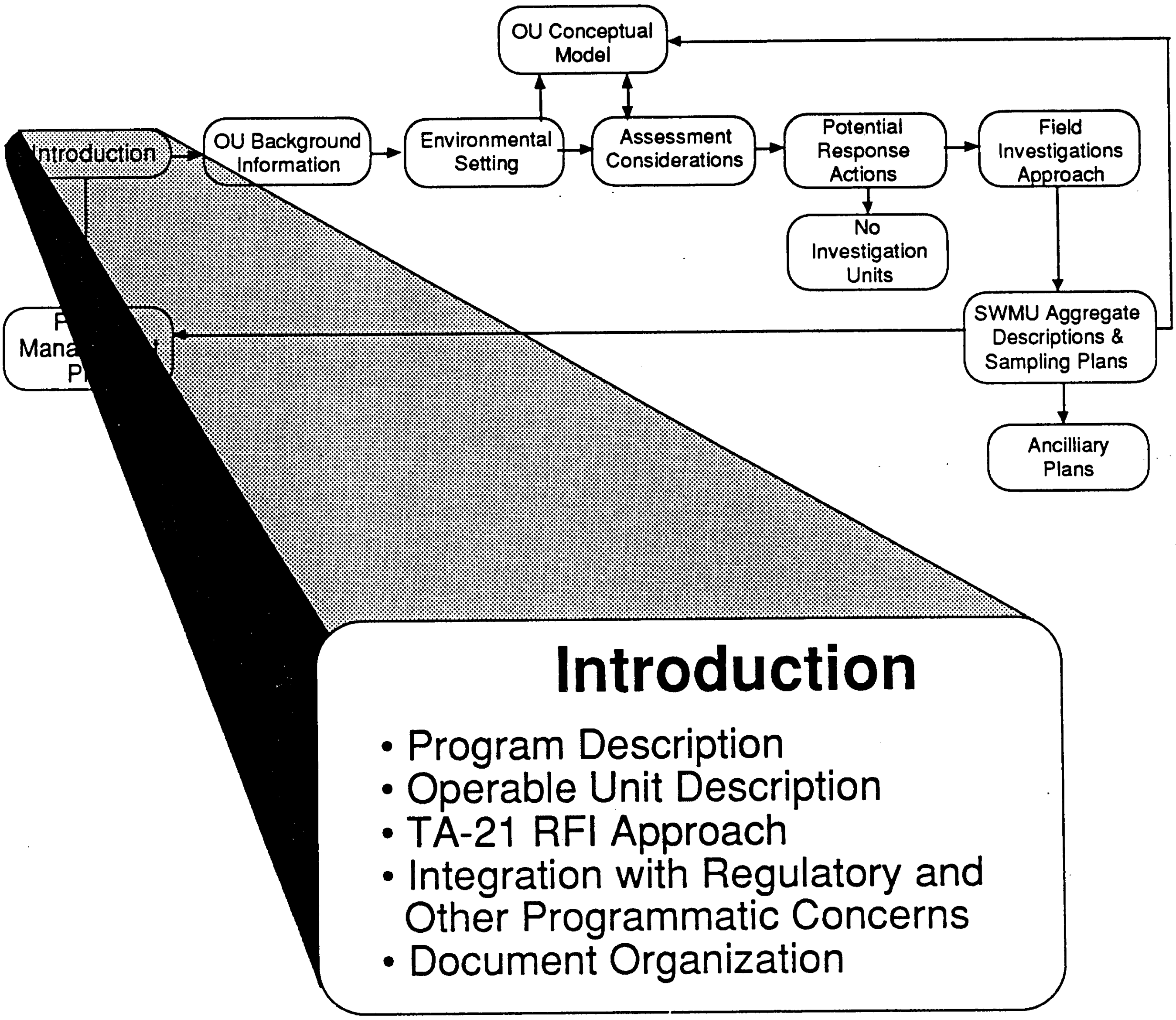
1.2.1 Technical Approach

The IWP provides for innovative use of the observational approach to select an eventual remedy in the face of continuing uncertainty. The technical approach also incorporates the use of action levels as criteria for identifying releases and determining the need for a CMS and a sequential sampling strategy wherein the results of each sample set guides the nature and location of subsequent sampling events.

1.2.2 Investigative Strategy

The ER Program will be conducting Laboratory-wide background studies of hydrology, geology, and geochemistry to support OU-specific investigations. Those studies, the results of which will have general applicability for all OUs' needs will only be done once. In addition, this work plan includes OU-wide surface and subsurface investigations that focus on general environmental characteristics and ambient levels of certain contaminants and provide data that serve as a context within which SWMU-specific contaminant data will be evaluated. The balance of the field sampling plans is directed toward groupings of SWMUs as appropriate, with specific studies of individual SWMUs as deemed necessary. These SWMU-specific characterizations focus on contaminant identification and nature and extent of contaminant migration. Investigation groups include the following:

CHAPTER 2


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
SWMU Aggregate Descriptions & Sampling Plans
Ancilliary Plans
Introduction
• Program Description
• Operable Unit Description
• TA-21 RFI Approach
• Integration with Regulatory and Other Programmatic Concerns
• Document Organization

2.0 INTRODUCTION

2.1 Program Description

In March 1987, the Department of Energy (DOE) established an Environmental Restoration (ER) Program to address environmental cleanup requirements at all of its facilities nationwide. Los Alamos National Laboratory (the Laboratory) is operated for the DOE by the University of California (UC) and is subject to the DOE's ER Program.

The Laboratory's Resource Conservation and Recovery Act (RCRA) operating permit sets forth requirements that are implemented by the Laboratory's ER Program. In particular, the Hazardous and Solid Waste Act Amendments (HSWA) Module and schedules of the permit issued by the Environmental Protection Agency (EPA), gives specific requirements affecting the conduct of the ER Program. The HSWA Module became effective on May 23, 1990 (EPA 1990).

2.1.1 Installation Work Plan

The HSWA Module requires the Laboratory to prepare an installation-wide work plan to contain the programmatic elements of a RCRA Facility Investigation (RFI) work plan. This requirement was satisfied by a Laboratory-wide Installation Work Plan (IWP) submitted to the EPA on November 19, 1990 (LANL 1990a). It serves as the plan by which DOE/UC will conduct the ER Program at the Laboratory. The IWP describes the ER Program and its history at the Laboratory, provides installation-wide descriptions of current conditions, identifies the Laboratory's solid waste management units (SWMUs) and their aggregation into a number of operable units, and presents the Laboratory's overall management and technical approach for meeting the requirements of the HSWA Module. The IWP is the document to which subsequent operable unit (OU) work plans will be tiered. Relevant information presented in the IWP will not be repeated in OU work plans.

2.1.2 TA-21 Operable Unit RFI

The HSWA Module also requires the Laboratory to prepare OU work plans for specific investigations. The Technical Area 21 (TA-21) work plan is one of 24 OU work plans that will be prepared. Within the ER Program, the TA-21 assessment task is identified as OU AL-LA-9, Activity

Data Sheet (ADS) 1106. Additional information regarding the ER Program, its implementation, and the guidance under which the TA-21 OU work plan was prepared, is given in Sec. 3 of the IWP.

The purpose of this document is twofold: first, to satisfy the regulatory requirements of the HSWA Module and second, to serve as the field sampling plan for personnel who will implement the RFI characterization activities detailed herein.

2.2 Operable Unit Description

The Laboratory's TA-21, also known as DP Site[1], has been used both for chemical research and production of plutonium metal from 1945 until 1978. Over the ensuing years, a number of other activities have been conducted there, as described in Chapter 3. TA-21 centers on DP Mesa immediately east-southeast of the Los Alamos townsite. Figure 2.2-1 shows the location of TA-21 with respect to the town of Los Alamos and other technical areas at the Laboratory. Figure 2.2-2 identifies the location and extent of the OU and indicates the areas referred to as DP East and DP West. The OU is approximately 311 acres in size with boundaries extending to the stream channels in the canyons to the north and south, DP Canyon and Los Alamos Canyon, respectively. Appendix G gives a detailed map of the TA-21 OU showing a 1000-ft buffer around the OU.

2.2.1 SWMUs Addressed in this OU

This plan addresses 10% of the Laboratory's SWMUs listed in Table A of the HSWA Module of the Laboratory's RCRA Part B Operating Permit (EPA 1990), including 20% of the SWMUs appearing on the HSWA Module's Table B list of priority SWMUs. By addressing these percentages of SWMUs, the Laboratory will meet the HSWA Module's schedule requirements for May 23, 1991. It includes 68 SWMU subunits grouped into 18 SWMU categories. Of these, 37 SWMU subunits are also in the HSWA Module's Table B list of priority SWMUs. Thus, this task incorporates 11% (68 of 603) of the SWMUs identified in the HSWA Module's Table A, and 20% (37 of 182) of the SWMUs identified in Table B.

Tables A and B of the HSWA Module were developed by EPA based on a SWMU Report prepared in 1988 (LANL 1988). Subsequent research and investigative effort culminated in a revised

[1] DP refers to D Prime, where D was D Building in the former TA-1 (now part of the current townsite). D Building was the wartime site where plutonium was purified in the early days at the Laboratory.

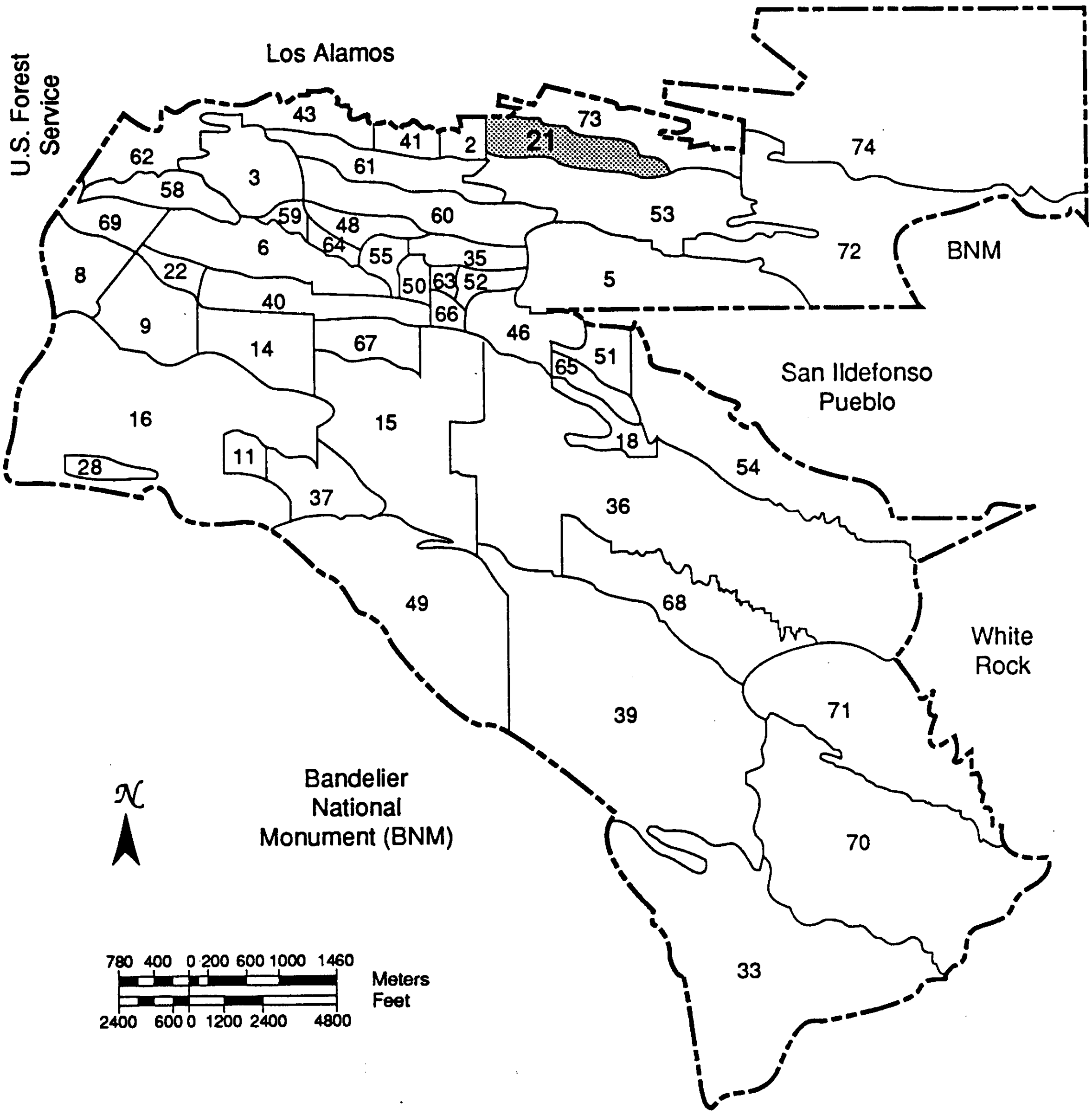


Fig. 2.2-1 Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.

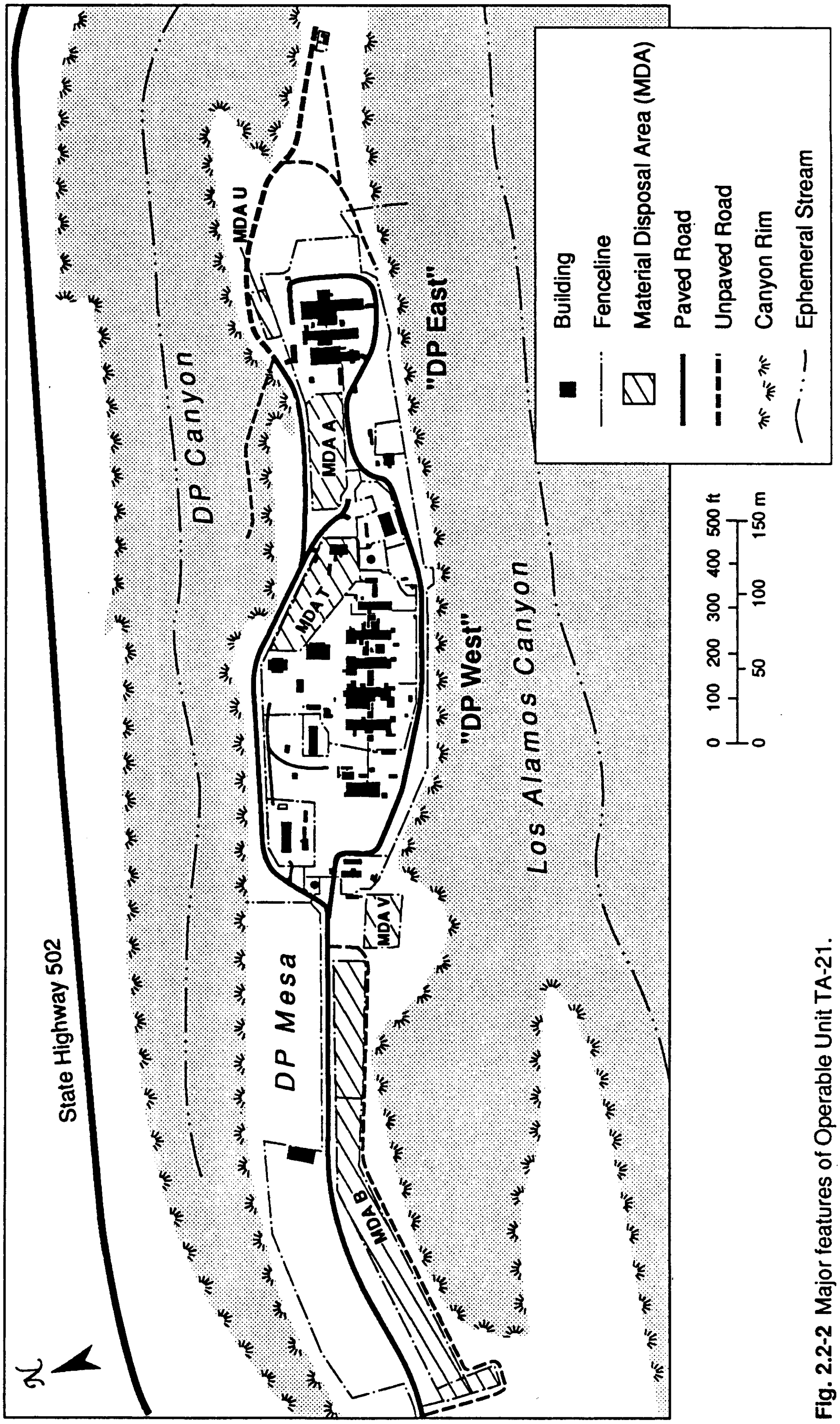


Fig. 2.2-2 Major features of Operable Unit TA-21.

SWMU Report submitted to EPA in November 1990 (LANL 1990b). As discussed in greater detail in Sec. 3.4.2 of the IWP, no sites were eliminated in the revisions leading to the new SWMU Report, but some were combined or added. The result, for the TA-21 OU, is a current list of 29 SWMUs including 112 SWMU subunits. The Laboratory's current SWMU list is presented in Appendix G of the IWP. Table 2.2-I summarizes the changes occurring in the SWMU list for TA-21. It identifies the original Table A and Table B SWMUs, indicates those that were combined and those that were added, tracks the renumbering that resulted from closing up the numbering gaps created by the combining of SWMUs, and presents the complete list of currently identified SWMUs.

2.2.2 Permit Modification

Section 3.5 of the IWP states that each OU work plan may propose a HSWA Module Class III permit modification to adjust the SWMUs listed in Table A of the HSWA Module. Such adjustments may be made to remove SWMUs determined not to need further investigation and to add SWMUs to the current SWMU Report. The basis for such a permit modification for TA-21 SWMUs is provided here as Table 2.2-II. It lists the currently identified SWMUs and proposes to delete five SWMU subunits based on information developed during the preparation of this RFI and discussed in Chapter 20, No Investigation Units.

2.2.3 Technical Memoranda and Work Plan Modification

Because the RFI is scheduled to take approximately five years at the TA-21 OU, the Laboratory is proposing to submit technical memoranda on site characterization activities on SWMU aggregates at the TA-21 OU to update the EPA on progress on RFI field work. As needed, these technical memoranda may also serve as work plan modifications to revise field sampling plans as appropriate reflecting initial characterization results. Therefore, technical memoranda are essentially partial RFI Phase I reports and partial RFI Phase II work plans. The schedule for these technical memoranda/work plan modifications is presented in Chapter 21, the Project Management Plan.

2.2.4 SWMU Investigation Groups

The large number of SWMUs and the wide diversity among them make it necessary to group the field investigations. The selected set of investigation groups by genre of SWMU (and the corresponding sections of this work plan) are identified below. Table 2.2-III identifies the work plan section in which each SWMU is addressed. Table 2.2-IV presents the same information in a

TABLE 2.2-I
TA-21 SWMU LIST

Original SWMU List in Table A, B of Permit	SWMUs Combined With Others	Renumbered SWMUs	Added SWMUs	Current SWMU List
			21-001	21-001
21-002		21-002 -> (a)	21-002(b)	21-002 (a),(b)
21-003				21-003
21-005			21-004 (a)–(d)	21-004 (a)–(d)
				21-005
21-006 (a-e)[a]	21-006(b)[b]	21-006(c) -> (b)	21-006 (e)–(f)	21-006 (a)–(f)[a]
		21-006(d) -> (c)		
		21-006(e) -> (d)		
21-007				21-007
			21-008	21-008
			21-009	21-009
21-010 (a-h)[a]				21-010 (a)–(h)[a]
21-011 (a-i)[a]		21-011(h) -> (i)	21-011(h)	21-011 (a)–(j)[a]
		21-011(i) -> (j)		
21-012[a]		21-012 -> (a)	21-012(b)	21-012 (a),(b)[a]
21-013 (a-c)			21-013 (d)–(g)	21-013 (a)–(g)
21-014[a]				21-014[a]
21-015[a]				21-015[a]
21-016 (a-g)[a]	21-016 (b)–(e)[c]	21-016(f) -> (b)		21-016 (a)–(c)[a]
		21-016(g) -> (c)		
21-017 (a-c)[a]				21-017 (a)–(c)[a]
21-018 (a,b)				21-018 (a),(b)[a]
			21-019 (a)–(m)	21-019 (a)–(m)
			21-020 (a), (b)	21-020 (a),(b)

TABLE 2.2-I (continued)

Original SWMU List in Table A, B of Permit	SWMUs Combine With Others	Renumbered SWMUs	Added SWMUs	Current SWMU List
21-021				21-021
21-022 (a-h)			21-022 (i), (j)	21-022 (a)–(j)
21-023 (a-d)				21-023 (a)–(d)
21-024 (a-k)			21-024 (l)–(o)	21-024 (a)–(o)
			21-025 (a)–(b)	21-025 (a),(b)
			21-026 (a)–(c)	21-026 (a)–(c)
			21-027	21-027
			21-028 (a)–(e)	21-028 (a)–(e)
			21-029	21-029

[a]SWMUs listed in Table B of the RCRA Part B Permit as priority SWMUs.
[b]SWMU 21-006(b), a gravel seepage pit, was determined to be the same as MDA T (SWMU 21-016(c)). The remaining subunits of 21-006 were renumbered.
[c]SWMUs 21-016(b-e), four concrete sumps, each 2 ft by 6 in. by 4 ft by 8 ft, associated with the four absorption beds within MDA T, were combined based on the determination that they were actually components of MDA T, rather than separate entities. They thus become part of SWMU 21-016(c), after renumbering of the remaining subunits.

TABLE 2.2-II
TA-21 OU'S SWMUS PROPOSED FOR NO FURTHER INVESTIGATION

SWMU Number	Basis for no further investigation
21-012(a)	This dry well inside the existing steam plant (TA-21-357) does not exist. Only a dry well associated with the former steam plant (TA-21-9) exists and is addressed in Sec. 17.4 as SWMU 21-012(b).
21-025(a)	Off-gas system located inside building TA-21-155 has had no documented releases to the environment and is covered under routine Laboratory operations. The off-gas system is separate from the exhaust stack, covered with stack emission sampling in Chapter 13.
21-025(b)	Off-gas system located inside building TA-21-209 has had no documented releases to the environment and is covered under routine Laboratory operations. The off-gas system is separate from the exhaust stack, covered with stack emission sampling in Chapter 13.
21-028(e)	Parts of this SWMU inside Building 210 are considered here. These are product storage areas with no evidence of routine releases. That part of 21-028(e) outside of the building, north of the loading dock is covered in Section 14.4.
21-029(b)	Three satellite container storage areas located inside building TA-21-150 are product storage areas with no evidence of routine releases.

Table 2.2-III TA-21 SWMU LOCATION IN DOCUMENT

SWMU No.	Title/Description	Where Addressed	Physical Location (Fig. No.)
21-001	Radioactive Waste Container Storage Area	Section 16.5	2.2-3
21-002(a),(b)	Container Storage	Sections 18.4, 14.6 Section 14.1	(a) Not shown (b) 2.2-3
21-003	PCB Storage Area	Section 14.2	2.2-4
21-004(a),(b),(c)	Aboveground Tanks	Section 14.3 Section 14.3	(a) 2.2-3 (b),(c) 2.2-4
21-004(d)	Above ground Tanks	Sections 14.3, 15.8	2.2-4
21-005	Acid Pit	Section 17.6	2.2-3
21-006(a),(c)–(f)	Underground Seepage Pits	Section 18.2 Section 18.2	(a),(c),(d),(f) 2.2-3 (e) Not shown
21-006(b)	Underground Seepage Pits	Sections 15.9, 17.2	2.2-3
21-007	Salamanders	Section 13.1	Not shown
21-008	Incinerator	Section 13.1	Not shown
21-009		Section 17.3	2.2-3
21-010(a)–(h)	Industrial Liquid Waste Treatment Facility	Section 16.4	2.2-3
21-011	New Industrial Waste Treatment Plant	Section 16.5	(a),(c)–(j) 2.2-3 (b) 2.2-4
21-011(c)		Section 16.3	
21-012(a),(b)	Dry Wells	Section 17.4, 20.4	2.2-3
21-013(a)	Surface Disposal	Section 14.8	2.2-4
21-013(b)–(f)	Surface Disposal	Section 14.7	(b),(d) 2.2-3 (c),(f) 2.2-4 (e) Not shown
21-013(g)	Surface Disposal	Section 14.7	2.2-3
21-014	Material Disposal Area A	Section 16.8	2.2-4
21-015	Material Disposal Area B	Section 16.2	2.2-3
21-016(a)–(c)	Material Disposal Area T	Section 16.3	2.2-3
21-017(a)–(c)	Material Disposal Area U	Section 16.6	2.2-4
21-018(a),(b)	Material Disposal Area V	Section 16.7	2.2-3
21-019(a)–(m)	Filter Houses/ Exhaust Stacks	Section 13.1	(a)–(d),(g)–(j),(m) 2.2-3 (e),(f),(k),(l) 2.2-4
21-020(a),(b)	Decommissioned Filter Houses	Section 13.1	(a) 2.2-3 (b) 2.2-4
21-021	Stack Emissions	Section 13.1	Not shown
21-022(a),(f) (b)–(e);(g) (h)–(j)	Acid Waste Lines and Sumps	Section 17.5 Sections 4, 15,18.5, 18.8 and 18.9	(a)–(e),(g)–(j) 2.2-3 (f) 2.2-4
21-023(a),(b),(d)	Decommissioned Septic Systems	Section 18.3	2.2-3
21-023(c)	Decommissioned Septic Systems	Section 15.2	2.2-3
21-024(a)–(o)	Septic Systems/Outfalls	Sections 15.2, 15.3, 15.4, 15.6, 15.8, 15.9	(a),(b),(d)–(g),(l),(o) 2.2-3 (c),(h)–(k),(m),(n) 2.2-4
21-025(a),(b)	Off-gas System	Section 20.1	2.2-4

Table 2.2-III TA-21 SWMU LOCATION IN DOCUMENT (cont'd)

SWMU No.	Title/Description	Where Addressed	Physical Location (Fig. No.)
21-026(a)	Outfall/Treatment Plant	Section 14.8	2.2-4
21-026(b),(c)	Outfall/Treatment Plant	Section 14.8	2.2-4
21-027	Surface Discharge	Sections 15.2, 15.5, 15.7	Not shown
21-028(a)	Active Container Storage Areas	Section 16.3	2.2-3
21-028(b),(c)	Active Container Storage Areas	Sections 18.4, 20.2	2.2-3
21-028(d),(e)	Active Container Storage Areas	Section 14.4	(d) 2.2-4 (e) 2.2-3
21-029	DP Tank Farm	Section 14.5	Not shown

TABLE 2.2-IV
TA-21 OPERABLE UNIT SWMU AGGREGATION

SWMU Aggregation	Document Section	SWMU numbers included
Stack Emissions	Chapter 13	
	Section 13.1	21-007, -008, -019, -020, -021
Surface Units	Chapter 14	
	Section 14.2	21-003
	Section 14.3	21-004(a)–(d)
	Section 14.4	21-028(d),(e)
	Section 14.5	21-029
	Section 14.6	21-002(b)
	Section 14.7	21-013(b)–(g)
	Section 14.8	21-013(a), -026(a)–(c)
Outfalls	Chapter 15	
	Section 15.2	21-023(c), -024(a),(g),(l), -027(c),(d)
	Section 15.3	21-024(b)–(e),(i)
	Section 15.4	21-011(k), -022(h), -024(n),(o), -026(d)
	Section 15.5	21-027(a)
	Section 15.6	21-024(j),(k)
	Section 15.7	21-024(m), -027(b)
	Section 15.8	21-024(h)
	Sections 15.8 and 14.3	21-004(d)
	Section 15.9	21-024(f)
	Sections 15.9 and 17.2	21-006(b)

TABLE 2.2-IV
TA-21 OPERABLE UNIT SWMU AGGREGATION (cont'd)

SWMU Aggregation	Document Section	SWMU numbers included
Material Disposal Areas	Chapter 16	
	Section 16.2	21-015
	Section 16.3	21-016,-028(a), -011(c)
	Section 16.4	21-010(a)-(h)
	Section 16.5	21-001, -011(a)–(j)
	Section 16.6	21-017
	Section 16.7	21-018
	Section 16.8	21-014
Subsurface Units	Chapter 17	
	Sections 17.2 and 15.9	21-006(b)
	Section 17.3	21-009
	Section 17.4	21-012(b)
	Section 17.5	21-022(a),(f)
	Section 17.6	21-005
SWMUs for Coordination with Building D&D	Chapter 18	
	Section 18.2	21-006(a),(c),(d),(e),(f)
	Section 18.3	21-023(a),(b),(d)
	Section 18.4	21-002(a), -028(c)
	Sections 18.5 and 18.8	21-022(b)–(e),(g)
	Section 18.9	21-022 (h)–(j)
No-investigation Units	Chapter 20	
	Section 20.1	21-025
	Section 20.2	21-028(b)
	Section 20.3	21-028(e)
	Section 20.4	21-012(a)

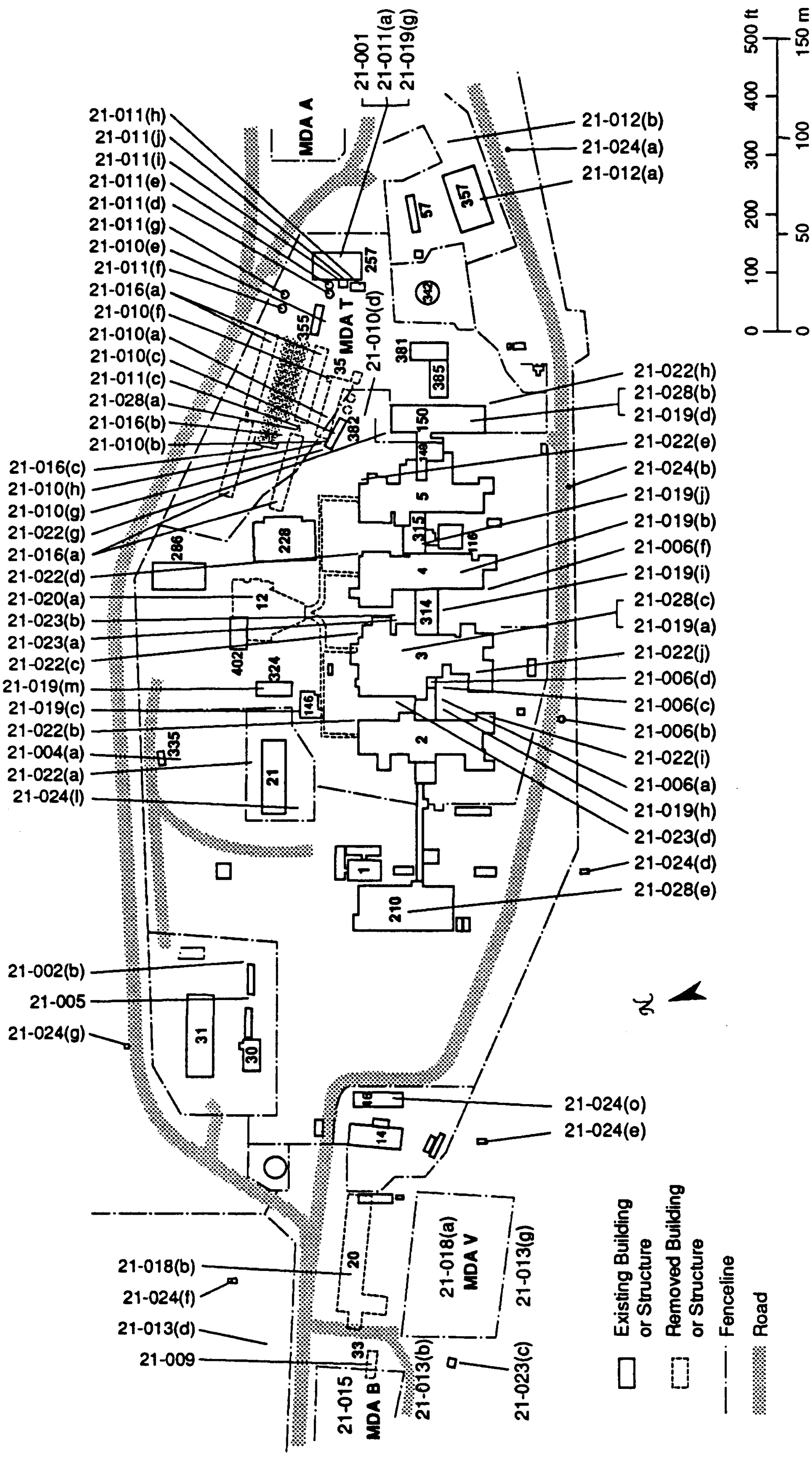


Fig. 2.2-3 Location of SWMUs at DP West.

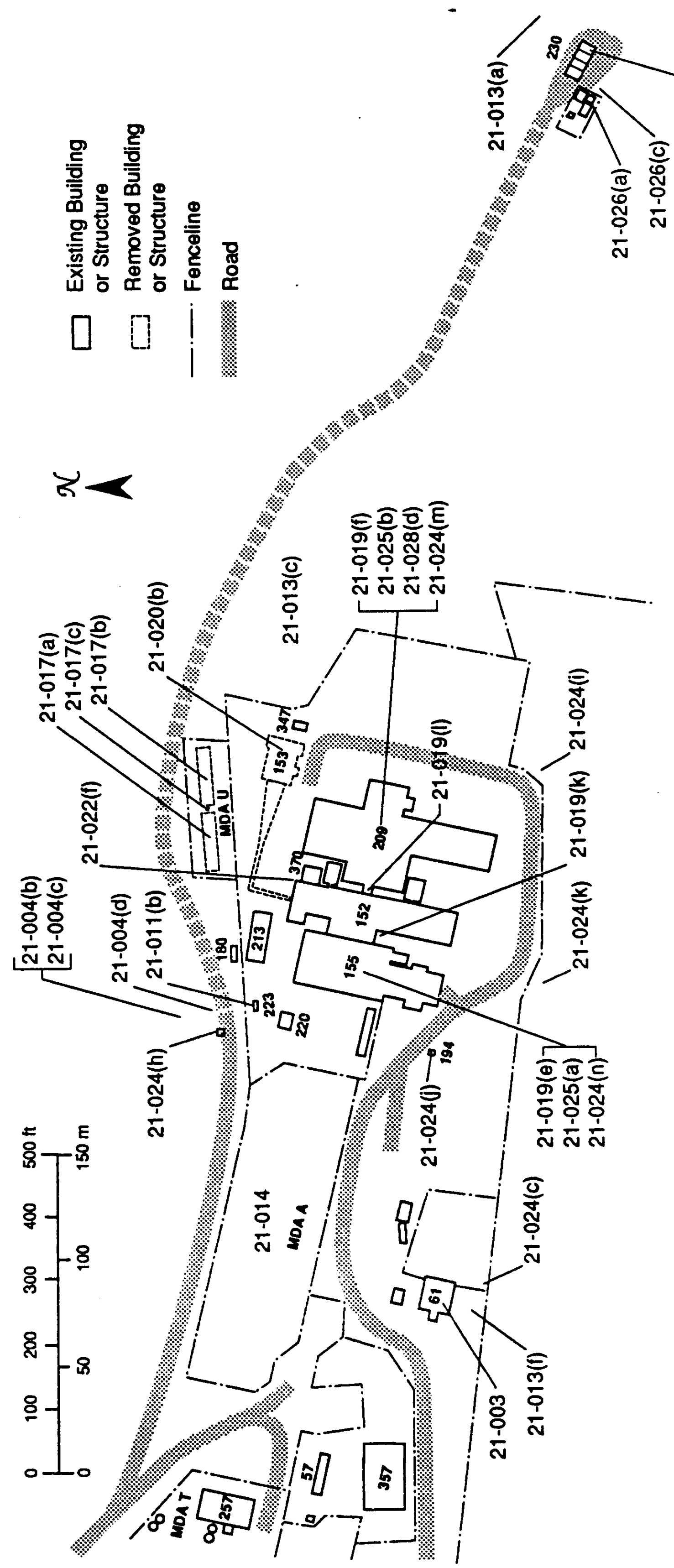


Fig. 2.2-4 Location of SWMUs at DP East.

reverse form: it identifies the SWMUs included in each field investigation section of this work plan. Figures 2.2-3 and 2.2-4 locate SWMUs at the TA-21 OU. The "Location" column of Table 2.2-III gives the figure number where each SWMU may be found. Appendix G shows all SWMUs on a larger-scale map.

Investigation groups:

Mesa top characterization (Chapter 12). Surface and subsurface characterization of the environmental setting of the entire OU is detailed. Unit-wide investigations will be used to determine geophysical and geochemical properties important to an understanding of the environmental and hydrologic processes affecting contaminant migration at the TA-21 OU.

Surface units (Chapters 13 and 14). These are SWMUs for which releases and potential contamination are expected to be confined to the soil surface. Atmospheric releases and routine and systematic surface spills are included in this category.

Outfalls and associated septic systems (Chapter 15). Near-surface and surface releases of potentially contaminated liquids are included. These are commonly floor drains and sanitary waste systems with discharges over the canyon rims of DP Mesa.

Material Disposal Areas (MDAs) (Chapter 16). This group covers Laboratory-designated liquid and solid waste disposal areas from past operations, typically large landfills and liquid absorption beds. It also includes waste treatment facilities associated with the MDAs.

Subsurface units (Chapter 17). SWMUs not addressed in a group above with primarily subsurface releases or leakage of potentially contaminated liquids are included in this group. Liquid waste sumps, seepage pits, dry wells for liquid disposal, and underground liquid waste-handling systems are example units.

SWMUs to be coordinated with building decontamination and decommissioning (D&D) (Chapter 18). Investigations of some SWMUs are precluded by the presence of buildings that have been built upon or in immediate proximity to the units. Coordination with the Laboratory's D&D program is necessary (see Sec. 2.4.1).

Areas of Concern (Chapter 19). An additional group of sites not qualifying as SWMUs will be investigated concurrently. These are called "areas of concern" herein and consist principally of past spill locations.

No Investigation Units (Chapter 20). As anticipated in Secs. 3.5 and 3.6 of the IWP, some units identified as potential SWMUs have proven, upon review of historical information, either to have been inappropriately listed as SWMUs or to require no further action. This Chapter presents information judged sufficient to remove the sites from the SWMU list (see Table 2.2-II).

2.3 TA-21 RFI Approach

The DOE/UC IWP (LANL 1990a) specifies the ER Program's technical and management approaches for compliance with the HSWA Module of the RCRA Part B operating permit (EPA 1990) and other regulatory obligations. Those approaches define the framework within which the TA-21 OU RFI work plan must function. The OU application of those program-wide approaches is discussed in this section. In addition, this section details the particular investigation concepts and objectives guiding the individual field investigation plans presented in this document.

2.3.1 Technical Approach

The DOE/UC approach for all ER Program activities is detailed in the IWP. In addition to detailing the management approach in the Program Management Plan (IWP, Annex I), the IWP presents several technical approaches that characterize the ER Program. These include

- use of action levels as criteria to trigger a corrective measure study (CMS);
- sequential sampling approach to site characterization, decision analysis and cost-effectiveness to support the selection of remedial alternatives; and
- the application of the "observational" or "streamlined" approach to the RCRA Facility Investigation (RFI)/CMS process as a general philosophical framework.

Several of these approaches are discussed below in terms of specific application to the TA-21 OU RFI work plan. For detailed discussions, however, the IWP sections cited should be referenced.

Action Levels. The use of action levels (in EPA's proposed Subpart S regulations) as criteria for identifying releases from SWMUs and for determining the need for a CMS is discussed in IWP Appendix F and in Chapter 11 of this work plan.

Sequential Sampling. Each field sampling plan presented in this document is based on sequential sampling as discussed in IWP Appendix H. The results of measurements from each set of samples are used to determine if additional sets of samples are required and to guide selection of the subsequent sample set. Each incremental set of samples aids in determining the required number of additional samples and their optimal locations. This process is intended to be repeated as many times as necessary, and in this work plan each field sampling plan provides guidance for subsequent sampling events based on assumptions regarding the results expected from initial sampling events. The process is described in Chapter 11 of this work plan.

Observational Approach. The essence of the observational approach is based on the philosophy that remedial action can and often should be initiated without "full" characterization of the nature and extent of contamination (IWP Appendix K). For many SWMUs, clear concepts for remedial action can be formulated before sufficient information has been collected to firmly define all uncertainties related to unit conditions. In some cases, there may be clear benefits to be obtained from focusing on particular remedial actions early in the characterization process. For a number of SWMUs, a clearly appropriate remedial action will involve stabilization-in-place and long-term monitoring. In this case, characterization sufficient only for leaving waste in place is required. For other SWMUs, removal will be the clearly appropriate remedial alternative. In these cases, characterization to determine the extent of contamination may be curtailed in preference to monitoring during removal. Probable remedial alternatives by SWMU are presented in Chapter 10 of the work plan.

Cost-effectiveness Analysis. Cost-effectiveness analysis involves comparison of costs of alternative strategies for achieving remedial action goals and selection of the least cost alternative if appropriate (IWP Appendix J). Coupled with the observational approach, the application of this philosophy during facility investigation activities may lead to a decision that additional characterization for a SWMU is less cost-effective than proceeding to a remedial action, assessing both the uncertainties that are left by incomplete characterization and the probable costs and benefits of the additional characterization effort.

Decision Analysis. The decision analysis framework discussed in IWP Appendix I provides a quantitative technique for implementing the observational approach and the cost-effectiveness analysis in an effort to streamline the characterization and remediation process. This methodology links the top level standards and criteria for selecting remediation alternatives to the technical requirements for characterization. The analysis supports decision making in situations with tradeoffs between objectives, uncertainties, and multiple-interested stakeholders, including those concerned with cost. The decision analysis approach provides a quantitative basis for defensible "early" decisions.

Table I-1 in the IWP describes the schedule for implementing the decision analysis methodology. As this RFI work plan is being prepared, the decision analysis implementation is in the early stages of Phase I, the formulation of the objective hierarchy for the overall ER effort. This RFI work plan is well ahead of the development of the decision analysis framework. As that framework develops, it will be implemented within the TA-21 RFI/CMS process.

2.3.2 TA-21 Objectives and Approach

The technical objectives of the TA-21 RFI, incorporating the technical approaches discussed above, are summarized below:

- Identify contaminants present at each SWMU, applying a sequential sampling approach.
- Determine the vertical and lateral extent of the contamination at each SWMU.
- Identify pathways of contaminant migration operable unit-wide and from each SWMU.
- Acquire sufficient information, guided by the observational approach and decision analysis, to allow quantitative migration pathway and risk assessment analyses, as necessary.
- Provide necessary data for the assessment of potential remedial alternatives.
- Provide the basis for planning detailed corrective measures studies.

Certain management objectives can be identified as well. These include the achievement of the technical objectives in an efficient and cost-effective manner and a proper coordination of the RFI process with other institutional constraints of the Laboratory. The following approaches are adopted in this work plan to attain the above objectives.

OU-wide Mesa Top Characterization. A fundamental understanding of the physical and chemical environment within which the TA-21 OU and its associated SWMUs lie is necessary as the basic level of information to support assessment and remediation activities. A mesa top characterization effort is planned to provide OU-wide soil, mineralogic, geologic, hydrologic, and geochemical data that will be applicable to all SWMUs. This investigation will aid in allowing each SWMU to be addressed within the hydrogeological framework of the entire OU. Further, the data collected will help define the OU conceptual model. Hydrogeologic characterization is required in the HSWA Module (Sec. P, Task III) (EPA 1990) to support investigations at each SWMU. The OU-wide characterization approach is an efficient means for providing these data. This effort will be integrated with regional characterization activities developed in the future as part of the ER Program and detailed in annual IWP updates.

A three-dimensional OU conceptual model of the geohydrologic framework is proposed in Chapter 6. The mesa top characterization data will support the development of the model by determining vertical and lateral changes in stratigraphy, lithology, and mineralogic and hydrologic characteristics beneath the OU. These data are necessary for hydrologic and contaminant transport calculations for either the OU as a whole or for individual SWMUs. Additionally, these studies will define the heterogeneity (variance) in various properties for the entire OU, and this variance can be used to determine the required SWMU-by-SWMU sampling intensity for certain properties, thereby minimizing the required sampling.

The mesa top characterization plans include the determination of contaminant levels in surficial materials on an OU-wide basis. As discussed in further detail below, concern for being able to distinguish SWMU-related contaminants from OU-wide contamination is an important motivation for the OU-wide investigation plan. Additional discussion of the mesa top characterization plan and its rationale is given in Chapter 12.

SWMU Characterization. The approach to individual SWMU characterization herein is typified by the sequential sampling approach described in Sec. 2.3.1. The investigations at individual SWMUs are limited primarily to defining contaminants, areas and depths of contamination, and affected migration pathways. Little emphasis is given to more general geologic and hydrologic material properties, which are planned to be obtained on an OU-wide basis as described above.

There is some concern for low-concentration, OU-wide contamination of portions of the TA-21 OU. In order to assess sampling results for each SWMU, a review of OU-wide contaminant levels must be made to establish "background" contaminant levels for the local area of the SWMU. Comparison of SWMU contaminant levels to such local background levels will be used to aid in determining the presence of SWMU-related contaminants and to limit the chance that an error will be made in determining that a particular SWMU has caused a release to the environment.

Existing Data. Available existing environmental data for TA-21 were acquired using standard practices and methods of the day. No attempt has been made to validate the data, in the EPA sense of the term. These data are used in this document solely to guide RFI characterization and sampling.

Field Investigation Methods. Due to the large number of SWMUs addressed in this work plan, common elements applying to the conduct of all field investigations at TA-21 are discussed once in Chapter 11 and not repeated in the field sampling plans. Field screening, field laboratory measurements, and analytical laboratory measurements will be used as appropriate for individual

SWMUs as determined using a decision process detailed in Chapter 11.

Risk Assessment. In general, RFI characterization leads to risk assessment. The OU-wide and SWMU-specific investigations are designed to provide the site characterization data needed for risk assessments for the entire OU or for the contributing SWMUs. Certain characterization data also may serve as input to the Canyon's Assessment OU RFI work plan, another of the OU work plans to be prepared under the umbrella of the IWP. Risk assessment results are part of the decision analysis input, and together with the observational approach are important in determining the need for remedial action. For the TA-21 RFI, risk assessment will be conducted for both radiological and nonradiological contaminants.

Coordination with D&D Program. From a management perspective, investigations of certain SWMUs, as well as potential remedial alternatives for those SWMUs, are tied closely to the Laboratory's long range plans for particular facilities (primarily at DP West). Investigations for SWMUs beneath or immediately adjacent to some buildings are impeded, and will, to the extent possible, be coordinated with plans for building D&D. The D&D Program is discussed further in Sec. 2.4.1. In the interim before full access to the SWMUs is possible, the lateral and vertical extent of potential contaminant plumes around DP West will be bounded and monitored to confirm that neither unknown nor uncontrolled contaminant migration is occurring. Chapter 18 provides the detailed approach for SWMUs in this category.

2.4 Integration with Other Programmatic Concerns

The Program Management Plan (Annex I) of the IWP (LANL 1990a) discusses the integration of the RCRA-based ER Program with other applicable requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA). It is the Laboratory's intent that the RCRA corrective action process comply with applicable requirements of CERCLA and NEPA, in addition to RCRA. Additionally, the ER Program will comply with all other applicable federal acts, state statutes, and DOE orders and policy statements as identified in the IWP Program Management Plan (Annex I). Two specific requirements affecting the planning and conduct of the RFI/CMS process for the TA-21 OU are discussed in greater detail below.

2.4.1 D&D Program

The DOE's Decontamination and Decommissioning Program (D&D Program) is managed by the DOE Office of Environmental Restoration and Waste Management, as is the DOE's ER Program.

The purpose of the D&D Program is the cleanup and either remediation or demolition of facilities contaminated with radioactive, hazardous, or mixed waste. The process for placing a facility in the D&D Program is described in the DOE's Draft Policy for Acceptance of Facilities for Decontamination and Decommissioning (DOE 1990). After a facility is accepted for D&D, DOE policy identifies a three-year period for integration into the planning and funding cycle for the D&D Program. TA-21 DP West has not yet been formally accepted for D&D. However, for SWMUs immediately adjacent to or underneath existing structures at DP West, both site investigation and site remediation will be addressed in the context of D&D (see Chapter 18).

2.4.2 DOE Orders

A number of DOE Orders applicable to the Laboratory's ER Program are identified in the IWP Program Management Plan (Annex I) (LANL 1990a). Compliance with the requirements of those orders is an integral part of operations at the Laboratory and is ensured through the documented polices, planning, auditing, and work review procedures of the Laboratory. However, for the TA-21 OU, it is important to recognize two aspects of DOE Order 5820.2A, Radioactive Waste Management (DOE 1988): (1) at the site characterization and (2) site assessment phase represented by this RFI work plan. First, in regard to buried transuranic waste (which may exist at the TA-21 OU in a few SWMUs), DOE Order 5820.2A Sec. II.3.i. identifies site characterization and closure planning requirements. Second, in regard to low-level radioactive waste, Chapter III of DOE Order 5820.2A specifies requirements that are applicable to some situations at the TA-21 OU or which provide useful guidance for assessments to be made as part of this RFI process. This RFI work plan incorporates elements that will provide data allowing both the assessment of options for site closure or disposal of any buried transuranic waste at TA-21 and the assessment of low-level waste disposal guidance and requirements.

2.5 Document Organization

This RFI work plan is prepared pursuant to both the HSWA Module (EPA 1990) and the IWP (LANL 1990a). The HSWA Module sets out the general scope of the work plan for the RFI, establishes the expected correspondence between the RFI tasks identified in EPA guidance documents (EPA 1989) and the equivalent ER Program tasks, specifies the requirements to be fulfilled by the IWP and the contents expected in the OU work plans such as this document.

TABLE 2.5-I
RFI GUIDANCE FROM THE LABORATORY'S RCRA PART B PERMIT

Scope of the RFI	ER Program Equivalent	
The RCRA Facility Investigation consists of five tasks:	LANL Installation RI/FS Work Plan	LANL Task/Site RI/FS
Task I: Description of Current Conditions A. Facility Background B. Nature and Extent of Contamination	I. LANL Installation RI/FS Work Plan A. Installation Background B. Tabular Summary of Contamination by Site	I. Quality Assurance Project Plan A. Task/Site Background B. Nature and Extent of Contamination
Task II: RFI Work Plan A. Data Collection Quality Assurance Plan B. Data Management Plan C. Health and Safety Plan D. Community Relations Plan	II. LANL Installation RI/FS Work Plan A. General Standard Operating Procedures for Sampling, Analysis and Quality Assurance B. Technical Data Management Program C. Health and Safety Program D. Community Relations Program	II. LANL Task/Site RI/FS Documents A. Quality Assurance Project Plan and Field Sampling Plan B. Technical Data Management Plan C. Health and Safety Plan D. Community Relations Plan
Task III: Facility Investigation A. Environmental Setting B. Source Characterization C. Contamination Characterization D. Potential Receptor Identification	III.	II. Task/Site Investigation A. Environmental Setting B. Source Characterization C. Contamination Characterization D. Potential Receptor Identification
Task IV: Investigative Analysis A. Data Analysis B. Protection Standards	IV.	IV. LANL Task/Site Investigative Analysis A. Data Analaysis B. Protection Standards
Task V: Reports A. Preliminary and Work Plan B. Progress C. Draft and Final	V. Reports A. LANL Installation RI/FS Work Plan B. Annual Update of LANL Installation RI/FS Work Plan C. Draft and Final	V. LANL Task/Site Reports A. Quality Assurance Project Plan, Field Sampling Plan, Technical Data Management Plan, Health and Safety Plan, Community Relations Plan B. LANL Task/Site RI/FS Documents and LANL Monthly Management Status Report C. Draft and Final

These expectations are summarized in Table 2.5-I, extracted from page 32 of the HSWA Module. In addition to the expectations defined in the HSWA Module, the IWP presents a proposed outline for OU work plans such as this. The organization of this TA-21 OU work plan with regard to these expectations is described in the following sections.

2.5.1 Correspondence with RFI Scope from the HSWA Module.

EPA defines five general tasks within the RCRA facility investigation process (EPA 1989; EPA 1990). Each of these tasks is discussed separately below, and the corresponding sections of this document are identified.

RFI Task I, Description of Current Conditions. This task consists of a presentation of facility background information and a discussion of the nature and extent of contamination. A TA-21 history and operations summary is presented in Chapter 3. The environmental setting is presented in Chapter 4, and the known data concerning the nature and extent of contamination are presented in the sections discussing the individual SWMUs, Chapters 13 through 20.

RFI Task II, RFI Work Plan. This task requires plans for Data Collection Quality Assurance, Data Management, Health and Safety, and Community Relations. These plans are presented as Appendices A through D of this document.

RFI Task III, Facility Investigation. This task sets out requirements for further characterization of the environmental setting, source, contamination, and potential receptors. This work plan describes these efforts as follows:

- environmental setting — mesa top sampling plan (Chapter 12);
- source characterization — individual SWMU sampling plans (Chapters 13–19);
- contaminant characterization — individual SWMU sampling plans (Chapters 13–19), mesa top sampling plan (Chapter 12); and
- potential receptor identification — migration pathways are assessed in the mesa top sampling plan (Chapter 12), and in certain individual SWMU sampling plans. Existing information is presented in Chapters 5 through 7.

RFI Task IV, Investigative Analysis. This task contains subsets of Data Analysis and Protection Standards. These considerations are addressed in the IWP.

RFI Task V, Reports. This task calls for preliminary, work plan, progress, draft, and final reports.

Work plans are provided on an installation-wide basis (the IWP) and for specific ER Program activities. This document is the RFI work plan for the TA-21 OU. It contains the Field Sampling Plans, Project Management Plan, Quality Assurance Project Plan, Records Management Plan, Health and Safety Plan, and Community Relations Plan.

Monthly progress reports for the entire ER Program will be submitted as described in the IWP, as will draft and final RFI Reports.

2.5.2 Correspondence with RFI Outline Proposed in IWP

A proposed outline for a OU RFI work plan is presented in Table 3.2 of the IWP (LANL 1990). This work plan has not adhered explicitly to that outline but incorporates all of the elements of that outline. Although the HSWA Module requires that the IWP present an OU RFI outline for approval by the Administrative Authority, the IWP reserved the option to modify the outline as necessary for individual activities (IWP Sec. 3.5.1). This work plan exercises that option and consolidates common elements and eliminates excessive repetition.

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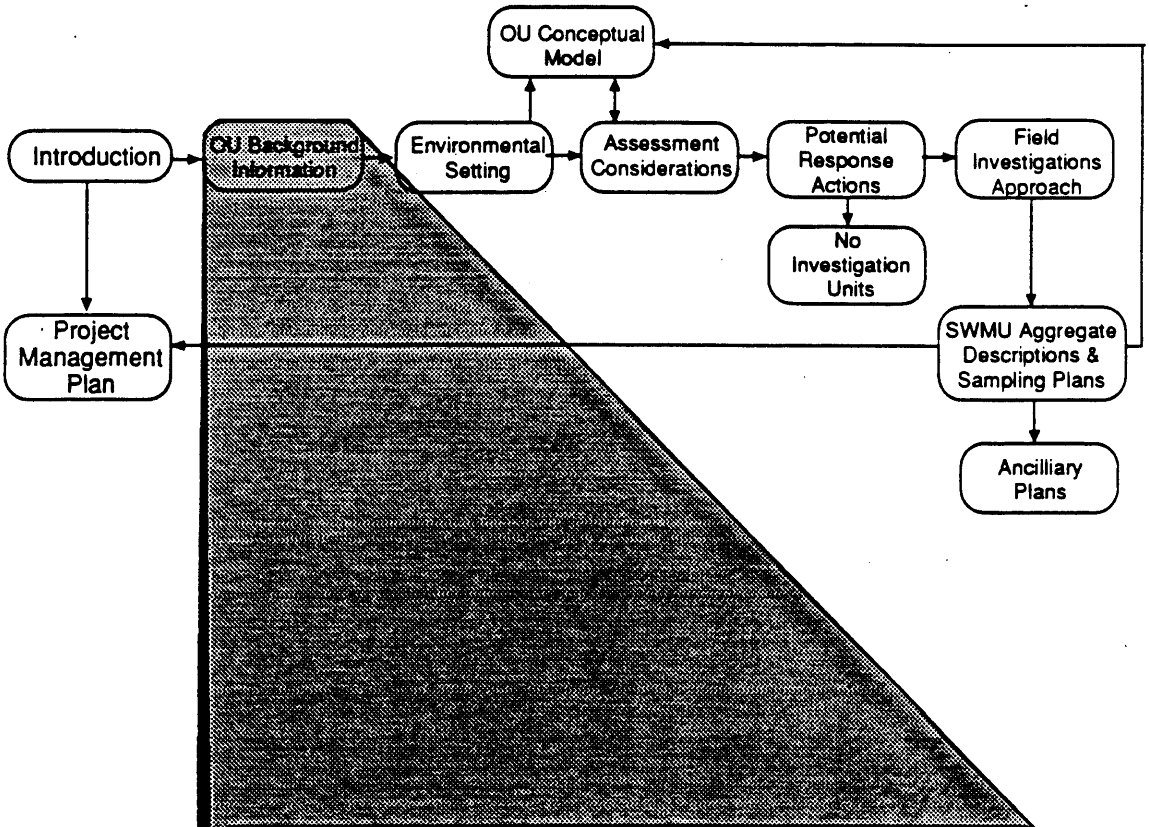
CHAPTER 3



OU Background Information

- History of TA-21
- Past Waste Management Practices
- Present Operations and Site Conditions

3. TA-21 OPERABLE UNIT BACKGROUND INFORMATION

3.1 History of TA-21

During World War II, Los Alamos National Laboratory was established with the responsibility for the research, development, and testing of the first deliverable nuclear weapon. In order to achieve this goal, much research was required to establish the chemical and metallurgical properties of the nuclear material necessary to achieve and sustain the required nuclear fission reaction. The Laboratory's Chemistry Division was created in 1943 and was given the responsibility for purifying the plutonium received from other production facilities. In 1945, these operations were transferred to the newly built facilities at TA-21. These facilities were located in the areas DP West and DP East. (DP West and DP East are historical designations for parts of TA-21 as shown in Fig. 2.2-2, Chapter 2.) The following subsections describe, in general, the activities and materials used at DP West and DP East.

3.1.1 DP West

DP West (Fig. 3.1-1) began operations in September 1945. Its main purpose was to provide the capability to produce metal and alloys of plutonium from the nitrate solution feedstock provided by other production facilities. This involved several acid dissolution and chemical precipitation steps to separate the plutonium and other valuable actinides from the feed stocks. A major research objective at DP West was the development of new purification techniques that would increase the efficiency of the separation processes (Christensen and Maraman 1969). Table 3.1-I lists the major separation processes used at the DP West facilities and the years each process was first employed. These separation techniques used a wide range of chemicals from the periodic table. In conjunction with improving purification techniques in the main process lines, research was conducted into reprocessing the waste produced to further enhance recovery. In addition, other operations, such as nuclear fuel reprocessing, were performed on occasion at DP West. Activities unrelated to plutonium processing also occurred at DP West; however, they are not detailed herein because they did not result in the SWMUs addressed in this document.

The main plutonium purification processes were contained in Buildings TA-21-2, 3, 4, 5, and later 150. Uranium and plutonium metal produced in these buildings was secured and stored in Building TA-21-21, the old vault. Research into methods of recovering additional plutonium from waste streams was conducted at Building TA-21-33. Additional research on the properties and uses of plutonium was conducted at Building TA-21-210, the plutonium research building.

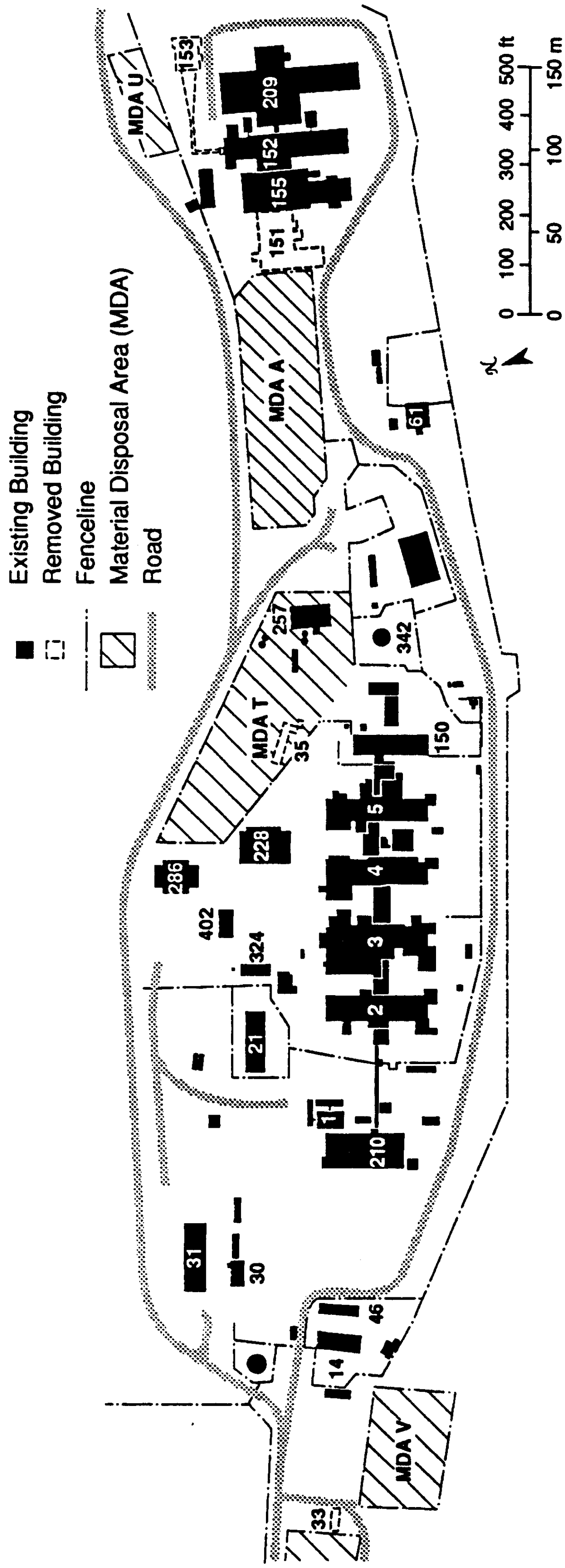


Fig. 3.1-1 Historical and current locations of major structures at TA-21. (LASL 1964)

TABLE 3.1.-I MAJOR PLUTONIUM SEPARATION TECHNIQUES AND ASSOCIATED CHEMICALS[a]

Year Process was first used	Separation Technique[b]
1945	HCl Dissolution
	Oxalate Precipitation
	Fluoride Precipitation
	Ethyl Ether Extraction
1947	HI Dissolution
	Ammonium nitrate Precipitation
	Sodium nitrate Precipitation
	Sodium bromotrioxide Precipitation
	Aluminum nitrate Precipitation
	Ammonium hydroxide Precipitation
	Sulfur dioxide Precipitation
	Sodium hydroxide Precipitation
	Thenoyl-tri-fluoracetone Extraction
1951	HNO_3-HF Dissolution
1953	Tri-n-butyl phosphate Extraction

[a]Christensen and Maraman (1969).
[b]All of these separation techniques used a wide range of chemicals from the periodic table.

In 1977, a transfer of work to the new plutonium facility at TA-55 began, and much of the DP West complex was vacated. At that time, cleanup of the old process lines was initiated. This included removing contaminated equipment and material from Buildings 2, 5, and 150 and from parts of Buildings 3 and 4 (Garde 1982). The buildings were then remodeled for use by other groups at LANL.

3.1.2 DP East

DP East is somewhat smaller than DP West. It began operation in September 1945 at Buildings TA-21-151, 152, 153. Building 155 was completed in December 1949 (LANL no date) (see Fig. 3.1-1). These facilities were used to process polonium and actinium and to produce initiators (a nuclear weapons component). In 1964, Building TA-21-209 was built to house research in high-temperature and actinide chemistry. TA-21-155 currently houses the Tritium Systems Test Assembly (TSTA) for developing and demonstrating effective technology for handling and processing deuterium and tritium fuels for use in fusion reactors.

3.2 PAST WASTE MANAGEMENT PRACTICES

The major contributor to waste streams at the TA-21 OU were plutonium-processing activities. Because of the scarcity of plutonium, much emphasis was placed on recovery of this material from process waste streams. Thus, waste stream recycling became a common practice.

3.2.1 Process Waste

Process waste consisted of the solid and liquid waste streams produced in the various research and production activities at TA-21. These waste streams were generally contaminated with radioactive and chemical waste. Process wastes from the early 1940s until the late 1970s were largely disposed of at five Material Disposal Areas (MDAs). These areas are known as MDAs A, B, T, U, and V (see Fig. 2.2-2). Estimates of the volumes and activity of waste disposed of in the MDAs are given in Table 3.2-I. The methods used in disposing of solid and liquid wastes at these MDAs differ and have evolved over the years. Chapter 16, Material Disposal Areas Description and Sampling Plan, contains detailed information on each MDA.

Solid wastes were, in general, either buried or incinerated. Burial of solid wastes was performed in pits at MDAs A and B. Transuranic (TRU) wastes were placed in corrugated metal pipes and placed in a pit at MDA T from which they could be retrieved. Debris produced from the destruction or remodeling of buildings at TA-21 was either buried at MDA A, occasionally pushed over

TABLE 3.2-I
ESTIMATES OF THE VOLUME AND ACTIVITY OF WASTES DISPOSED OF IN TA-21 MDAs.

MDA	Area (acres)	Solid/ liquid waste disposal	Estimated Volume of waste (cubic yards)[a]	Activity	Date Ceased Operation	Potential Contaminants
A	1.25	Solid	7,007	unknown	1978	radionuclides, organics, inorganics, metals, solvents
B	6.03	Solid	210,473	unknown; estimated 100 gm Pu (Walker et al. 1981)	1948	radionuclides, organics, inorganics, metals, solvents
T	2.21	Liquid/ Solid[b]	71,962	absorption beds 1945-1951 Pu 9.8 Ci and ^{3}H 14.0 Ci disposal shafts 1968-1983 ^{241}Am 3743 Ci, ^{238}Pu 31 Ci, ^{239}Pu 151 Ci, and ^{233}U 6.9 Ci	1983	radionuclides, organics, inorganics, metals, acids
U	0.20	Liquid	60,558	2.5 Ci ^{227}Ac released in 1953	1968	radionuclides, organics, inorganics, metals, PCB
V	0.88	Liquid	241,939	small quanitites ^{90}Sr and ^{239}Pu	1961	radionuclides, organics, inorganics, metals, solvents

[a]Estimates from WIN data base 12/17/90.
[b]Liquid waste went into absorption beds and solid cement paste went into disposal shafts.

the edge of the mesa south of MDA V, piled up northeast of DP East, or abandoned in other places at TA-21(See Chapter 14, Surface Units Description and Sampling Plan).

Liquid wastes produced at TA-21 were carried to the various disposal and treatment sites via a system of waste lines and sumps that may have leaked. Virtually every building at TA-21 that contained processing or research operations was served by this system. Over the years, this system was altered many times as the waste disposal and reprocessing operations changed. Chapter 18, SWMUs for Coordination with building D&D, contains detailed information on the waste lines and sumps.

Initially, liquid wastes were stored in tanks pending future improvements in the extraction processes. In the late 1940s and early 1950s, it was found that the natural soils and clays at TA-21 were effective in removing radioactive contaminants from waste liquids (LASL 1955). Therefore, absorption beds began to be used in which process effluent was emptied into a trench filled with absorption material consisting of cobble, gravel, and fine sand. These absorption beds were located at MDAs T, U and V. By 1952, sufficient progress had been made in research for recovering additional plutonium from waste liquids to make reprocessing the liquid waste viable. This reprocessing of liquid effluent was initially performed at a specially built waste treatment laboratory, TA-21-35. TA-21-35 began reprocessing waste in 1952. In 1967, liquid waste treatment operations were transferred to a newly built waste treatment facility, TA-21-257. Waste treatment operations at TA-21-35 and 257 are discussed in Chapter 16, Material Disposal Area Description and Sampling Plan. Treated liquid wastes from these operations were occasionally discharged to the absorption beds in MDA T until 1967. From 1968 to 1976, wastes were mixed with cement and pumped down asphalt-coated shafts augured between two absorption beds at MDA T. From 1975 to 1983, TRU wastes were mixed with cement and pumped into corrugated metal pipes, which were stored in the retrievable storage pit dug between two absorption beds at MDA T. These wastes were retrieved from 1984 to 1986 and relocated to MDA G.

3.2.2 Sanitary Waste

In the early period of operations at TA-21, a separate sewer system was not available. Therefore, sanitary waste was mixed with liquid waste from floor drains, laboratory sinks, and cooling tower blowdown. Buildings at TA-21 were built with drain lines to carry this waste away from the buildings. These lines led to the mesa edge where they discharged. Some drain lines led to septic tanks, which then discharged overflow to the mesa edge. The discharge points are known as outfalls. These outfall lines were not intended to discharge radioactive or otherwise contaminated waste, but occasionally contaminated material would be washed down a floor drain or poured into a sink. The majority of the outfall system was abandoned in 1966 when the sewage treatment plant located at the east end of DP Mesa came on line. Some outfall lines discharging cooling water blowdown are still in operation and are NPDES-permitted. Outfalls and septic systems are discussed in Chapter 15, Outfalls Description and Sampling Plan. The sewage treatment plant is discussed in Sec. 14.7.

3.2.3 Airborne Effluents

Air from the process areas and some rooms at DP West and DP East were cleaned by using filters and electrostatic precipitators. These cleaning processes were principally contained in filter houses TA-21-12 and TA-21-153. TA-21-12, which served DP West, was decommissioned in 1972, and TA-21-153, which served DP East, was decommissioned in 1970. Building areas that were not served by these two filter houses exhausted air through stacks located at each area being served. These stacks generally contained HEPA filters or scrubbers and were monitored for the particular radionuclide associated with operations in the rooms the stack served. HEPA filtered exhausts are still in operation at TA-21 for various radionuclides (see Chapter 13).

In the 1960s and 1970s, several incinerators called salamanders were used to burn organic transuranic solvents and oils contaminated with radionuclides. The salamanders were long trays used for the open burning of solid waste and were associated with the waste treatment facilities at TA-21-35 and TA-21-257. Detailed information on air discharge systems is contained in Chapter 13, Surface Contamination from Airborne Emissions Description and Sampling Plan.

3.3 PRESENT OPERATIONS AND SITE CONDITIONS

This section discusses ongoing research activities at TA-21 facilities, the waste management practices to support these activities and the planned D&D of DP West.

3.3.1 Current Operations

The three major current operations at TA-21 involve the Isotope and Structural Chemistry Group (INC-4) at DP West, the Tritium Science and Technology Group (MST-3) at DP East, and the Laboratory's operations and maintenance contractor, Johnson Controls, at both DP East and DP West. The Radiation Protection Group (HSE-1) and the Waste Management Group (HSE-7) also conduct operational ES&H activities at TA-21. Several other groups conduct varied activities in one or two buildings at TA-21.

INC-4 occupies the majority of the old plutonium-processing buildings (TA-2,3,4,5,150) at DP West. The buildings house from 75 to 100 people. They conduct research in the following five activity areas: condensed-phase spectroscopy, organo-metallic chemistry, actinide chemistry, bioinorganics, and environmental chemistry. MST-3 operates the Tritium Systems Test Assembly (TSTA) in TA-21-209. The objective of TSTA is to develop and demonstrate technology for processing deuterium and tritium fuel for use in the magnetic fusion energy program. Johnson Controls uses TA-21-14 at DP West to house fitters, welders, painters, electricians, and tinners (sheet metal workers) to support all of Construction Area 2 (S-Site, TA-53, TA-42, TA-2, TA-21, and townsite). The sewage treatment plant and steam plant at DP East are also operated by Johnson Controls.

3.3.2 Waste Management

Waste management practices at TA-21, initiated in the 1940s to accommodate plutonium processing, were largely terminated by 1978 when plutonium-processing operations were transferred to TA-55. However, work with plutonium at a much reduced level continues at TA-21 by INC-4 generating some wastes. The five material disposal areas at TA-21 ceased operation at various times prior to 1983 (see Table 3.2-I). Additionally, in 1986, treated effluent from Building 257, the industrial waste treatment plant, was transferred via pipeline for NPDES-permitted discharge to Mortandad Canyon. Prior to that time, treated liquid waste from Building 257, and previously Building 35, had discharged to DP Canyon by an outfall pipe (see Chapter 16, Material Disposal Areas Description and Sampling Plan).

3.3.3 Decontamination and Decommissioning

Laboratory management realizes that DP West is a facility that has outlived its useful life, steadily deteriorates, and, because of changing ES&H requirements, will not be in compliance in the future. To address these issues, an action plan (Gancarz 1990) is under development. Short-term activities of this plan are to control access, phase out property storage, and designate INC division as the landlord-site manager for DP West (see Fig. 3.3-1). Long-term plans are to relocate programmatic activities from DP West and implement decontamination and demolition of DP West. In light of these activities, current and expected future operations at TA-21 are discussed.

The D&D Program is part of the ER Program; however, it is managed by the Waste Management Group (HSE-7) and not the Environmental Restoration Group (HSE-13).

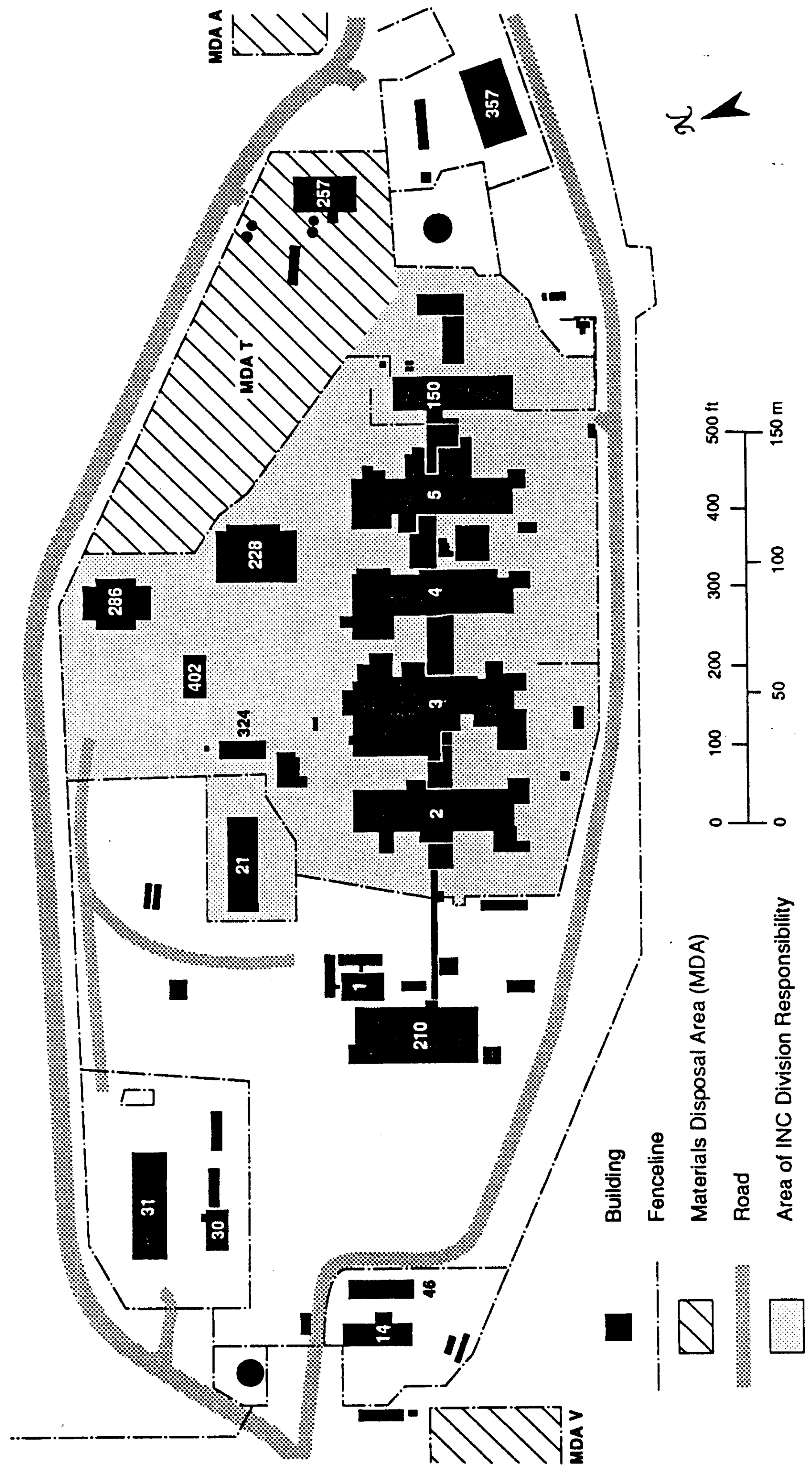


Fig. 3.3-1 Portion of DP West under INC Division as landlord site manager.

The following D&D activities are scheduled and budgeted:

- routine surveillance and maintenance of Buildings 3 and 4 south, the former enriched uranium-processing facility, which was operated by MST Division until July 1984, is budgeted for FY91. This activity involves radiological and hazardous waste measurements, physical inspections, reporting and record-keeping requirements, and correction of any deficiencies identified (Montoya 1990).
- decommissioning of Buildings 3 and 4 south is budgeted at $1.25 million each year in FY92 and FY93.

A D&D plan including building demolition is currently being developed for DP West. This plan will be incorporated into the Five Year Plan (FYP) for Environmental Restoration and Waste Management. However, the process outlined in DOE's Draft Policy for Acceptance of Facilities for Decontamination and Decommissioning (DOE 1990) suggests this will take time. The DOE Headquarters Office of Environmental Restoration (EM-40) will only consider facilities once they are made surplus and inactive. DP West is not yet surplus. Additionally, this guidance states that "there will be a 'transition period' of up to 3 years to allow for time required to appropriate funds for the cleanup and to provide for the orderly integration of the project into the EM-40 program." Cleanup activities will be scheduled on the basis of the prioritization process in the FYP.

As a result of all the above-mentioned uncertainty, it is not known when DP West will actually be decontaminated, decommissioned, and demolished. The planned D&D/ER interface, as it pertains to field sampling plans for SWMUs at DP West, is discussed in more detail in Chapter 18.

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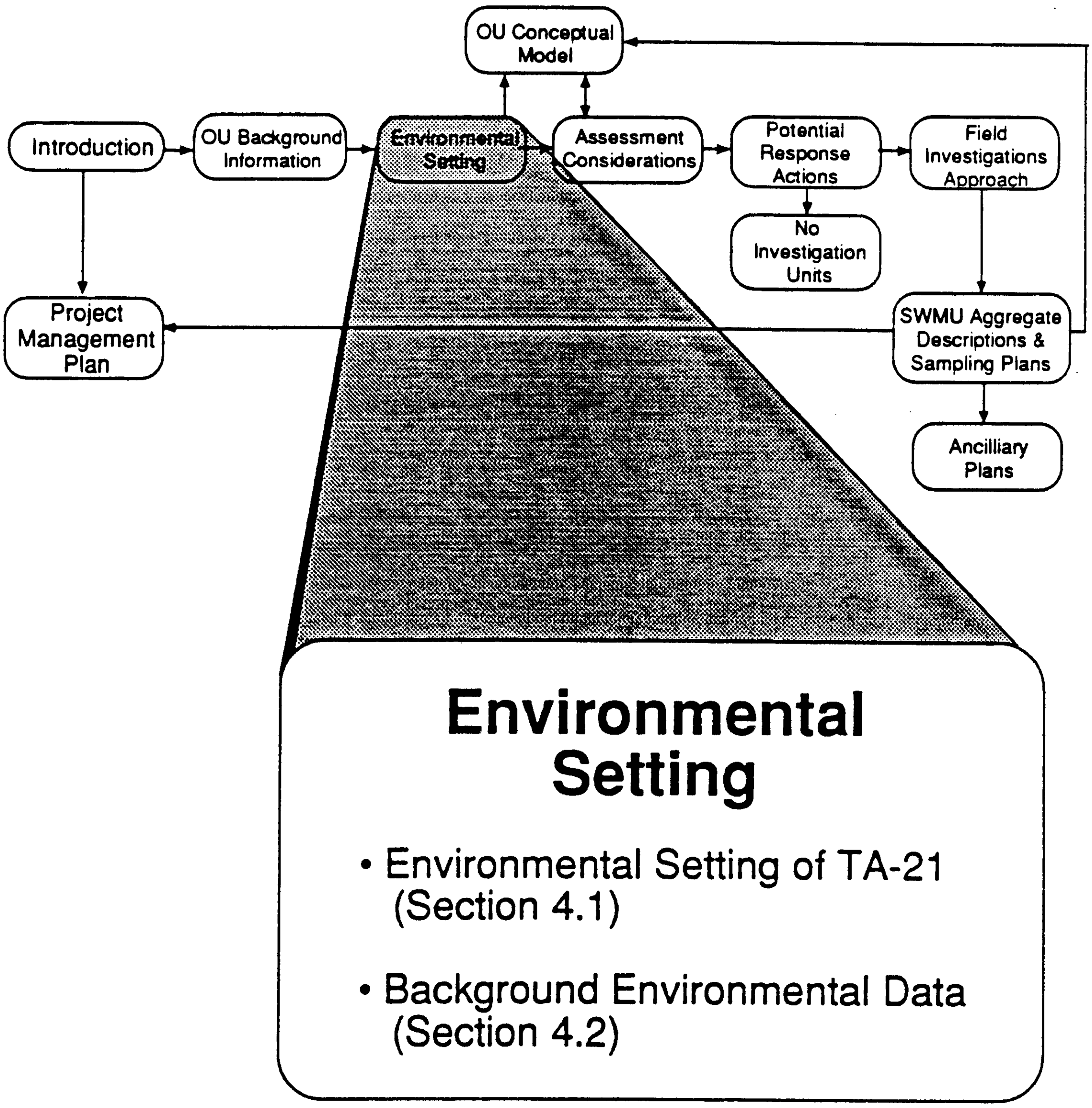
CHAPTER 4


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
Project Management Plan
SWMU Aggregate Descriptions & Sampling Plans
Ancilliary Plans
Environmental Setting
• Environmental Setting of TA-21 (Section 4.1)
• Background Environmental Data (Section 4.2)

4. ENVIRONMENTAL SETTING

Chapter 4 and Chapters 5 through 9 are intended to build an understanding of the environment at TA-21 and the significance of different contaminant migration pathways at the TA-21 OU. The RFI investigation plans presented in Chapters 12 through 19 are based on the understanding developed here.

The next three chapters present and interpret the details of existing information as follows:

- General environmental description—Sec. 4.1, Environmental Setting
- Existing data on contaminants in environmental media—Sec. 4.2, Background Environmental Data, and Sec. 5.2, Environmental Pathways.
- Description of pathways of importance for different types of SWMUs—Sec. 5.1, SWMU Conceptual Categories.
- TA-21 OU-specific discussion of the contaminant migration pathways—Sec. 5.2, Environmental Pathways.
- Evaluation of receptors affected by releases along each pathway—Chapter 6, Identification of Potential Receptors.

Throughout each of these discussions, an effort is made to explicitly identify additional information and data needs. Such needs may relate to expanding our conceptual understanding of the environmental processes at work or to providing the parameter values that will be needed to assess the magnitude and importance of those processes as potential exposure routes.

The general foundation prepared by the above-listed sections culminates in the description of a conceptual model of contaminant release, transport, and effect for the TA-21 OU as follows:

- Summary of the existing information and the current understanding presented as a conceptual model—Chapter 7, Conceptual Site Model.

The final two chapters of this six chapter sequence bring together, as summaries, a list of information and data needs and an evaluation of the nature and quality of data required to support the purposes of the RFI as follows:

- Summary of identified OU-wide and SWMU-specific data needs—Chapter 8. Data Needs.
- Summary of data quality requirements for meeting the objectives of the different aspects of the investigation—Chapter 9, Data Quality Objectives.

Data needs have been identified throughout this work plan. Data needs related to the OU as a whole are identified primarily in Chapters 4 through 6. SWMU-specific data needs are identified in the evaluations prepared for each individual SWMU in Chapters 12 through 19. The summary of data quality objectives addresses the different aspects of the RFI in view of the primary objective of selecting a remedial alternative on the basis of human health, environmental impact, and implementation and cost considerations.

The field sampling plans presented in Chapters 12 through 19 are intended to satisfy the data requirements identified in Chapters 4 through 9, as well as provide information allowing the identification of contaminants, contaminant source term, and nature and extent of environmental releases. As the results of the field sampling efforts become available, an iterative process will begin in which the current understanding documented in the next six chapters will be updated; the sufficiency of the data for supporting the RFI objectives will be assessed; new data needs will be identified; and new investigations will be designed to fulfill those needs.

This chapter presents information about the characteristics of the TA-21 environment. It describes the environmental setting of TA-21 and identifies available information that may be used to assess the presence, movement, and importance of contaminants in the TA-21 environs. This chapter has two sections. The first section, Environmental Setting of TA-21, contains descriptive information about the climate, soil, geology, and hydrology at TA-21. It also identifies additional data needed to evaluate the potential for a contaminant release to move through environmental pathways. Chapter 5 will discuss pathway significance and present data needs by pathway.

The second section, Background Environmental Data, presents regional data on surface and groundwater quality, air quality, external penetrating radiation, and soil chemical and radiological constituents. These data represent environmental conditions beyond the range of influence of Laboratory operations and provide the basis against which TA-21 data can be compared. Additional data on background levels that are needed to provide the foundation for comparisons are identified in this section.

4.1. Environmental Setting of TA-21

The environmental setting of the Laboratory as a whole is discussed in the IWP's Sec. 2, Installation Description (LANL 1990). The following descriptions of the environmental setting of TA-21 focus on the detailed situation at this OU. In this chapter, reference is made to information given in the IWP and additional detail is provided, as appropriate. In addition to giving a general description of the environmental setting, a purpose of this section is to identify information needed to assess the potential for movement of contaminant releases through the environment at TA-21. A summary of the identified data needs is presented in Chapter 8, Data Needs.

4.1.1. Geographic Setting

The geographic setting of the Laboratory is described in the IWP at Sec. 2.1, Geographic Setting. TA-21 is located on the northern edge of the Laboratory, at an elevation of 2176 m (7140 ft). It is centrally located on the Pajarito Plateau, roughly midway between the rising of the Jemez Mountains to the west and the White Rock Canyon of the Rio Grande to the east (Fig. 4.1-1). TA-21 is sited on the relatively narrow DP Mesa, and is underlaid by approximately 800 ft of volcanic ash deposits, the Bandelier Tuff, which is the bedrock throughout the OU. Groundwater lies at a depth of approximately 1150 ft.

The TA-21 OU is defined as the area between the drainage channel in DP Canyon, on the north, to the drainage channel in Los Alamos Canyon, on the south. The eastern boundary is formed by the confluence of the two drainages, and the western boundary is defined by the property boundary for TA-21 (see Fig. 4.1-2).

4.1.2. Climate

Los Alamos County has a semiarid, temperate mountain climate. The climate of the county, including frequency analyses of extreme events, is discussed in detail in Bowen (1990) and summarized in the IWP at Sec. 2.5.3, Climate. Climatic aspects of interest include

- atmospheric transport of contaminants: wind speed, frequency, direction, and stability classification;
- atmospheric pressure cycling ("pumping") resulting in the movement of vapors to the surface; and
- surface water run-off and infiltration: precipitation form, frequency, intensity, and evaporation potential.

Wind speed and direction are measured at five locations around the Laboratory, as indicated in Fig. 4.1-3 (ESG 1989). The East Gate monitoring station is 1.6 km (1.0 mi) east of TA-21. Wind speeds in 1988 were less than 2.5 m/s (5.5 mph) 38 % of the time and greater than 5 m/s (11 mph) 21 % of the time. Strong winds occur predominantly in the spring. The predominant wind direction, especially for strong winds, is south-southwest. This information implies that deposition patterns for wind-borne contaminants may be more prominent to the north-northeast of the TA-21 OU.

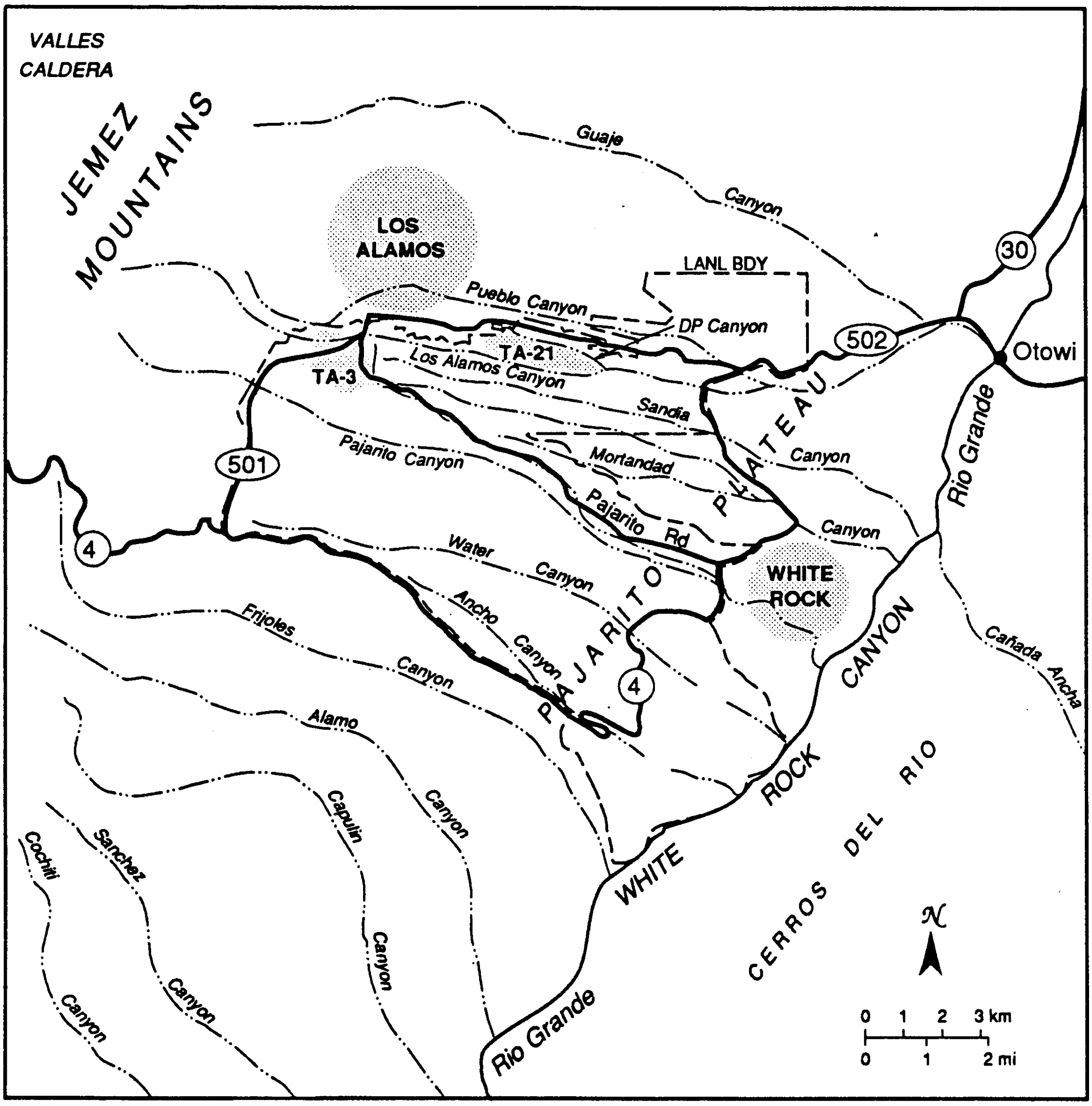


Fig. 4.1-1 Location of TA-21 on the Pajarito Plateau.

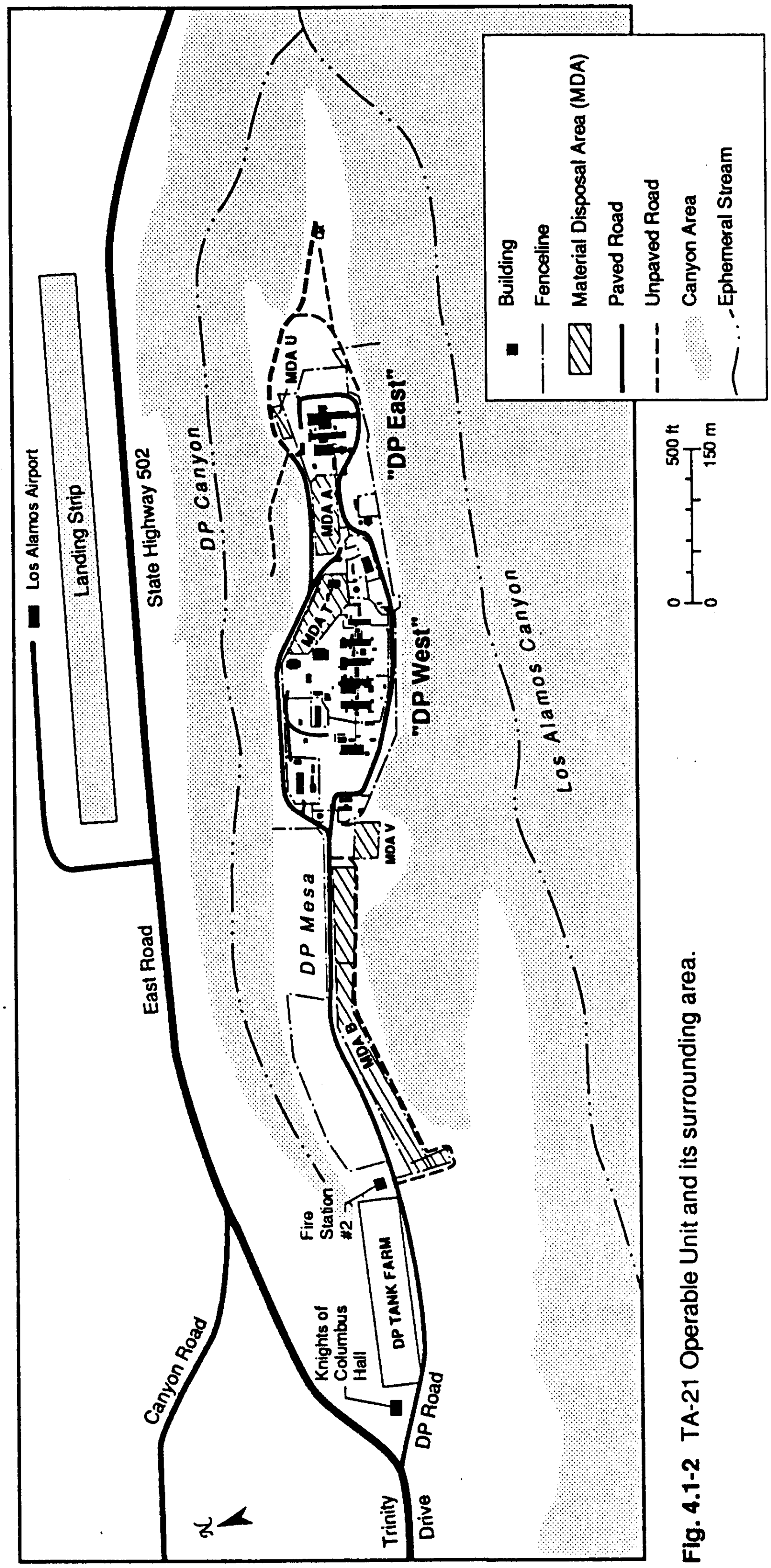


Fig. 4.1-2 TA-21 Operable Unit and its surrounding area.

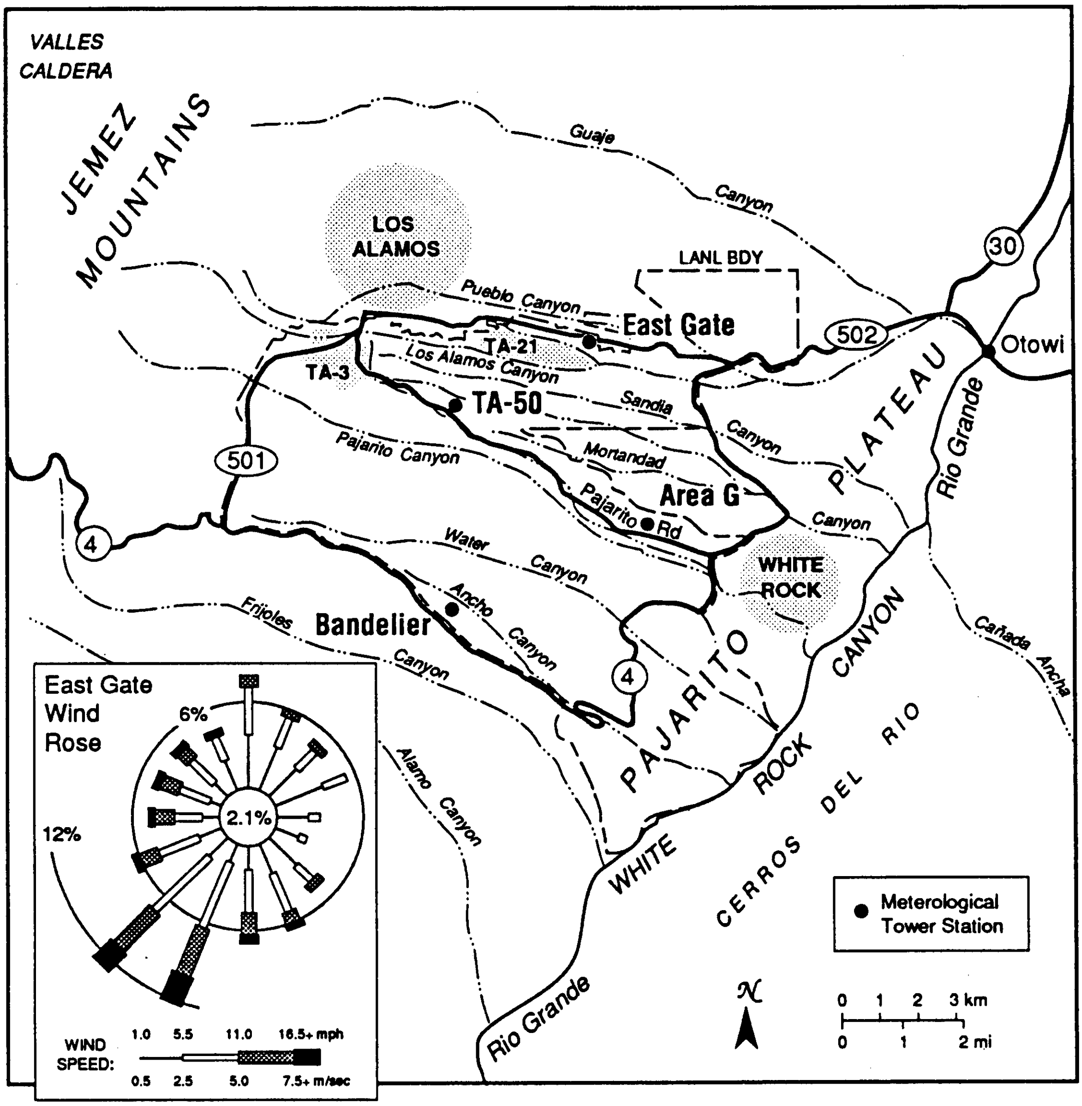


Fig. 4.1-3 Meterological tower stations at Laboratory during 1988 (ESG 1989).

Forty percent of the precipitation on the Pajarito Plateau occurs as brief, intense thunderstorms during the period of July and August. Significant run-off of surface water often occurs with these events. In the winter, snowfall averages 130 cm (51 in.) annually (ESG 1989). Figure 4.1-4 summarizes precipitation data from 1911 to 1987. The prevalence of short, intense precipitation events indicates that surface erosion and run-off transport of soils may be important mechanisms for the movement of surficial contaminants at the TA-21 OU.

Data needs. For application at TA-21, available climatic data are sufficient. Atmospheric pressure cycling is discussed further in conjunction with the atmospheric dispersion pathway in Chapter 5.

4.1.3. Soils

IWP Sec. 2.6.2.3, Soils, discusses the soils of the Pajarito Plateau. Soils in the vicinity of TA-21 are typical of those, and are generally poorly developed, derived from Bandelier Tuff bedrock, and formed under a semiarid climate. Soils in the Laboratory vicinity were mapped and described by Nyhan et al. (1978). Relevant aspects of soils include

- presence/absence, native/disturbed;
- potential for wind and water erosion: particle size distribution, classification, vegetative cover; and
- contaminant retardation/neutralization capability: ion exchange capacity, pH, K_d, clay content, permeability barriers.

Mesa Top Soils. Soils on the TA-21 mesa top are mainly shallow, well drained sandy loams of the Hackroy series. As described by Nyhan et al. (1978). "The surface layer of the Hackroy soils is a brown sandy loam, or loam, about 10-cm thick. The subsoil is a reddish brown clay, gravelly clay, or clay loam, about 20-cm thick. The depth to tuff bedrock and the effective rooting depth are 20 to 50 cm." Hackroy soils are classified as Alfisols, in part reflecting the clayey subsurface horizons.

Intermixed with the Hackroy soils on the mesa tops are small areas of deeper loams of the Nyjack series and patches of bedrock. The Nyjack soils are texturally similar to Hackroy soils and are distinguished by thicknesses of 50 to 102 cm and by the common presence of pumice fragments in the lower soil (Nyhan et al. 1978). Areas of exposed rock are predominant toward the end of the mesa, east of the TA-21 development.

IWP Sec. 2.6.3.1.2, Movement of Fluids Through Tuff, describes a distinct clay layer often formed

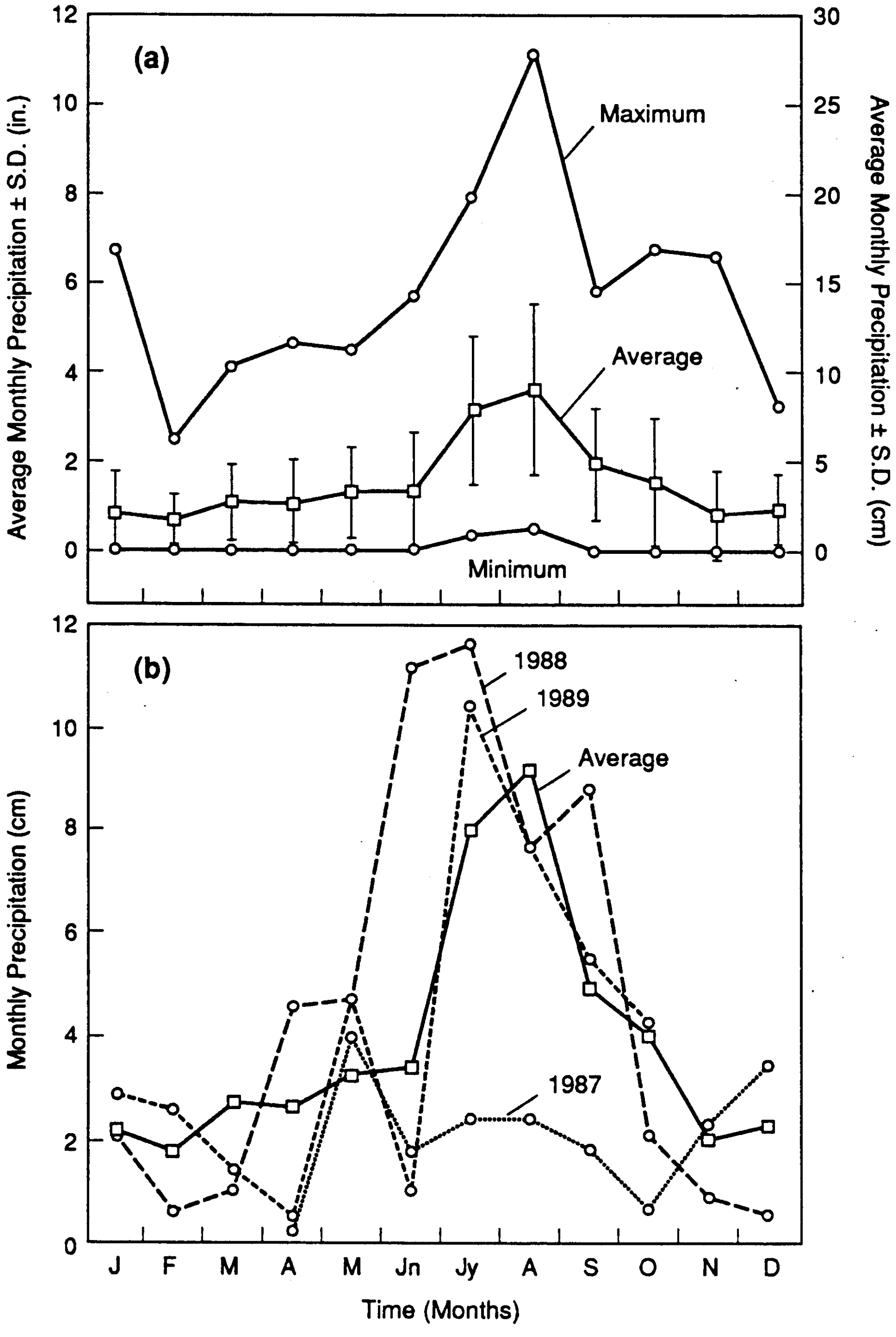


Fig. 4.1-4 (a) Distribution of average, maximum, and minimum monthly precipitation from 1911 to 1986, and (b) monthly precipitation totals from 1987 to 1989 at Los Alamos.

at the base of the soil profile. This layer has been cited as a potential barrier against infiltration of precipitation into the underlying bedrock (Abeele et al. 1981; Weir and Purtymun 1962). Areas where soils have been removed or disturbed may not exhibit this reduction of infiltration (Abrahams et al. 1961).

Data needs. Determine areas of disturbed versus undisturbed soils and the presence of a distinct clay horizon to address erodibility and contaminant-holding properties. This data need is discussed further in conjunction with the surface water run-off pathway in Chapter 5.

Canyon Walls and Canyon Bottom Soils. The slopes between the mesa tops and canyon bottoms are mostly mapped as steep rock outcrops, consisting of about 90% bedrock outcrop and patches of shallow, undeveloped soils. South-facing canyon walls are very steep and have little or no soil material or vegetation; north-facing walls are less steep and often have areas of very shallow dark-colored soils (Nyhan et al. 1978).

Part of the lower south-facing wall of Los Alamos Canyon, south of TA-21, is mapped as unnamed soils of the Typic Ustorthents-Rock Outcrop Complex, formed on colluvial material mantling the lower slope. The Typic Ustorthents are deep, well drained soils. The surface layers of the Typic Ustorthents are generally a pale brown stony or gravelly sandy loam about 5-cm thick. The substratum is about 150-cm thick and generally consists of a very pale brown, or light gray, gravelly loamy sand, or sand. Measurements at TA-21 indicate that the depth to tuff bedrock is greater than 155 cm (Nyhan et al. 1978).

The valley bottoms north and south of TA-21 are underlaid by deep, poorly developed, well drained soils of the Totavi series formed in alluvium. The surface soil is a brown, gravelly loamy sand, or sandy loam, to 150 cm or more, with 15 to 20% gravel (Nyhan et al. 1978). Totavi soils are classified as Entisols (Birkeland 1984).

Data needs. The same data are needed as for mesa top soils.

4.1.4. Surface Water Hydrology

Neither Los Alamos Canyon nor DP Canyon in the area of the TA-21 OU has perennial stream flow. Both canyon drainages contain ephemeral streams. These streams flow only in limited segments because of effluent releases and flow along their full course only during spring snowmelt and summer thunderstorm run-off events.

Run-off and infiltration are the significant aspects of surface water hydrology at TA-21. These aspects are of importance as mechanisms by which contaminants can be mobilized and transported through the environment. Run-off may carry contaminants into surface waters, concentrate dispersed surficial contamination into drainages, and carry and deposit contaminants downstream. Surface water infiltration provides the mechanism by which contaminants may begin to move into subsurface soils and can allow contaminants to reach alluvial aquifers. Surface hydrology aspects of interest include

- areas and paths of surface water run-off, sediment transport rates, and sediment deposition areas;
- soil erosion rates, relevant to exposure of covered wastes;
- locations and sizes of areas of disturbed and undisturbed surface soils in drainages;
- infiltration versus run-off ratios for precipitation and surface releases of liquids;
- presence and effectiveness of clay soil horizons in retarding infiltration;
- presence and effectiveness of fracture-filling materials in retarding infiltration; and
- fate of infiltrating water on mesa tops and in canyons (springs, alluvial or perched aquifers, evapotranspiration).

4.1.4.1. Surface Water Run-off

Run-off in the ephemeral streams of the Pajarito Plateau occurs due to effluent releases, summer thunderstorms, and spring snowmelt. Effluent releases result in flow along limited stream segments. Run-off from summer storms reaches a maximum discharge in less than 2 hours and has a duration generally less than 24 hours. The high discharge rate carries large masses of suspended and bed sediments for long distances that may include the full stream length. Spring snowmelt occurs over a period of several weeks to several months at a low discharge rate. Although the long duration of flow results in the movement of significant masses of suspended and bed sediments, the mass transported by snowmelt run-off is small compared to that carried by summer run-off events (Purtymun et al. 1990).

4.1.4.1.1. Mesa Top Run-off

Surface run-off from DP Mesa would enter either Los Alamos Canyon (to the south) or DP Canyon (to the north). Storm run-off for DP Canyon during the period May 29 to September 26, 1967, was 343.5 m^3 (12,128.8 ft^3) with a sediment load of 453.9 metric tons (500.3 tons) (Hale 1968). The drainage area was estimated to be 152.8 ha (377.6 ac) (Hale 1968). This area would have included the portion of TA-21 draining to DP Canyon and the areas on Middle Mesa to the north and west that drain to DP Canyon.

Other data on naturally occurring surface run-off from mesa tops at Los Alamos are lacking. Experimental data from a rainfall simulator study at TA-51, approximately 5 miles south of TA-21 (Nyhan et al. 1984; Nyhan and Lane 1986) indicate that run-off is more than three times greater from an area of backfilled soil than for natural, vegetated soil.

Data needs. Mapping of disturbed and undisturbed soil areas, drainage areas and channels, and estimates of erosion and sediment transport rates are needed. These data needs are discussed further in conjunction with the surface water run-off pathway in Chapter 5.

4.1.4.1.2. Canyon Run-off

DP Canyon. DP Canyon heads on the Pajarito Plateau and is 2.4 km long above its juncture with Los Alamos Canyon. The drainage area of the canyon is approximately 1.6 km^2, of which approximately 0.5 km^2 is developed area. Channel gradient in the upper 1.6 km of the Canyon is 19 m/km. In contrast, the lower 0.8 km reach of the Canyon is deep and narrow with a channel gradient of 144 m/km. The stream flow in DP Canyon is intermittent, consisting of industrial and sanitary effluent and storm water run-off. Only during storm run-off in DP Canyon does surface flow reach Los Alamos Canyon.

Over the period of May through September 1967, storm run-off and sediment transport were measured at the mouth of DP Canyon (Purtymun 1974). There were 23 run-off events during the period of study. The mean discharge ranged from 6 to 111 L/sec; while run-off ranged from 80 to 9000 m^3. The storm run-off of 36,800 m^3 that occurred over the 5-month study transported approximately 88,000 kg of suspended sediment out of the canyon.

Los Alamos Canyon. Los Alamos Canyon drainage area extends to the drainage divide on the Sierra de los Valles and enters the Rio Grande to the east near Otowi. Surface flow in the canyon across the Pajarito Plateau is intermittent. During the summer, storm water run-off in Los Alamos Canyon occasionally reaches the Rio Grande. For the reach of Los Alamos Canyon's intermittent flow across the Pajarito Plateau above Pueblo Canyon, the peak discharge in the active channel (3.99 m^3/sec) is greater than the estimated 2-year flood (2.83 m^3/sec) (Lane 1985). The average peak discharge of out-of-bank flow exists for the period 1943 to 1980 and is estimated to be 10.87 m^3/sec; and the maximum peak discharge for out-of-bank flow is 25.53 m^3/sec.

The transport of radionuclides in suspended sediments during run-off is discussed in Sec. 5.2.2.2.

Data needs. Run-off and sediment transport in Los Alamos and DP Canyons have been studied for a number of years. The available data are sufficient for the TA-21 OU. Whether additional data are required will be re-evaluated under the Canyons' Assessment Task (ADS 1049).

4.1.4.2. Surface Water Infiltration

The context of infiltration information is important as differences may exist for the following types of situations:

- infiltration of precipitation (or surface liquid releases) through native soils;
- infiltration in areas where the native soil profile has been destroyed, replaced or removed; and
- infiltration of liquids from releases occurring deeper in the geologic profile (e.g., liquid waste pits or leaking sumps excavated into the tuff).

Studies summarized in several IWP sections indicated that for native soil profiles infiltration of water into the tuff bedrock is not a significant mechanism for the movement of contaminants. Even with the prolonged presence of a water source, the transfer of moisture to the tuff is limited. Strong evaporative potential coupled with transpiration in vegetated areas quickly removes water from the soil and upper tuff profiles.

- IWP Sec. 2.6.3.1.2, Movement of Fluids Through Tuff, notes that much infiltrating water is quickly lost through evapotranspiration, that a natural clay layer in native soil profiles may form an infiltration barrier, and that clay filling of joints and fractures in the tuff may inhibit infiltration.
- IWP Sec. 2.6.3.3.1, Pit Infiltration Studies, reports a study in which a continuous supply of water to a pit dug in soil above the natural clay layer did not significantly increase the moisture content of the underlying tuff.
- IWP Sec. 2.6.3.4.2, Fracture Orientation Patterns, describes jointing and fracturing of the tuff and notes that many joints are filled with caliche, brown clay, or limonitic material that can block flow along fractures.
- IWP Sec. 2.6.3.4.3, Moisture Studies, indicates that little precipitation passes through undisturbed soil profiles, whereas a greater amount of infiltration penetrates to the tuff in areas where the soil has been disturbed. Moisture from single storm events has been found to penetrate as deep as 6.5 ft through disturbed fill, but is rapidly depleted by evaporation. Seasonal

moisture fluctuations were detected both in the bedrock tuff and in fill to depths of 13 ft. A downward moisture flux can be identified at that depth in fill but not in the tuff bedrock.

- IWP Sec. 2.6.3.4.6, Vadose Zone Studies, indicates that precipitation moisture does not penetrate deeper than 10 to 22 ft into tuff.

Studies of water balance where the native soil profile has been destroyed are being conducted as part of capping design pilot studies at Material Disposal Areas (MDAs) B, F, and G at the Laboratory.

Data needs. Moisture profiles in soil and tuff at TA-21 in areas of present and historical liquid releases to evaluate infiltration depths.

4.1.5. Alluvial Aquifers

IWP Sec. 2.6.4, Geohydrology of Canyon Surface Waters and Alluvial Aquifers, discusses alluvial aquifers in the canyons of the Pajarito Plateau on a canyon-by-canyon basis. Surface water infiltration creates these small, localized saturated zones in the alluvial fill of the canyon bottoms. Water infiltrates through the alluvium until the downward movement is impeded by the less permeable tuff. Depletion by evapotranspiration and movement into the underlying rock limits the size of the alluvial aquifers. These aquifers are of interest because of the following issues:

- Contaminated surface water recharging an alluvial aquifer may be stored in the canyon system and be available for uptake by biota.
- The alluvial aquifers are potential zones for infiltration into the underlying tuff and are sources of water that could move toward the much deeper main aquifer.

An alluvial aquifer occurs in Los Alamos Canyon from its upper reaches to below the confluence with DP Canyon and is monitored by several wells (see Chapter 5). The alluvial aquifer in Los Alamos Canyon is described in IWP Sec. 2.6.4.4.2. It is not known if an alluvial aquifer occurs in DP Canyon, although it is likely that at least a limited zone of saturation would occur there particularly because effluent enters the canyon from the sewage treatment plant.

Data needs. Determine if an alluvial aquifer exists in DP Canyon, because if present, it may be contaminated. If it is contaminated, it could serve as a potential pathway for biotic uptake or for downward movement of contaminants. These data needs are discussed in the context of pathways in Chapter 5.

4.1.5.1. Perched Aquifers

Perched water aquifers exist in the basalts and sediments in two canyon systems in their lower reaches below the Bandelier Tuff, as described in IWP Sec. 2.6.5, Perched Water. Neither area is close to the TA-21 OU. However, perched water has been found at depths of 117 ft in Test Well 2 and about 253 ft in Otowi 4. A clay layer 5- to 10-ft thick in the upper conglomerate layer of the Puye Conglomerate is probably responsible for this perched zone. These boreholes are near TA-21 as shown in Fig. 4.1-5. No occurrence of perched water within the Bandelier Tuff has ever been identified.

Data needs. Assess all boreholes placed during site characterization for evidence of perched water within the Bandelier Tuff. Perched water may be of concern as a potential migration pathway as detailed in Chapter 5.

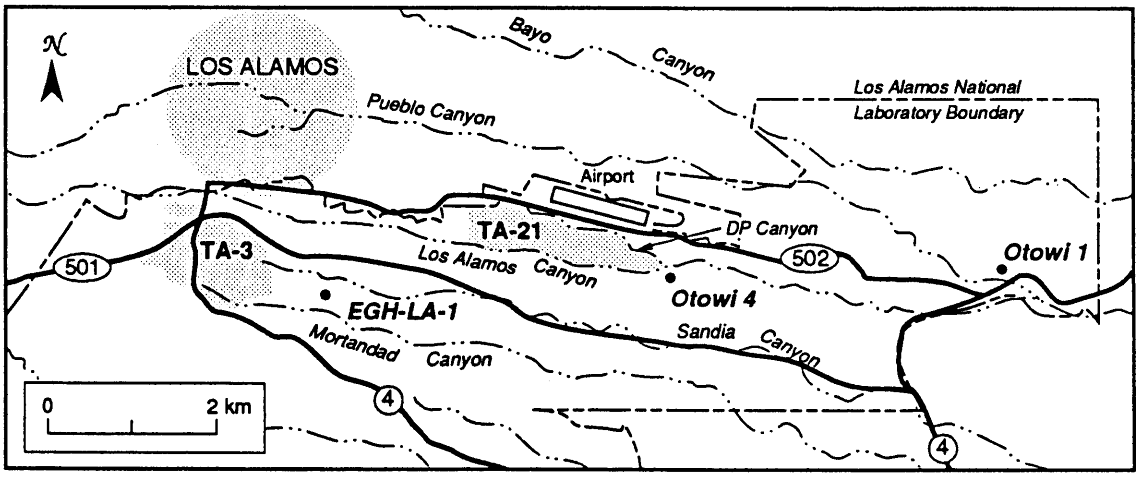


Fig. 4.1-5 Deep well locations near TA-21.

4.1.6 Springs

During reconnaissance geologic work around DP site in May 1990, a previously undescribed cold spring was discovered discharging from the north wall of DP Canyon, about 1 km from DP site (see Fig. 4.1-2). Based on established vegetation, the spring is estimated to be at least 10 years old. The discharge occurs at the contact of colluvium of tuff resting on an old erosional surface cut into the upper Bandelier Tuff. The origin of the discharging water is not known. Elevated tritium concentrations in the water indicate a potential hydraulic connection to liquid discharges from the sewage treatment plant at TA-21, although the path of the connection is not clear because the spring is on the opposite side of the canyon from TA-21. It is remotely possible that flow crosses the canyon floor on a low-permeability surface and emerges at the spring.

Data needs. Determine whether other springs are present at the TA-21 OU. Define hydraulic corrections of springs to alluvial aquifers, perched aquifers, or effluent discharges. Why these data are needed is discussed in the context of potential migration pathways in Chapter 5.

4.1.7. Geology

The geologic setting of the Pajarito Plateau is described in Sec. 2.6.2 of the IWP. As illustrated in Figs. 4.1-6 and 4.1-7, TA-21 is situated on the Bandelier Tuff, which includes (from top to bottom) the Tshirege, Cerro Toledo, Otowi, and Guaje members. These units are volcanic ash flows and ash falls. Depending on the nature of the deposit, the rock varies from loose pumice to hard, highly welded tuff. Degrees of welding vary within the individual units depending on the conditions of deposit and cooling.

The volcanic ash deposits are underlaid by the sediments of the Santa Fe Group (Puye and Tesuque Formations) and basalt flows (basaltic rocks of Chino Mesa). The geologic sequence below the Bandelier Tuff at the TA-21 OU may be complex because of its location on the Pajarito Plateau and may vary rapidly over short distances.

Knowledge of the geology beneath the TA-21 OU is of importance because it is believed that this geologic setting provides substantial impedance to contaminant migration. There is approximately 1150 feet of volcanic and sedimentary materials between the contaminant-bearing units and groundwater. Geological aspects of interest include

- the detailed stratigraphy of the upper units of the Bandelier Tuff, specifically the erosional surfaces or other contacts between units that may form barriers to migration or create paths to divert the path of liquid or vapor movement;
- joints in the Bandelier Tuff that may provide paths for liquid and vapor movement;
- the mineralogy of the geologic strata that may be important in the retardation of contaminant movement; and
- faulting within the upper units of the Bandelier Tuff that may provide zones of fracturing along which contaminant transport may be enhanced.

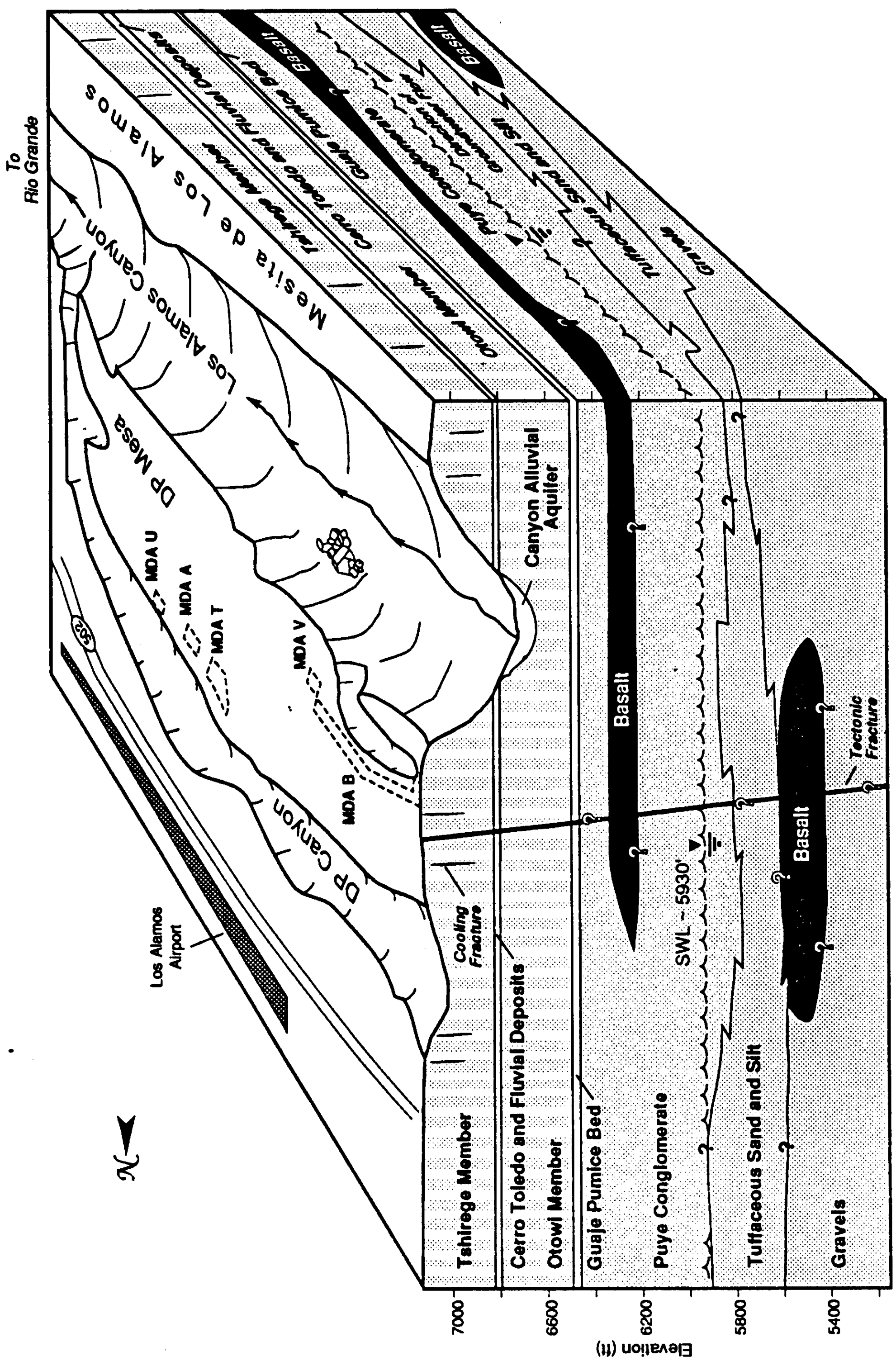


Fig. 4.1-6 Generalized geologic block diagram of TA-21.

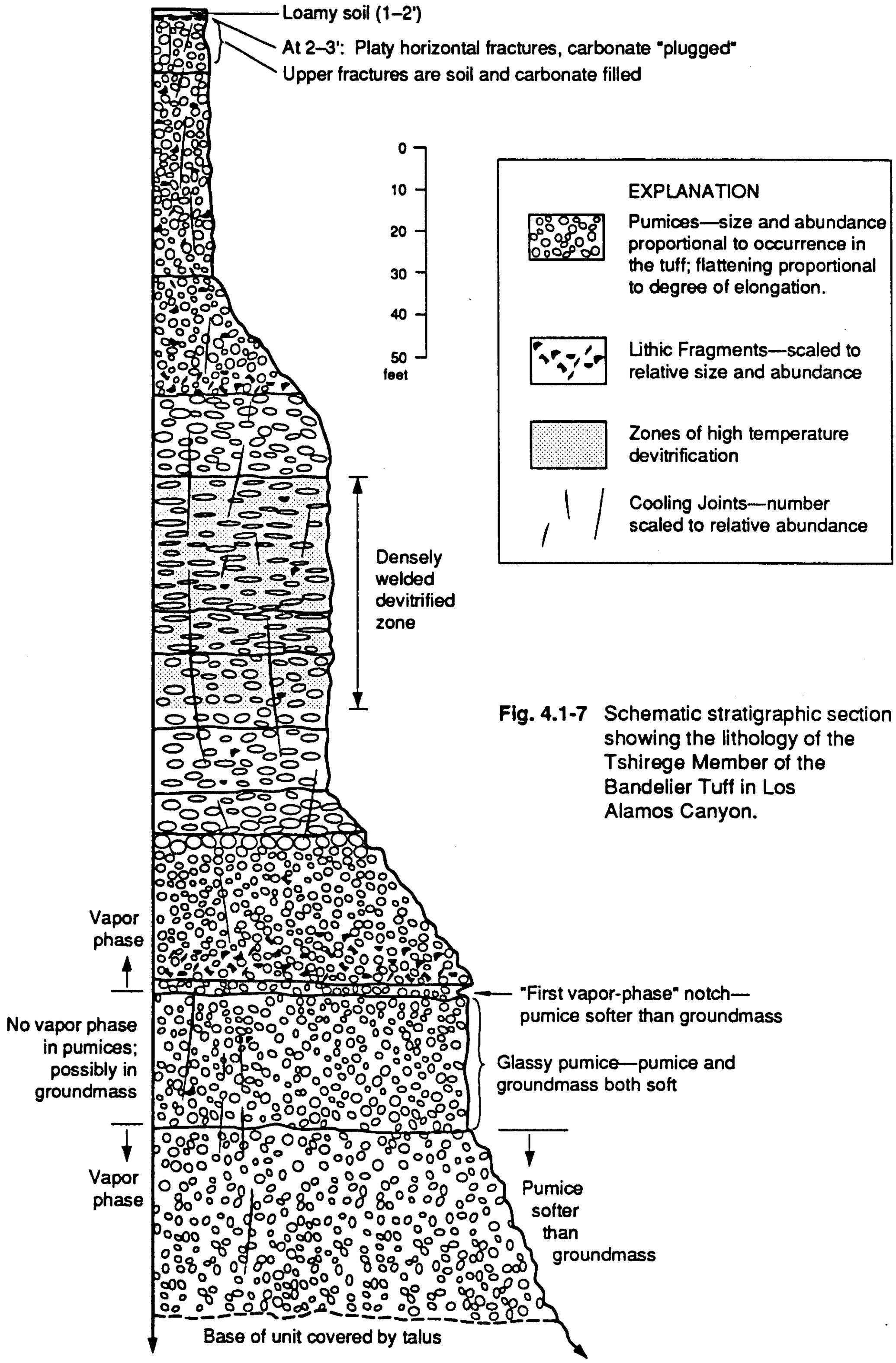


Fig. 4.1-7 Schematic stratigraphic section showing the lithology of the Tshirege Member of the Bandelier Tuff in Los Alamos Canyon.

The following discussions are specific to the geology in the immediate vicinity of TA-21 and are confined to those rock units in the vadose zone and the upper saturated zone that are considered relevant to site characterization and potential contaminant movement.

4.1.7.1. Stratigraphy

General stratigraphy for the Laboratory is discussed in IWP Sec. 2.6.2.2. The stratigraphy in the area of TA-21 is given in Table 4.1-I, including anticipated depths of stratigraphic contacts and thicknesses of rock units. No boreholes at TA-21 have penetrated to depths greater than 100 ft. The stratigraphy of the upper rock units at TA-21 can be observed directly in excellent exposures of outcrops on canyon walls and slopes surrounding the site.

The interpretation of the subsurface is based on data from three deep wells relatively close to TA-21, from regional exposures to the north and east, and from regional geologic maps. The three wells include: EGH-LA-1 located west of TA-21 on Sigma Mesa; Otowi 4 located east of TA-21 at the confluence of DP and Los Alamos Canyons: and Otowi 1 located further east at the intersection of State Roads 502 and 4 (Fig. 4.1-5). Figure 4.1-8 shows the stratigraphy and lithologies of rock units encountered in the deep wells, based on preliminary interpretations.

Significant differences in unit depths and thicknesses may be found, particularly for the lower sedimentary units, because of TA-21's location on the eastern edge of the Pajarito Plateau. Factors that may affect the geometry of subsurface units include rapid lateral and vertical facies variations in the lower sedimentary rock units, significant relief on paleotopographic surfaces on which rock units were deposited, and fault offsets in the older sedimentary units that are masked by the younger volcanic rocks that show little or no displacement.

Individual flow units in the Bandelier Tuff contain vertical and horizontal cooling joints. The vertical joints may or may not cross flow-unit boundaries. Cooling-joint spacings vary primarily with the thickness of the unit, its emplacement temperature, the substrate temperature at the time of placement, and topography (Crowe et al. 1978). The locations and relative abundances of cooling joints in the Tshirege Member are indicated schematically in Fig. 4.1-7.

Data needs. Use stratigraphic exposures to map upper units of the Bandelier Tuff. Assess boreholes drilled during site characterization activities to identify and describe stata in upper units of the Bandelier Tuff. Identify and characterize unit boundaries in the context of presenting barriers to vertical contaminant movement or preferential horizontal flow paths. Evaluate the frequency and nature of joints within the tuff, again with regard to migration paths.

TABLE 4.1-I
ESTIMATES OF STRATIGRAPHIC THICKNESS FOR MAJOR ROCK UNITS
AT TA-21, LOS ALAMOS, NEW MEXICO

Thickness ft	m	Description
260-325	79-99	Tshirege Member Bandelier Tuff: crystal-rich non-to moderately-welded rhyolitic tuff; phenocrysts of sanidine and quartz; 2% lithic fragments; at least four flow units; thin (~0.5 m) Tsankawi Pumice Bed exposed at base.
0-30	0-10	Cerro Toledo Rhyolite: discontinuous unit of three to five air-fall tuffs interbedded with epiclastic sands and gravels; tuffs are nearly aphyric; epiclastic units dominated by dacite clasts from Tschicoma Formation.
290-310	88-94	Otowi Member, Bandelier Tuff: crystal-rich rhyolitic tuff; similar to Tshirege Member but generally non-welded and vitric throughout; more lithics; Guaje Pumice Bed may be 10-m thick; base of unit not exposed.
940	287	Puye Formation: Grey conglomerate consisting of boulders, cobbles, and gravels in a sandy matrix; dominated by dacitic clasts from Tschicoma Formation, may contain interbedded basalt flows of Cerros del Rio and dacitic to andesitic flow of Tschicoma Formation.
unknown		Santa Fe Group: tan to pink sandstone and siltstone generally containing fragments of granitic rocks and quartzite from Precambrian sources to north; may contain interbedded flows of Cerros del Rio basalts and Tschicoma Formation dacite; may be interbedded with Puye Formation.

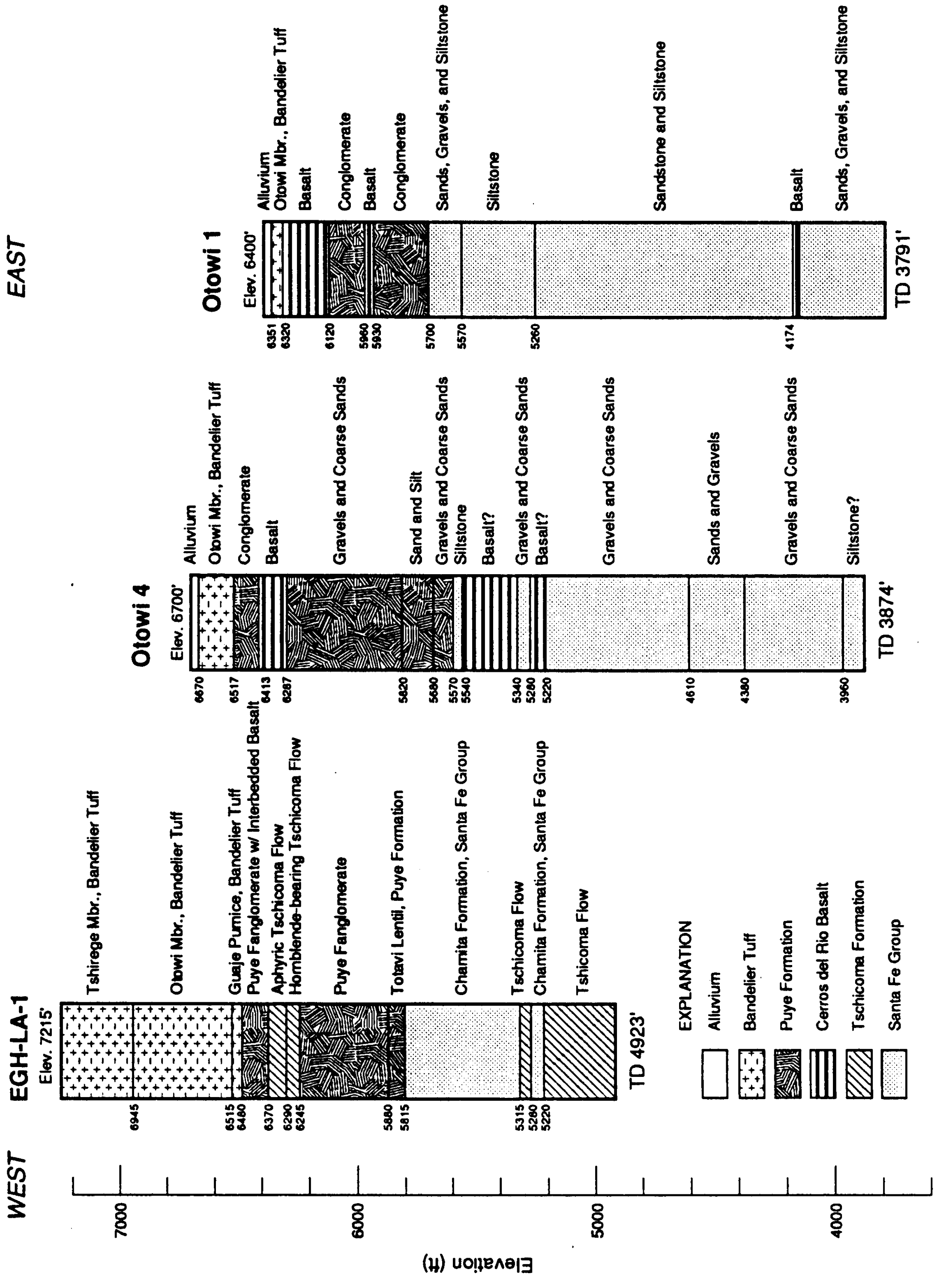


Fig. 4.1-8 Lithologic logs for deep wells near TA-21.

4.1.7.2. Faulting and Seismicity

Sec. 2.6.2.4 of the IWP discusses faulting and seismic activity for the area of the Laboratory. The Pajarito Plateau is within the Espanola Basin of the Rio Grande rift. The western edge of the Pajarito Plateau is marked by the Pajarito Fault system (Fig. 4.1-9), which also forms the western margin of the Espanola Basin. The Pajarito Fault system has had Holecene movement and historic seismicity (Gardner and House 1987).

The Guaje Mountain and Rendija Canyon Faults (Fig. 4.1-9) displace the surface of the Bandelier Tuff west of DP Mesa. Where exposed to the north, these faults are characterized by zones of gouge and breccia up to several meters wide and produce visible offset of stratigraphic horizons. To the south, the discreet faults are replaced by zones of intense fracturing superimposed on the network of cooling joints in the Bandelier Tuff. Interest in the fault systems focuses on the following:

- tectonic fractures that are likely to cross flow-unit and lithologic-unit boundaries (Gardner 1990);
- tectonic fractures that may provide more continuous and deeper penetrating flow paths for water or vapor migration than cooling joints; and
- displacements among deeper stratigraphic units that may present enhanced paths for deep contaminant movement.

Recent mapping for the Laboratory's Seismic Risk Program projects a possible fault through DP Mesa in the vicinity of MDA V (Vaniman and Wohletz 1990). Fracture mapping associated with the Seismic Risk Program has shown that fracture abundances and apertures increase over fault projections. Fracture abundances and apertures also increase towards mesa margins where large blocks tend to shift outwards as the mesa erodes.

Deeper faulting has been identified in the pre-Bandelier Tuff surface beneath the Pajarito Plateau (Dransfield and Gardner 1985). If deep migration of any contaminants is discovered, characterization activities would then be needed to determine if these faults are significant in the distribution of subsurface geologic units and/or influence transport pathways and migration mechanisms.

Data needs. Assess data from boreholes drilled during site characterization for evidence of the presence of tectonic fractures in the area of MDA V. If such fractures are found, assess their effect on contaminant movement.

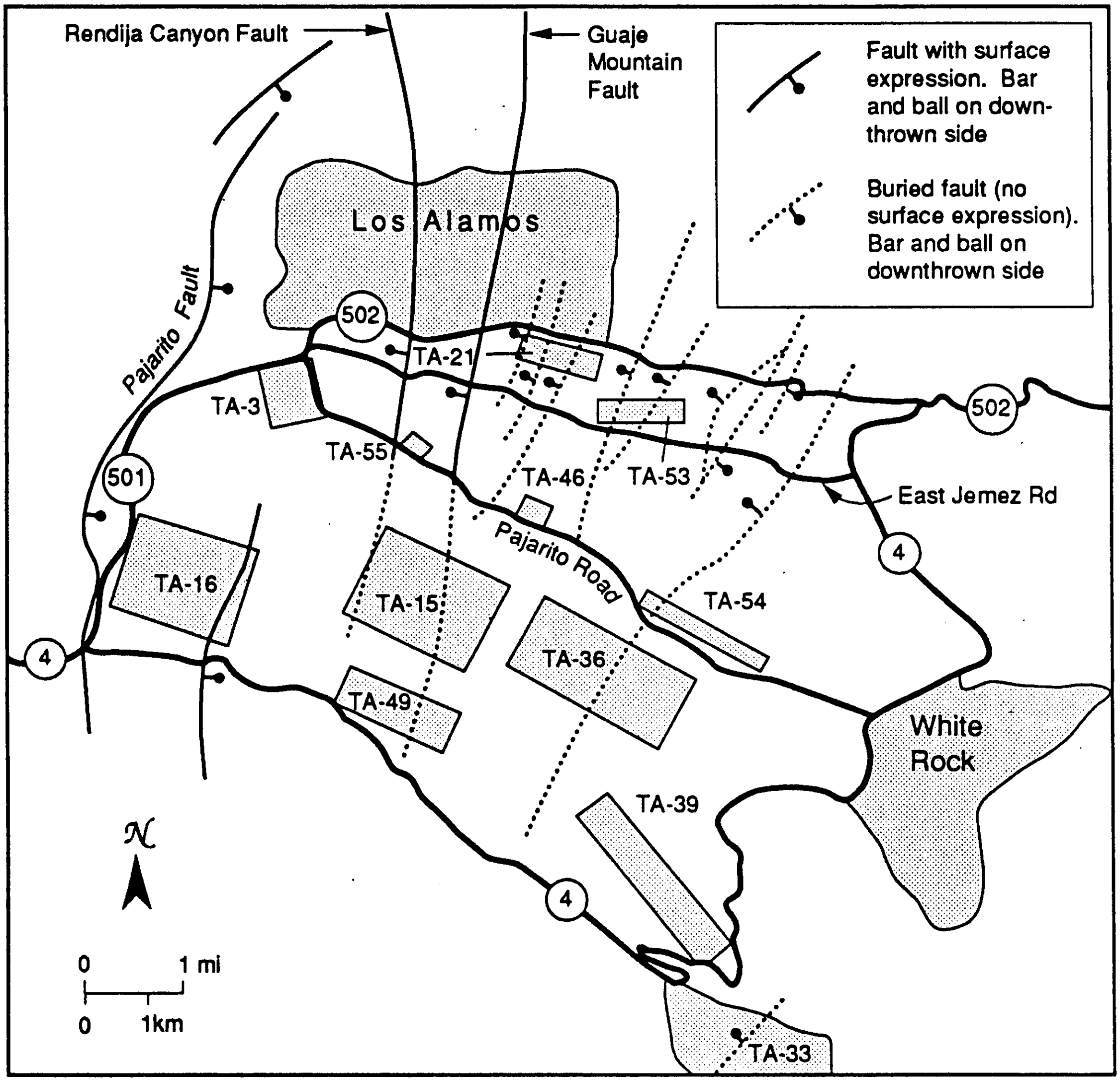


Fig. 4.1-9 Faults at selected Laboratory Technical Areas, Los Alamos, White Rock, and major roads (modified from Dransfield and Gardner 1985 and Gardner and House 1987).

4.1.8. Vadose Zone Hydrology

The hydrology of the unsaturated zone of the Pajarito Plateau is discussed in IWP Sec. 2.6.3, Geohydrology of Mesa Tops and Vadose Zone. It includes discussions of the hydrogeologic properties of the tuff and the movement of fluids through the tuff and describes related studies that have been conducted at the Laboratory The summary of the studies provides strong support for the concept that the unsaturated zone of the Bandelier tuff provides substantial impedance to the movement of liquid in the subsurface.

Detailed understanding of the vadose zone at TA-21 is important because it is believed to be the primary barrier to the movement of liquids and vapors originating from the SWMUs. Features of the unsaturated zone that are of interest include

- physical properties of the Bandelier Tuff (density, porosity, specific gravity);
- geohydrologic properties of the tuff (such as air and water permeabilities and conductivities, and moisture characteristic curves);
- frequency, orientation, and filling material of joints and fractures, degree of interconnectedness, flow paths or barriers at unit contacts or paleo-surfaces; and
- geochemical properties of the tuff related to water, air, or contaminant transport (specific surface, ion exchange capacity, K_d, and mineralogy).

For a depth of more than 1000 ft, the subsurface hydrology at TA-21 is dominated by unsaturated flow conditions. The top of the saturated zone occurs approximately 350.5 m (1,150 ft) below the surface of the mesa, and most of this distance, 243.8 m (800 ft), is in the Bandelier Tuff. Hydrologic characterization of the Bandelier Tuff has concentrated on the top 30.5 m (100 ft) throughout most of the Laboratory (Abrahams 1963; Abeele et al. 1981; Kearl et al. 1986). The same holds true for TA-21. The following subsections present some information useful in assessing movement of water and vapors in the unsaturated zone.

4.1.8.1. Properties of Tuff

Hydrogeologic properties of tuff such as porosity, permeability, moisture content, hydraulic conductivity, and moisture characteristic curves are required for hydrogeological modeling of vadose zone contaminant movement. Most available data are for crushed tuff; little data on *in situ* properties are available.

Porosity. The various units of the Bandelier Tuff tend to have relatively high porosities. Porosity ranges from 30 to 60% by volume, generally decreasing for more highly welded tuff (IWP Sec. 2.6.3.1.1, Hydrogeologic Properties of Tuff). The effective porosity ranges from 18 to 52%, indicating the interconnected or fluid-accessible porosity (Purtymun et al. 1990). No TA-21 porosity data are available.

Permeability. Permeability refers to the movement of a fluid through porous or fractured media. Permeability varies for each cooling unit of the Bandelier tuff. Values for the Tshirege member of the Bandelier tuff at TA-54, determined using *in situ* vacuum and water injection tests and laboratory analyses of cores range from 0.1 to 0.6 Darcies (Kearl et al 1986; Stoker and McLin 1990). No TA-21 specific data are available.

Moisture Content. The moisture content of native tuff is low, generally less than 5% by volume throughout the profile (IWP Sec. 2.6.3.1.1 Hydrogeologic Properties of Tuff). Previous studies at TA-21 disposal areas where liquid has been added have shown that moisture content changes little below 40 ft (Abrahams 1963; Christenson and Thomas 1962). Water content data are unavailable below 100 ft. The specific retention of the tuff ranges from 18 to 38% by volume, indicating a considerable field capacity for holding moisture (Purtymun et al. 1990).

Hydraulic Conductivity. Hydraulic conductivity is the term used to quantify the permeability of the medium. It is dependent on the porous medium and the fluid. Saturated tuff has a hydraulic conductivity in the range 0.02 cm/hr for welded tuff to 1.12 cm/hr for nonwelded tuff (IWP Sec. 2.6.3.1.1 Hydrogeologic Properties of Tuff, [Purtymun et al. 1990]). Laboratory saturated hydraulic conductivity measurements from cores at MDAs T and V range from 0.16 to 1.10 cm/hr (Abrahams 1963; Nyhan et al. 1984). *In situ* hydraulic conductivity values for TA-54 range from 1.63 to 4.44 cm/hr using air injection and vacuum tests, respectively (Kearl et al. 1986).

The hydraulic conductivity of unsaturated tuff varies with moisture content and has values two to five orders of magnitude lower than saturated tuff (Purtymun et al. 1990).

Moisture Characteristic Curve. One of the key relationships describing the status of water in unsaturated porous media is the water characteristic curve that relates water content to suction, tension, or negative pressure head. The characteristic is also used to determine the relative hydraulic conductivity, so that flux values can be calculated for water contents below saturation.

There have been a considerable number of moisture characteristic determinations on crushed Bandelier tuff (Abeele 1984; Abeele et al 1986). A question remains concerning the applicability of crushed tuff data to intact tuff. Abrahams (1963), comparing core and cuttings values from

MDA T at TA-21 concluded that cuttings could not be used to determine physical properties other than the water content at one-third bar. Similar results were found by Kearl et al. (1986). Little *in situ* moisture characteristic data are available, particularly for low water contents generally found in tuff.

Hysteresis. The moisture characteristic curve is hysteretic, meaning that it has a different shape when soil is wetting than when it is drying. If a system exhibits significant hysteresis, the time history of wetting and drying will be required in order to predict pressure head from water content values. Abrahams (1963) found that MDA T samples exhibited hysteresis. For example, the difference in water content at the 333-cm pressure head for this sample was a value of 0.22 on the wetting curve versus 0.14 on the drying curve.

Data Needs. Laboratory and *in situ* measurements of hydrogeological properties of tuff at the TA-21 OU are needed.

4.1.8.2. Injection Well Study.

The hydrologic characteristics of the Bandelier Tuff are presented in a recent report documenting an injection well study conducted in 1964 (Purtymun et al. 1990). The purpose of the study was twofold: first, to investigate the rates and conditions at which the unsaturated tuff would accept water from an injection well, and second, to monitor the movement of fluids from the injection zone into the adjacent tuff. The original intent of the injection well program was to evaluate the tuff as a sorptive medium into which liquid radioactive waste could be injected and be held indefinitely. The injection well disposal technique was never implemented, but the concept of the tuff as a sorptive medium remains valid.

Purtymun et al. (1990) determined that a moderately welded tuff with an effective porosity of about 38% by volume has four different forms of moisture movement as follows:

- No movement of moisture occurs at moisture contents below 6% by volume.
- Fluid movement is governed by diffusion in the moisture range from 6 to about 12% by volume.
- Movement is primarily controlled by capillary forces in the range from about 13 to about 24% by volume. In the higher end of this range gravity begins to supplement capillary forces.
- For 24 to 38% moisture by volume, gravity dominates as the moisture moving force.

During the injection well tests, it was found that considerable injection pressure was required to continuously inject water. It was found that tuff near the well became saturated, but further from the well the three, slower, unsaturated-flow mechanisms dominated and resisted the rapid movement of fluid that was possible in the saturated zone. Further it was found that when injection ceased, the zone of saturation was gradually depleted as unsaturated flow mechanisms removed the fluid and, with time, the system stabilized at low-moisture contents where further moisture movement was minimal (Purtymun et al. 1990).

Two aspects of this description are important. First, the unsaturated tuff effectively resists the rapid influx of water. This may supplement the clay layer in the lower soil profile as an explanation of the low observed precipitation infiltration rates. Second, fluids accepted by the tuff may not be rapidly transmitted downward through the tuff but may rather be retarded and dispersed in the tuff near the point of infiltration.

Data needs. None.

4.1.8.3 Zones of High Moisture Content

The presence of joints, fractures, and erosional surfaces at unit contacts within the tuff raises issues of potential fracture flow, interception and diversion of vertical flow by less permeable horizontal surfaces, enhanced flow across unit boundaries in tectonic fracture systems, or channel flow controlled by fractures or contacts.

In contrast to the results of the injection study discussed above, which suggests water does not move downward in the tuff, moisture measurements in boreholes in a number of investigations have identified discrete zones of higher moisture content beneath liquid waste disposal pits. Two examples can be seen in Figs. 4.1-10 and 4.1-11.

Figure 4.1-10 shows data collected from 1959 through 1961 at TA-21 MDA V beneath pit 3. The high-water contents at 33 ft in Hole 1 and at 20 to 25 ft in Hole 2 were believed to be a function of low-permeability layers that "perch" water (Abrahams 1963). (Note: these moisture contents are below saturation, and the above statement does not imply a "perched aquifer" similar to that discussed above in Sec. 4.1.7.)

Figure 4.1-11 shows data collected in 1978 at TA-21 MDA T, directly through and beneath absorption beds 1 and 2. The moisture contents were measured gravimetrically, and the zones of high-moisture content were correlated with a clay unit and with permeability zones or contacts that may divert water (Nyhan et al. 1984).

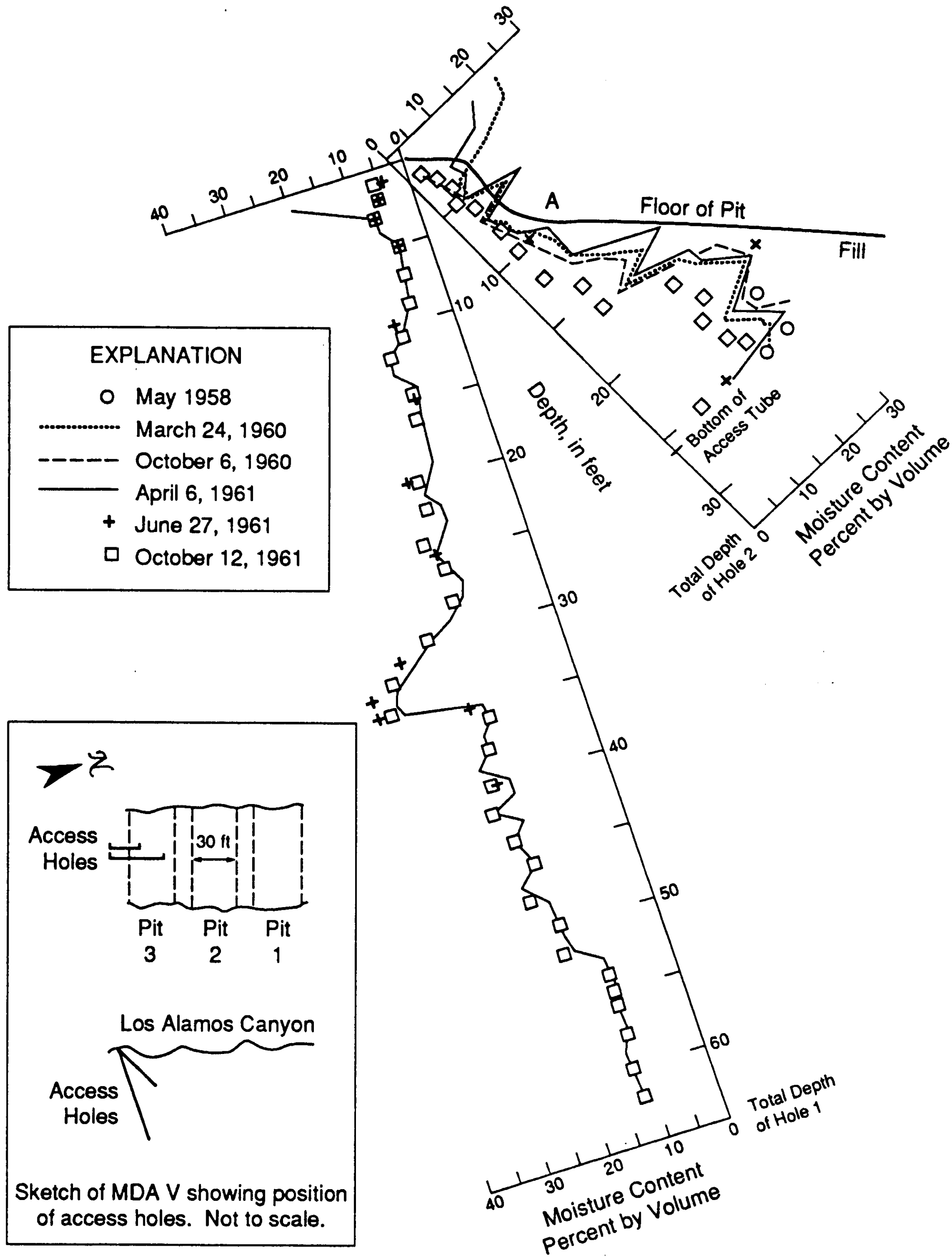


Fig. 4.1-10 Moisture content of tuff beneath the disposal pit at MDA V, Pit 3 (Abrahams 1963).

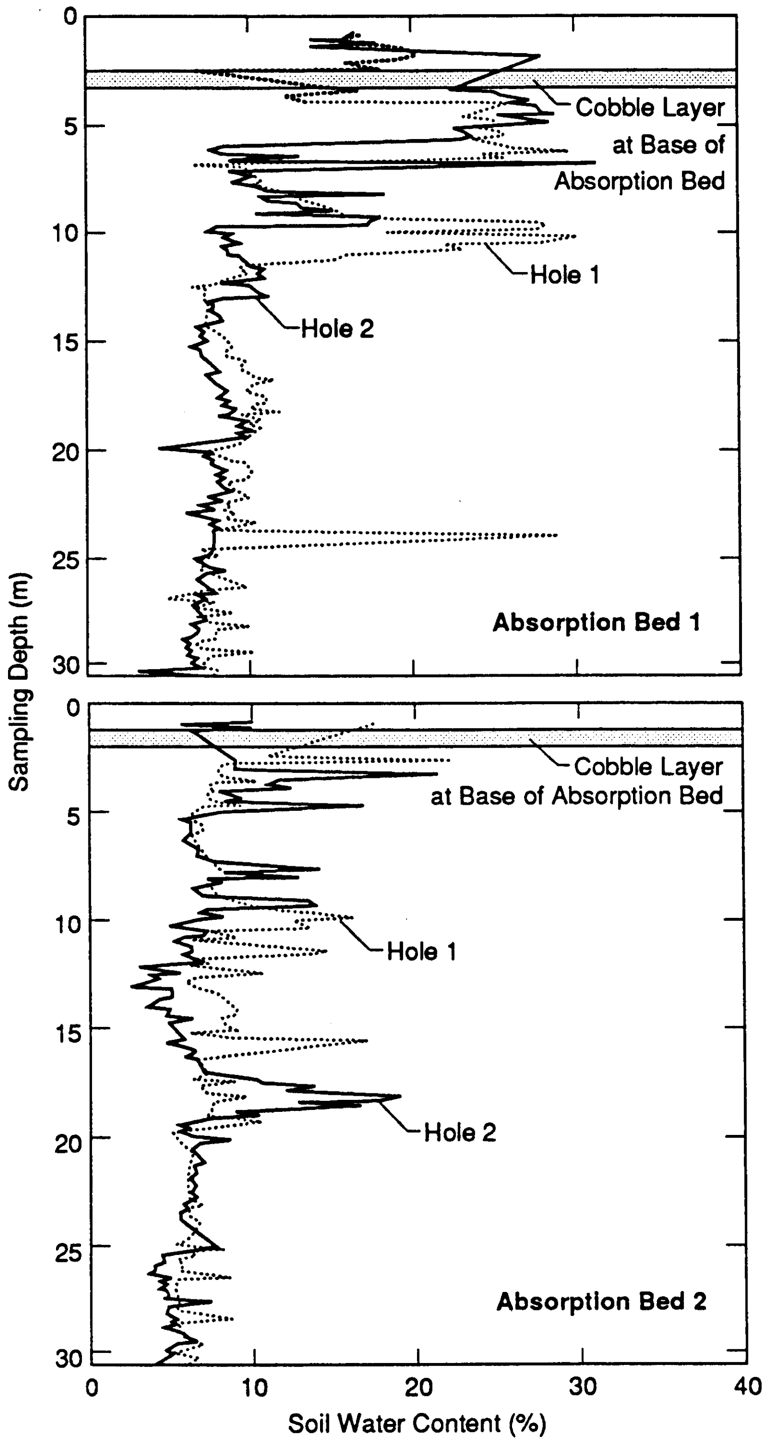


Fig. 4.1-11 Gravimetric soil water content as a function of sampling depth for MDA T absorption beds 1 and 2 in 1978 (Nyhan 1984).

Data Needs. Assess moisture content correlations with geologic features and material properties in boreholes drilled during site characterization.

4.1.9. Saturated Zone Hydrology

IWP Sec. 2.6.6, Hydrology of the Main Aquifer, describes the main aquifer beneath the Pajarito Plateau. As indicated in Fig. 4.1-5, the surface of the aquifer lies in the sediments well below the base of the Bandelier Tuff. Figure 4.1-12 shows the regional aquifer surface contours (Purtymun and Johansen 1974). The depth to the aquifer beneath TA-21 is not precisely known but is estimated to be approximately 1150 ft. While general flow of the aquifer is from recharge areas in the Jemez Mountains on the west toward the Rio Grande on the east, the exact groundwater flow direction beneath TA-21 is not known.

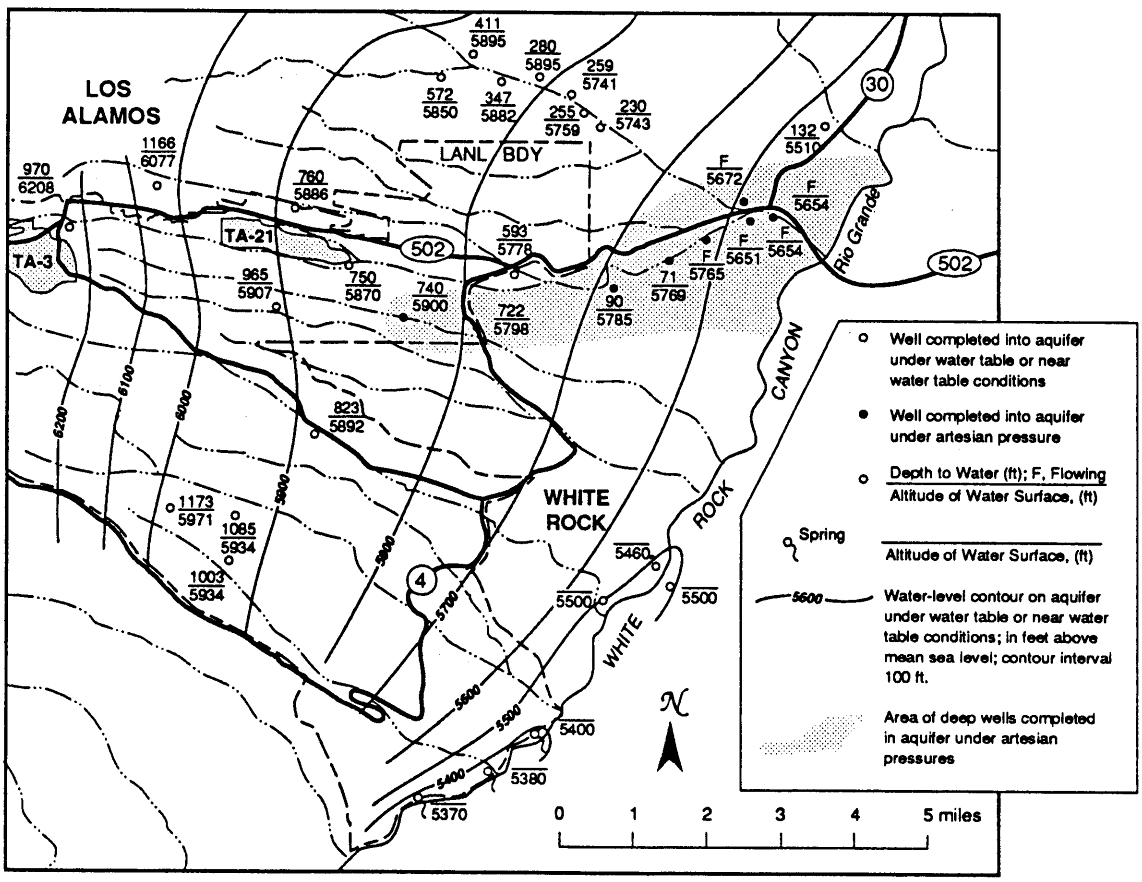


Fig. 4.1-12 Generalized contours on top of main aquifer (Purtymun and Johansen 1974).

Water quality in the main aquifer, based on samples from all wells and springs is discussed in Sec. 4.2, below. No evidence of any Laboratory-related contamination has ever been detected in the main aquifer. Sampling of the main aquifer in immediate proximity to TA-21 has not been done, and in the absence of evidence of contaminant migration through the more than 1000 ft of overlying vadose zone, there is no compelling reason to do so.

Data needs. None, unless deep contaminant migration is identified during site characterization.

4.2 Background Environmental Data

This section presents a summary of environmental data representing the natural, or background, conditions for surface and groundwater, air, soil, and radioactivity in the region surrounding the TA-21 OU. These data are presented for comparison to analysis results on samples from individual SWMUs and from the general vicinity of TA-21. These data are tied to potential migration pathways in Chapter 5 and to potential receptors in Chapter 6.

This summary is also used to identify gaps and weaknesses in the existing set of background data. Some of the identified data needs will be addressed in the RFI work plan. Others will be used as input for planning a Pajarito Plateau background study, planned in support of the ER Program Laboratory-wide.

4.2.1. Sources of Information

Three categories of information sources have been used to develop this summary of background environmental data as follows:

- the Laboratory's environmental monitoring network (described below), which includes perimeter stations and regional stations that are uninfluenced by Laboratory operations;
- special studies conducted at the Laboratory and in the region, which address environmental data in areas unaffected by Laboratory operations; and
- general environmental literature addressing concentrations of chemicals, elements, and radionuclides in natural systems.

The Laboratory's environmental surveillance program includes 406 stations sampled for various media, as summarized in Table 4.2-I (ESG 1989). Three categories of monitoring stations are defined as follows:

TABLE 4.2-I
NUMBER OF SAMPLING LOCATIONS[a]

Type of Monitoring	Regional	Perimeter	On Site
External radiation	4	12	139
Air	3	11	12
Surface and ground waters[b]	6	32	37
Soil and sediments	16	16	34
Foodstuffs	10	8	11

[a]ESG (1989).
[b]An additional 22 stations for the water supply and 33 special surface and groundwater stations related to the Fenton Hill Geothermal Program were also sampled and analyzed as part of the monitoring program.

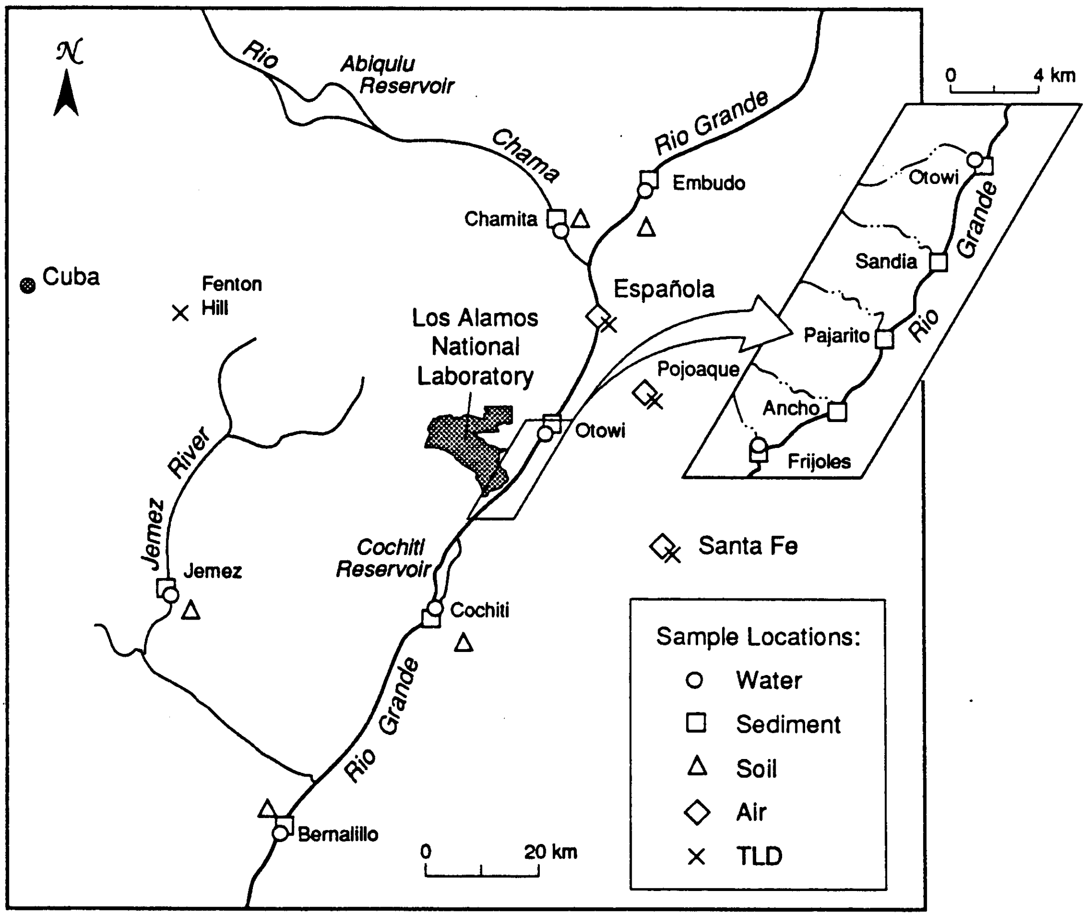


Fig. 4.2-1 Location of regional water, soil, TLD, sediment, and air sampling stations. (Purtymun et al. 1987; ESG 1989)

1. **Regional** stations determine conditions beyond the range of potential influence from Laboratory operations. The regional stations are located within the five counties surrounding Los Alamos County, at distances up to 80 km (50 mi) from the Laboratory (Fig. 4.2-1).

2. **Perimeter** stations are located closer to the Laboratory boundaries. These stations are not expected to be routinely affected by Laboratory operations, although unexpected releases could affect these stations. They are used to confirm that any releases beyond the Laboratory boundary are evaluated and remain minimal (Fig. 4.2-2).

3. **On site** stations are in proximity to Laboratory facilities and monitor the effect of releases close to the source. Data from these stations have not been used in this section. Data from on site stations close to TA-21 are used in the pathways discussions of Chapter 5.

Data collected from regional stations and selected perimeter stations have been included in the summaries in the following sections. Most of the existing environmental data were acquired using standard practices and methods of the day. These data are used in this document solely to guide assessment of available data. These data represent the best available information to describe unimpacted natural conditions for the vicinity of the Laboratory and the TA-21 OU.

The remainder of this section includes tables summarizing data on background concentrations of chemicals, elements, and radionuclides in several environmental media. In addition, background levels for ambient gamma radiation levels are given.

4.2.2. Surface Water

Data from the Laboratory's environmental surveillance program's regional and perimeter stations from 1988 sampling are summarized here as an indicator of background water quality (ESG 1989). For the purposes of this document, the perimeter stations are assumed to include the stations in White Rock Canyon. Also, surface water stations have been assumed to include the springs that are sampled in White Rock Canyon, in addition to streams and reservoirs.

Surface water is collected for analysis at six regional stations within 75 km (47 mi) of the Laboratory. These locations are at US Geological Survey Gaging Stations on the Rio Chama, Rio Grande, and Jemez River (Fig. 4.2-1). Data for 33 perimeter and White Rock Canyon stations are summarized; seven stations represent open surface waters (two reservoirs, four streams, and a sanitary effluent), and 26 are springs (Fig. 4.2-2).

Radionuclides. Tables 4.2-II and 4.2-III summarize the radiochemical quality of surface water from the regional, perimeter and White Rock Canyon stations, and springs in White Rock Can-

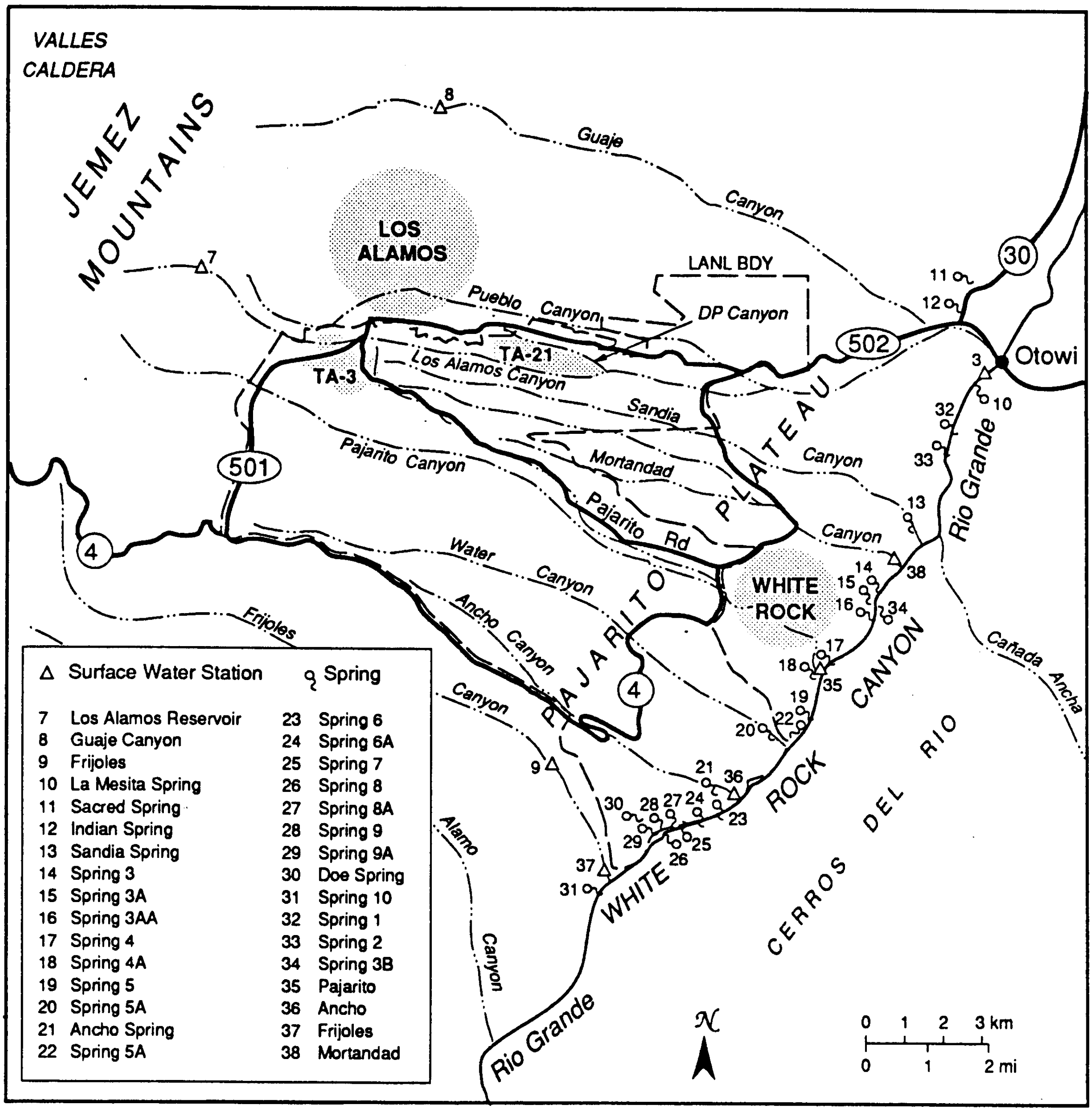


Fig. 4.2-2 Surface water and spring sampling locations on and near the Laboratory site (ESG 1989).

TABLE 4.2-II
RADIOCHEMICAL QUALITY OF SURFACE WATER FROM REGIONAL, PERIMETER, AND WHITE ROCK CANYON STATIONS[a]

Station	Tritium (pCi/mL)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu (pCi/L)	$^{239/240}Pu$ (pCi/L)
Regional Stations[b]					
Rio Chama					
Chamita	-0.4 (0.3)	86 (68)	2 (1)	0.004 (0.010)	0.000 (0.010)
Rio Grande					
Embudo	0.5 (0.3)	93 (67)	2 (1)	0.017 (0.012)	0.013 (0.010)
Otowi	-0.5 (0.3)	145 (69)	2 (1)	0.011 (0.011)	-0.004 (0.009)
Cochiti	-0.5 (0.3)	-65 (66)	3 (1)	-0.008 (0.012)	0.004 (0.007)
Bernalillo	-0.5 (0.3)	185 (67)	4 (1)	0.011 (0.013)	-0.004 (0.010)
Jemez River					
Jemez	-0.3 (0.3)	1 (59)	1 (1)	-0.009 (0.007)	0.005 (0.012)
Perimeter Stations[b]					
Los Alamos Reservoir	-1.2 (0.3)	77 (60)	1 (1)	0.000 (0.010)	-0.009 (0.010)
Guaje Reservoir	-0.8 (0.3)	6 (60)	1 (1)	0.000 (0.010)	0.007 (0.009)
Frijoles Canyon	-0.7 (0.3)	86 (60)	1 (1)	0.013 (0.016)	-0.008 (0.006)
Streams[c]					
Pajarito	-0.1 (0.3)	101 (62)	1 (1)	-0.004 (0.004)	0.004 (0.010)
Ancho	0.1 (0.3)	47 (69)	1 (1)	0.004 (0.012)	0.012 (0.014)
Frijoles	0.7 (0.3)	-43 (53)	1 (1)	0.000 (0.010)	0.000 (0.010)
Sanitary Effluent[c]					
Mortandad	0.3 (0.3)	47 (67)	1 (1)	0.005 (0.011)	0.024 (0.011)
Limits of detection	0.7	40	1	0.009	0.03

[a]ESG (1989).
[b]Samples were collected in March 1988; counting uncertainty is in parentheses.
[c]Samples were collected in October 1988; counting uncertainty is in parentheses.

TABLE 4.2-III
RADIOCHEMICAL QUALITY OF SPRING WATERS FROM WHITE ROCK CANYON[a,b]

Station	Tritium (pCi/mL)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239/240}Pu$ (pCi/L)
Group I					
Sandia Spring	0.2 (0.3)	21 (68)	1 (1)	0.016 (0.018)	0.016 (0.012)
Spring 3	0.2 (0.3)	-111 (66)	1 (1)	0.000 (0.010)	0.000 (0.010)
Spring 3A	0.0 (0.3)	-105 (70)	1 (1)	0.013 (0.016)	0.018 (0.012)
Spring 3AA	-0.1 (0.3)	-82 (67)	1 (1)	0.005 (0.005)	0.000 (0.010)
Spring 4	0.0 (0.3)	0 (60)	2 (1)	0.000 (0.010)	0.000 (0.010)
Spring 4A	0.4 (0.3)	-59 (61)	1 (1)	0.000 (0.010)	0.005 (0.005)
Spring 5	0.1 (0.3)	-5 (62)	1 (1)	0.013 (0.010)	0.000 (0.010)
Spring 5AA	0.8 (0.3)	0 (62)	1 (1)	0.000 (0.010)	0.000 (0.010)
Ancho Spring	0.1 (0.3)	20 (60)	1 (1)	0.026 (0.014)	0.009 (0.011)
Group II					
Spring 5A	0.0 (0.3)	3 (61)	1 (1)	0.000 (0.010)	0.009 (0.007)
Spring 5B	0.2 (0.3)	101 (79)	1 (1)	0.004 (0.008)	0.032 (0.015)
Spring 6	0.2 (0.3)	-82 (55)	1 (1)	0.000 (0.010)	0.005 (0.005)
Spring 6A	0.3 (0.3)	50 (67)	1 (1)	0.004 (0.004)	0.000 (0.010)
Spring 7	0.4 (0.3)	-35 (59)	1 (1)	0.008 (0.006)	-0.004 (0.007)
Spring 8A	0.2 (0.3)	71 (67)	1 (1)	0.010 (0.007)	0.000 (0.010)
Spring 9	-0.4 (0.3)	-15 (60)	1 (1)	0.000 (0.010)	0.000 (0.010)
Spring 9A	0.0 (0.3)	100 (70)	1 (1)	0.015 (0.013)	0.000 (0.010)
Doe Spring	0.2 (0.3)	—	1 (1)	-0.004 (0.004)	0.004 (0.008)
Group III					
Spring 1	0.1 (0.3)	65 (69)	1 (1)	0.004 (0.008)	0.005 (0.013)
Spring 2	0.4 (0.3)	-16 (52)	3 (1)	0.019 (0.019)	0.005 (0.008)
Group IV					
Spring 3B	0.2 (0.3)	21 (67)	13 (1)	0.012 (0.013)	-0.004 (0.011)

[a]Samples were collected in October 1988.
[b]ESG (1989).

yon. All values were low; none indicate any impact from Laboratory operations, including those below the Laboratory in White Rock Canyon and along the Rio Grande.

Data needs. None. The available data are suitable for background comparisons.

Chemical and Trace Elements. Surface water samples from regional stations for chemical analyses were collected in March 1988. Tables 4.2-IV and 4.2-V summarize the chemical quality of surface water from the regional, perimeter, and White Rock Canyon stations and from springs in White Rock Canyon.

Tables 4.2-VI and 4.2-VII summarize trace element concentrations in surface water from White Rock Canyon stations and from springs in White Rock Canyon. A number of trace elements were not detected in any of the waters tested. These are summarized in Table 4.2-VIII.

Data needs. None. The available data are sufficient for comparisons.

4.2.3. Ground Water

No regional groundwater sampling stations are included in the environmental surveillance program. Perimeter groundwater samples are collected from three springs (La Mesita Springs, Indian Springs, and Sacred Springs) and the main aquifer beneath the Pajarito Plateau to provide background water quality data (ESG 1989).

La Mesita Spring is east of the Rio Grande, whereas Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. These springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and from small seep areas. Total discharge at each spring is probably less than 1 L/s (0.3 gal/s).

The main aquifer beneath the Laboratory is sampled in both the supply and distribution systems. The water quality depends on well depth, lithology of the aquifer adjacent to the well, and yield from beds within the aquifer.

Radionuclides. Radiochemical quality of groundwater from the perimeter stations is given in Table 4.2-IX. Maximum concentrations for radiological constituents in the main aquifer are given in Table 4.2-X. All radionuclides are below EPA's maximum concentration levels (MCL) (values are provided in the table).

Data needs. None. The available data are sufficient for comparisons.

TABLE 4.2-IV
CHEMICAL QUALITY OF SURFACE WATER FROM REGIONAL, PERIMETER, AND WHITE ROCK CANYON STATIONS (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	ph	Conductivity (mS/m)
Regional Stations[b]																
Rio Chama																
Chamita	13	45	10	2.0	24	1	89	<0.2	92	6	0.3	<0.2	268	160	8.3	39
Rio Grande																
Embudo	24	27	5.7	2.8	20	0	77	<0.2	37	6	0.5	0.3	189	95	8.2	26
Otowi	24	27	5.7	2.8	20	0	78	<0.2	36	6	0.5	0.2	183	96	8.1	27
Cochiti	19	37	7.8	2.9	22	1	97	<0.2	51	8	0.5	0.2	228	127	8.3	34
Bernalillo	19	37	7.8	3.1	24	0	100	<0.2	54	9	0.5	0.3	220	133	8.2	35
Jemez River																
Jemez	14	17	1.7	4.0	9	0	48	<0.2	4	9	0.3	0.2	98	52	7.9	15
Perimeter Stations[b]																
Los Alamos Reservoir	30	6	1.9	1.6	5	0	23	<0.2	5	3	0.1	0.3	68	21	7.4	7.2
Guaje Canyon	50	6	2.5	2.5	6	0	30	<0.2	6	2	0.2	<0.2	99	25	7.6	8.5
Frijoles Canyon	29	6	1.9	1.6	5	0	20	<0.2	5	3	0.1	0.8	75	22	7.1	7.2
Streams[c]																
Pajarito	67	20	4.6	3.5	13	2.1	85	<0.2	7	5	0.5	0.6	173	66	8.4	19
Ancho	69	13	3.5	1.3	10	6.5	67	<0.2	2	2	0.4	<0.2	133	45	8.7	14
Frijoles	57	10	3.5	2.4	10	0	55	<0.2	3	3	<0.2	<0.2	110	38	8.2	12
Sanitary Effluent[c]																
Mortandad	83	26	7.9	1.3	76	0	125	9.5	32	4	14	7.8	389	93	7.8	59

[a]ESG (1989).
[b]Samples were collected in March 1988.
[c]Samples were collected in October 1988.

TABLE 4 2-V
CHEMICAL QUALITY OF SPRING WATERS FROM WHITE ROCK CANYON[a,b]

Station	SiO_2	Ca	Mg	K	Na	CO_2	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hard-ness	pH	Conduc-tivity (mS/m)
Group I																
Sandia Spring	44	33	3.2	2.6	15	0	116	<0.2	6	4	0.7	<0.2	177	100	8.2	27
Spring 3	49	20	1.6	2.7	15	0	82	<0.2	5	3	0.5	0.8	132	57	8.2	18
Spring 3A	50	20	1.8	3.6	14	0	80	<0.2	5	4	0.5	0.6	137	63	8.1	18
Spring 3AA	40	24	0.5	4.4	17	0	101	<0.2	6	5	0.6	<0.2	151	60	8.0	23
Spring 4	51	24	4.6	2.4	13	0	90	<0.2	11	7	0.6	1.4	159	80	8.2	22
Spring 4A	57	20	5.0	1.9	11	0	80	<0.2	8	6	0.6	1.3	165	71	8.2	19
Spring 5	64	19	5.0	2.2	12	0.7	82	<0.2	6	5	0.6	0.4	162	65	8.3	18
Spring 5AA	62	31	6.5	2.5	14	0	130	<0.2	7	7	0.6	<0.2	198	105	8.2	28
Ancho Spring	70	13	3.2	2.1	10	0	61	<0.2	3	3	0.5	0.3	140	42	8.2	13
Group II																
Spring 5A	52	24	2.9	2.6	21	2.0	106	<0.2	11	5	0.5	0.4	169	78	8.4	25
Spring 5B	42	23	5.7	2.1	14	0	75	<0.2	14	8	0.5	5.7	180	79	8.2	25
Spring 6	66	12	3.8	1.8	10	0	63	<0.2	3	3	0.4	0.5	140	43	8.2	13
Spring 6A	72	9	2.7	1.9	9	0	53	<0.2	2	2	0.3	0.4	127	35	8.2	12
Spring 7	64	20	4.5	2.3	17	1.7	96	<0.2	11	4	0.4	1.1	193	68	8.3	23
Spring 8A	61	11	3.2	2.0	11	0	62	<0.2	3	2	0.5	<0.2	149	42	8.2	13
Spring 9	71	10	3.2	1.4	10	0	62	<0.2	3	2	0.5	<0.2	132	41	8.2	13
Spring 9A	66	10	3.2	1.4	10	0	59	<0.2	2	2	0.6	<0.2	134	41	8.0	13
Doe Spring	73	12	3.7	1.4	12	0	66	<0.2	2	3	0.6	<0.2	139	46	8.1	14
Group III																
Spring 1	32	16	1.1	1.6	28	3.7	102	<0.2	6	3	0.7	0.9	123	49	8.4	22
Spring 2	39	24	1.3	1.6	60	2.1	183	<0.2	7	4	1.2	<0.2	230	75	8.4	37
Group IV																
Spring 3B	40	32	4.2	3.0	139	6.6	359	<0.2	25	4	1.1	<0.2	469	96	8.4	72

[a]Samples were collected in October 1988.
[b]ESG (1989).

TABLE 4.2-VI TRACE ELEMENTS IN SURFACE WATERS FROM WHITE ROCK CANYON (μg/L)[a,b]

Station	As	B	Ba	Br	Co	Cr	Cu	Fe	I	Li	Mn	Mo	Rb	Sc	Sr	U	V
Streams[a]																	
Pajarito	<10	<10	<1	62	<1	<10	<1	<100	10	85	10	<1	<1	30	230	<1	<1
Ancho	<10	<10	<1	<10	<1	<10	<1	<100	<10	66	11	<1	<1	32	86	<1	<1
Frijoles	<10	<10	<1	<10	<1	<10	12	<100	<10	40	28	<1	8	<1	92	<1	<1
Sanitary Effluent[a]																	
Mortandand	<10	<10	<1	140	<1	<10	56	<100	<10	112	66	<1	26	88	218	<1	34

[a]Samples were collected in October 1988.
[b]ESG (1988).

TABLE 4.2-VII TRACE ELEMENTS IN SPRING WATERS FROM WHITE ROCK CANYON (μg/L)[a,b]

Station	As	B	Ba	Br	Co	Cr	Cu	Fe	I	Li	Mn	Mo	Rb	Sc	Sr	U	V
Group I																	
Sandia Springs	<10	<10	180	90	<1	<10	<1	<100	—	100	820	<1	<1	55	800	<1	<1
Spring 3	<10	<10	<1	90	<1	<10	<1	<100	<10	75	<1	<1	<1	60	480	<1	34
Spring 3A	<10	60	<1	90	<1	<10	<1	<100	<10	90	<1	<1	<1	120	500	<1	60
Spring 3AA	<10	50	<1	<10	<1	<10	<1	1200	<10	80	260	<1	<1	70	400	<1	50
Spring 4	<10	<10	150	180	10	<10	<1	2300	<10	90	1100	<1	<1	30	380	2	60
Spring 4A	<10	<10	<1	130	<1	<10	<1	<100	<10	80	<1	<1	<1	130	210	<1	20
Spring 5	<10	<10	<1	80	<1	<10	<1	<100	<10	80	40	<1	<1	140	220	<1	40
Spring 5AA	<10	50	130	130	<1	<10	<1	300	10	<10	530	<1	<1	130	400	<1	<1
Ancho Spring	<10	<10	<1	25	<1	<10	<1	<100	<10	70	170	<1	<1	140	130	<1	22
Group II																	
Spring 5A	<10	<10	<1	<10	<1	20	<1	<100	10	90	140	<1	<1	60	440	1	<1
Spring 5B	<10	<10	<1	130	<1	<10	<1	<100	<10	70	70	<1	<1	30	290	<1	20
Spring 6	<10	<10	<1	50	<1	<10	<1	<100	<10	70	<1	<1	<1	100	120	<1	<1
Spring 6A	<10	<10	<1	30	<1	<10	<1	<100	<10	60	15	<1	<1	100	100	<1	<1
Spring 7	<10	<10	<1	<10	<1	<10	<1	<100	10	70	15	<1	10	80	240	1	50
Spring 8A	<10	10	<1	10	<1	<10	<1	<100	<10	70	10	<1	<1	80	110	<1	<1
Spring 9	<10	<10	<1	20	<1	<10	<1	<100	<10	17	14	<1	<1	50	80	<1	<1
Spring 9A	<10	<10	<1	40	<1	<10	<1	<100	<10	20	12	<1	<1	40	80	<1	<1
Doe Spring	<10	<10	<1	<10	<1	<10	<1	<100	<10	72	110	<1	<1	11	114	<1	<1
Group III																	
Spring 1	<10	<10	<1	40	<1	<10	10	<100	14	100	24	<1	<1	<1	400	1	24
Spring 2	60	100	15	70	10	10	<1	<100	16	150	950	<1	<1	<1	600	2	150
Group IV																	
Spring 3B	24	170	<1	30	<1	<10	20	<100	32	300	240	8	<1	<1	930	13	74

[a]Samples were collected in October 1988.
[b]ESG (1989).

TABLE 4.2-VIII
TRACE ELEMENTS NOT DETECTED AT ANY STATION[a,b]

Ag	<1	Os	<1
Au	<1	Pb	<1
Be	<10	Pd	<1
Bi	<1	Pr	<1
Cd	<1	Pt	<1
Ce	<1	Re	<1
Cs	<1	Rh	<1
Dy	<1	Ru	<1
Er	<1	Sb	<1
Eu	<1	Se	<10
Ga	<1	Sm	<1
Gd	<1	Sn	<1
Ge	<1	Ta	<1
Hf	<1	Tb	<1
Hg	<1	Te	<1
Ho	<1	Th	<1
In	<1	Ti	<100
Ir	<1	Tl	<1
La	<1	Tm	<1
Lu	<1	W	<1
Na	<10,000	Y	<1
Nb	<1	Yb	<1
Nd	<1	Zn	<1
Ni	<1	Zr	<1

[a]Samples were collected in October 1988.
[b]ESG (1989).

TABLE 4.2-IX
RADIOCHEMICAL QUALITY OF GROUNDWATER FROM PERIMETER STATIONS[a,b]

Station	Tritium (pCi/mL)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239/240}Pu$ (pCi/L)
La Mesita Spring	-0.8 (0.3)	19 (59)	1 (1)	0.019 (0.013)	0.016 (0.010)
Sacred Spring	-10 (0.3)	71 (67)	2 (1)	0.004 (0.009)	0.019 (0.010)
Indian Spring	-0.7 (0.3)	145 (63)	4 (1)	0.004 (0.011)	-0.009 (0.008)
Limits of detection	0.7	40	1	0.009	0.03

[a]Samples were collected in March 1988; counting uncertainty is in parentheses.
[b]ESG (1988) (modified from Table G-17).

TABLE 4.2-X

MAXIMUM CONCENTRATIONS OF RADIOACTIVITY IN WATER SUPPLY WELLS AND DISTRIBUTION SYSTEM[a]

	Number of Stations	Tritium (pCi/mL)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239/240}Pu$ (pCi/L)
Supply wells (Los Alamos)	10	-0.6 (<1)[d]	56 (28)	2 (<1)	0.009 (<1)	0.024 (<1)
Distribution (Los Alamos)	6	-0.8 (<1)	135 (68)	1 (<1)	0.032 <1	0.016 (<1)
Analytical limits of detection		0.7	40	1.0	0.009	0.03
Maximum concentration level (MCL)[b]		20	200	1800[c]	15	15

[a]Copied from Table 16, ESG 1988.
[b]EPA (1976).
[c]ICRP (1977).
[d]Percentage of EPA's MCL is in parentheses; this usage is for comparison only.

Chemical Quality. Chemical quality data for groundwater from the perimeter stations are given in Table 4.2-XI. Maximum concentrations for chemical constituents in the main aquifer are given in Table 4.2-XII. All constituents are below EPA's drinking water standards (values are provided in the table).

Data needs. None. The available data are sufficient for comparisons.

4.2.4. Soil and Sediment

This section describes regional background concentrations of organic compounds, radionuclides, and stable elements in soil and in river and stream sediments.

Organic Chemicals. No data are available for organic chemicals that may occur naturally in the soil or sediments on the Pajarito Plateau. For this document it is assumed that any natural compounds are below the detection limit of the analytical techniques specified for the analysis of the samples (see Chapter 11 and Appendix A).

Data needs. For the purposes of the work described in this plan, it is not considered necessary at this time to define the presence of background organic compounds in soils or sediments. Many of the investigations are biased to worst-case locations to identify contaminants if they are present. If contaminants not believed to be present are identified at above-background levels, background levels may need to be re-evaluated to determine if levels present are naturally occurring or contaminated.

Radionuclides. Table 4.2-XIII and 4.2-XIV summarize the mean and "upper limit" background radionuclide concentrations in soil and sediments to be used for data comparisons in this document. In this discussion, the term "background" will be used to mean both the naturally occurring radionuclides (its normal usage), and the man-made radionuclides that have been deposited worldwide as fallout from nuclear weapons testing (which are now an integral part of the world's environments). The term "upper limit" of background was defined for Laboratory use as the mean plus two standard deviations (Purtymun et al. 1987).

The values from Purtymun et al. (1987) are for soil and sediment samples collected over a 13-year period at the regional environmental monitoring stations (Fig. 4.2-1). The values from Myrick et al. (1981) are for soil samples collected at 13 locations in the north western corner of New Mexico (Fig. 4.2-3).

TABLE 4.2-XI
RADIOCHEMICAL QUALITY OF GROUNDWATERS FROM PERIMETER STATIONS (mg/L)[a,b]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
La Mesita Spring	48	7	2.4	2.5	6	0	29	<0.2	6	2	0 2	<0.2	105	28	7.5	8.4
Sacred Spring	29	20	0.3	2.6	20	0	83	<0.2	7	3	0 6	<0.2	155	56	7.5	19
Indian Spring	42	12	2.1	2.2	20	0	85	<0.2	5	12	0.5	0.7	172	73	8.1	24
Maximum	48	20	2.4	2.6	20	0	85	<0.2	7	12	0.6	0.7	172	73	8.1	24

[a]Samples were collected in March 1988.
[b]Modified from ESG (1988), Table G-19.

TABLE 4.2-XII
MAXIMUM CHEMICAL CONCENTRATION IN WATER FROM SUPPLY WELLS AND DISTRIBUTION SYSTEM[a]

	Standard[b]	Supply Wells	Percentage of Standard	Distribution System	Percentage of Standard
Number of Stations		10		7	
Chemical Constituents (mg/L)					
Primary					
Ag	0.05	<0.001	<2	0.002	4
As	0.05	0.034	68	0.011	22
Ba	1.0	0.086	9	0.105	11
Cd	0.01	<0.001	<10	<0.001	<10
Cr	0.05	0.006	12	0.006	12
F	4.0	0.8	20	0.6	15
Hg	0.002	<0.0002	<10	<0.0002	<10
NO_3 (N)	10	0.6	6	0.5	5
Pb	0.05	0.007	14	0.002	4
Se	0.01	0.001	10	0.001	10
Secondary					
Cl	250	7	3	30	12
Cu	1.0	0.104	10	0.033	3
Fe	0.3	0.042	14	0.350	117
Mn	0.05	0.002	4	0.001	2
SO_4	250	6	2	9	4
Zn	5.0	0.081	2	0.230	5
TDS	500	230	46	279	56

[a]Copied from Table 17, ESG (1988).
[b]USEPA primary and secondary drinking water standards are used for comparison only.

TABLE 4.2-XIII
SUMMARY OF BACKGROUND LEVELS OF RADIONUCLIDES IN SOIL

Source	Radionuclides	Units	Mean $\bar{x}$	Standard Deviation (s)	Upper Limit Background ($\bar{x}$ + 2s)	Number of Analyses	Detection Limit
	Naturally Occurring						
a	^{226}Ra	pCi/g	1.5	0.5	2.5	13	0.3
a	^{232}Th	pCi/g	1.0	0.4	1.8	13	0.3
a	^{238}U	pCi/g	1.1	0.5	1.7	13	0.01
b	Total Uranium	µg/g	2.4	0.5	3.4	34	1.0
b	Tritium	pCi/L	2.6	2.3	7.2	43	0.3
	Fallout						
b	^{90}Sr	pCi/g	0.34	0.27	0.88	29	0.05
b	^{137}Cs	pCi/g	0.43	0.33	1.09	64	0.1
b	^{238}Pu	pCi/g	0.001	0.002	0.005	76	0.002
b	$^{239/240}Pu$	pCi/g	0.007	0.009	0.025	76	0.002

[a] Myrick et al. (1981).
[b] Purtymun et al. (1987).

TABLE 4.2-XIV
SUMMARY OF BACKGROUND LEVELS OF RADIONUCLIDES IN SEDIMENT[a]

Radionuclides	Units	Mean $\bar{x}$	Standard Deviation (s)	Upper Limit Background ($\bar{x}$ + 2s)	Number of Analyses	Detection Limit
Naturally Occurring						
Total Uranium	μg/g	2.6	0.9	4.4	59	1.0
Fallout						
^{90}Sr	pCi/g	0.23	0.32	0.87	36	0.05
^{137}Cs	pCi/g	0.18	0.13	0.44	103	0.1
^{238}Pu	pCi/g	0.	0.003	0.006	113	0.002
$^{239/240}Pu$	pCi/g	0.005	0.009	0.023	113	0.002

[a]Myrick et al. (1981).

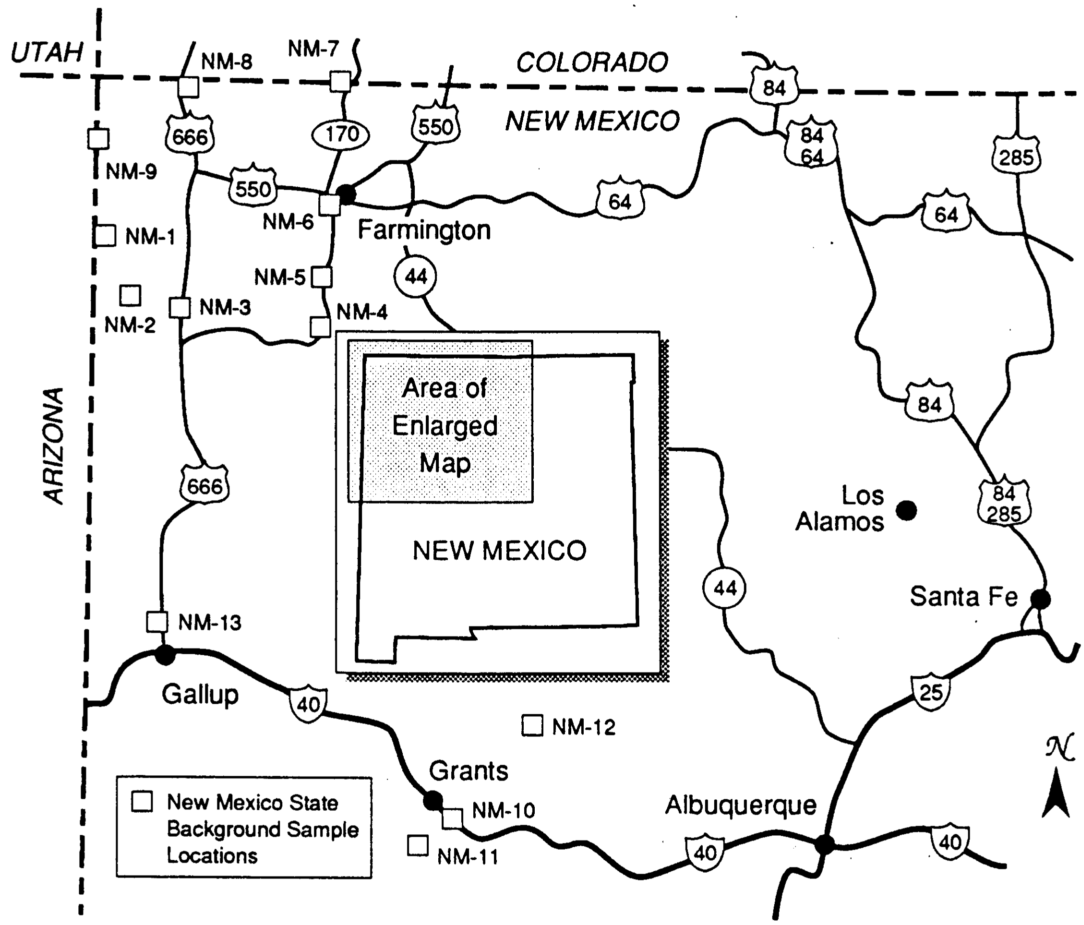


Fig. 4.2-3 Location of background samples in New Mexico (Myrick et al. 1981).

In evaluating the soils data summarized in Table 4.2.XIII, the following observations were made:

Sample increment. All sample analyses reported by Purtymun et al. (1987) were 5-cm (2-in.) increments taken from the earth surface. Soil samples to be collected for this RFI work plan will be either 15-cm (6-in.) or 2.5-cm (1-in.) increments. For uniform soils within a soil profile these differences would not be important. For surface soil samples, however, and particularly for the fallout deposited radionuclides, sample thickness may be important because the concentrations of the radionuclides may change rapidly with depth in the first few inches of the soil profile. In assessing data comparability, these background data may overstate the concentration of fallout radionuclides in background soil when compared to results for a 15-cm sample and understate the concentration when compared to a 2.5-cm sample.

Sample depth. The background levels reported by Purtymun et al. (1987) were based on samples from the soil surface. Many of the investigations for this RFI work plan will target deeper soils and the tuff bedrock. Because the surficial soils are those most impacted by the deposition of fallout radionuclides, the background data may overstate the concentration of fallout radionuclides when compared to subsurface soils and rock. Surface soil background levels may not be representative of those at greater depths.

Sample locations. Soils are generally derived from the underlying rock and often share a common mineralogy and background levels of the naturally occurring radionuclides. The background samples collected by Purtymun et al. (1987) were not taken on the Pajarito Plateau but rather from the Rio Grande or Chama River valleys to the north and south or the Jemez Mountains to the west. Similarly, the samples collected by Myrick et al. (1981) were from the northwestern corner of New Mexico, quite distant from the Laboratory. The mineralogy of these areas is different from that of the Pajarito Plateau. The background samples may not be representative of materials found on the Pajarito Plateau.

The following issues were identified during the assessment of radionuclide data from past investigations at the MDAs (see data tables in Sec. 16.2 or 16.3, for example). Three common trends were noted as follows:

1. Concentrations of ^{137}Cs (a fallout radionuclide), in deeper soils and tuff from areas where contamination would be unlikely, tended to be generally below the mean background value for ^{137}Cs and seldom approached the upper limit of background. For detecting trace subsurface migration, use of the surface soil background value may be misleading.

2. Concentrations of ^{238}Pu and $^{239/240}Pu$ (fallout radionuclides), in deeper soils and tuff from areas where contamination would be unlikely, were far below the levels given in Table 4.2-XIII. These appeared to be at the detection limit of the method and may represent soils that are relatively unimpacted by worldwide fallout. For detecting trace subsurface migration, use of the surface soil background values may be misleading.

3. Concentrations of total uranium (naturally occurring radionuclides) in deeper soils and tuff from areas where contamination would be unlikely were consistently above the upper limit of background. Given the pattern described for ^{137}Cs, ^{238}Pu, and $^{239/240}Pu$ it is unlikely this consistent "elevated" uranium concentration site-wide at TA-21 represents a contamination problem. Rather it is likely that the background level of uranium in tuff and tuff-derived soils is naturally greater than in the soils used to develop the background data. In the data assessments given for each SWMU in Chapters 12–19, the upper limit background value in Table 4.2-XIII was used, resulting in the conclusion that there may be widespread uranium contamination. This assessment may be in error.

In evaluating the sediment data of Table 4.2-XIV, the following observations were made:

Sample locations. These samples were collected in the Rio Grande, Chama River, and Jemez River channels. The mineralogy of these sediments may not be representative of those on the Pajarito Plateau.

Drainage type. The drainages sampled were perennial streams. The drainages in immediate proximity to TA-21 (i.e., the DP Canyon and Los Alamos Canyon drainages) are ephemeral, running primarily during heavy snow melt and after thunderstorms. This may affect the nature of the sediments, reducing the comparability of the background data to sediments on the Pajarito Plateau.

Similarity to soils. The data for sediments are very similar to those for soils (with the exception of ^{137}Cs). This may indicate that a distinction between soil and sediment samples is unnecessary. This may be particularly true for ephemeral drainages where the sediments are eroded soil materials that are not continually washed by flowing water.

Data needs. A need for better soil and sediment background radionuclide data is evident, particularly for deeper soils and tuff. Investigations are included in this plan to provide such data. Until such data are available, comparisons will be based on the information given in Tables 4.2-XIII and XIV.

Stable Elements. Table 4.2-XV gives the mean and range of concentrations of stable elements in soils that will be used for comparisons in this document. A portion of the data was obtained from samples collected on Sigma Mesa (Fig. 4.2-4) at the Laboratory where the soils were assumed to be representative of background conditions (Ferenbaugh et al. 1990). In addition, values for soils from the western United States (Shacklette and Boerngen 1984) are provided to supplement the suite of values for stable elements.

Data needs. For the purposes of the work described in this plan, it is not considered necessary at this time to define precisely the background levels of all stable elements in soils or sediments. Many of the investigations are biased to worst-case locations to identify contaminants if they are present. If contaminants not believed to be present are identified at above-background levels, background levels may be re-evaluated to determine if levels present are naturally occurring or contaminant caused.

4.2.5. Air

This section describes available data for radionuclides in air in the region surrounding the Laboratory. Three regional air monitoring stations are located 28 to 44 km (18 to 28 mi) from the Laboratory at Espanola, Pojoaque, and Santa Fe (Fig. 4.2-1). Eleven perimeter air monitoring stations are located within 4 km (2.5 mi) of the Laboratory boundary (Fig. 4.2-5) (ESG 1989).

Radionuclides. For use as a measure of background radionuclide levels in air, a summary of the perimeter and regional air sample analysis results for the period 1984 through 1988 is given in Table 4.2-XVI (ESG 1985–1989). Also included in the table are comparable values for a station in Santa Fe from an EPA study (ESG 1989).

TABLE 4.2-XV
STABLE ELEMENT CONCENTRATIONS IN SOIL

Element	No. of Samples	Sigma Mesa[a](μg/g) Mean $\bar{x}$	Std. Dev. s	Upper Limit of Background $\bar{x} \pm s$	Western United States[b](μg/g) Arithmetic Mean (Range)	Geo Mean ± Geo. Std. Dev.
Aluminum	40	58000	3500	65,000	58,000 (5000->100,000)	58,000 ± 2.00
Antimony	---	---	---	---	0.62 (<1-2.6)	0.47 ± 2.15
Arsenic	40	3.9	1.6	7.1	7.0 (<0.1-97)	5.5 ± 1.98
Boron	38	16	7.2	30.4	29 (<20-300)	23 ± 1.99
Barium	40	410	220	850	670 (70-5000)	580 ± 1.72
Beryllium	37	1.9	0.5	2.9	0.97 (<1 -15)	0.68 ± 2.30
Bromine	38	1.9	1.2	4.3	0.86 (<0.5-11)	0.52 ± 2.74
Cadmium	36	0.17	0.10	0.37	---	---
Calcium	----	---	---	---	33,000 (600-320,000)	18,000 ± 3.05
Chlorine	40	---	---	<100	---	---
Chromium	40	27	24	75	56 (3-2000)	41 ± 2.19
Cobalt	---	---	---	---	9.0 (3-50)	7.1 ± 1.97
Copper	40	10	4.5	19	27 (2-300)	21 ± 2.07
Fluorine	40	240	74	388	440 (10-1900)	280 ± 2.52
Iron	40	17000	4800	26,600	26,000 (1000-100,000)	21,000 ± 1.95
Lead	40	24	15	54	20 (10-700)	17 ± 1.80
Lithium	40	24	4.6	33.2	25 (5-130)	22 ± 1.58
Magnesium	40	2300	1200	4,700	10,000 (300->100,000)	7,400 ± 2.21
Manganese	40	510	130	770	480 (30-5000)	380 ± 1.98
Mercury	39	0.018	0.006	0.03	0.065 (<0.01-4.6)	0.046 ± 2.33
Molybdenum	---	---	---	---	1.1 (<3-7)	0.85 ± 2.17
Nickel	40	8.9	4.8	18.5	19 (<5-700)	15 ± 2.10
Phosphorous	---	---	---	---	460 (40-4500)	320 ± 2.33
Potassium	---	---	---	---	18,000 (0.19-6.3)	---
Rubidium	40	120	15	150	74 (20-210)	69 ± 1.50
Selenium	---	---	---	---	0.34 (<0.1-4.3)	0.23 ± 2.43
Silver	---	---	---	---	---	---
Sodium	---	---	---	---	12,000 (500-100,000)	9,700 ± 1.95
Strontium	---	---	---	---	270 (10-3000)	200 ± 2.16
Thallium	---	---	---	---	---	---
Thorium	---	---	---	---	9.8 (2.4-31)	9.1 ± 1.49
Titanium	40	2600	1500	5,600	2,600 (500-20,000)	2,200 ± 1.78
Uranium	---	---	---	---	2.7 (0.68-79)	2.5 ± 1.45
Vanadium	---	---	---	---	88 (7-500)	70 ± 1.95
Zinc	40	54	12	78	65 (10-2100)	55 ± 1.79

[a]Ferenbaugh et al. (1990).
[b]Shacklette and Boerngen (1984).

TABLE 4.2-XVI
RADIONUCLIDE CONCENTRATIONS IN AIR AND AMBIENT GAMMA RADIATION LEVELS

Radionuclide	Units	EPA[a] 1986-1988	Laboratory 1984–1986 Regional	Perimeter
Gamma Radiation	mrem/yr	---	100 ± 20	114 ± 15
^{3}H	10^{-6}pCi/L	---	4.7 ± 3.3	10.5 ± 8.4
$^{239/240}Pu$	10^{-12}pCi/L	0.6 ± 0.3	0.8 ± 0.7	1.1 ± 1.2
^{241}Am	10^{-12}pCi/L	---	2.5 ± 0.7	3.2 ± 1.5
Total Uranium	pg/m^3	73 ± 35	76 ± 47	34 ± 20

[a]EPA data, January 1986—March 1988, from Santa Fe, NM, as reported in ESG (1988).

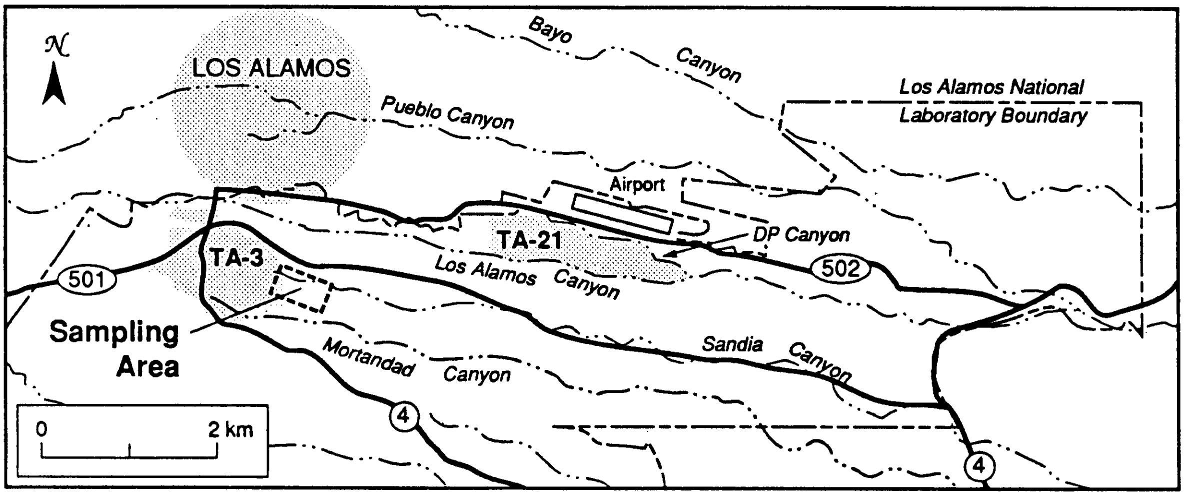


Fig. 4.2-4 Location of stable element soil sampling area (Ferenbaugh et al. 1990).

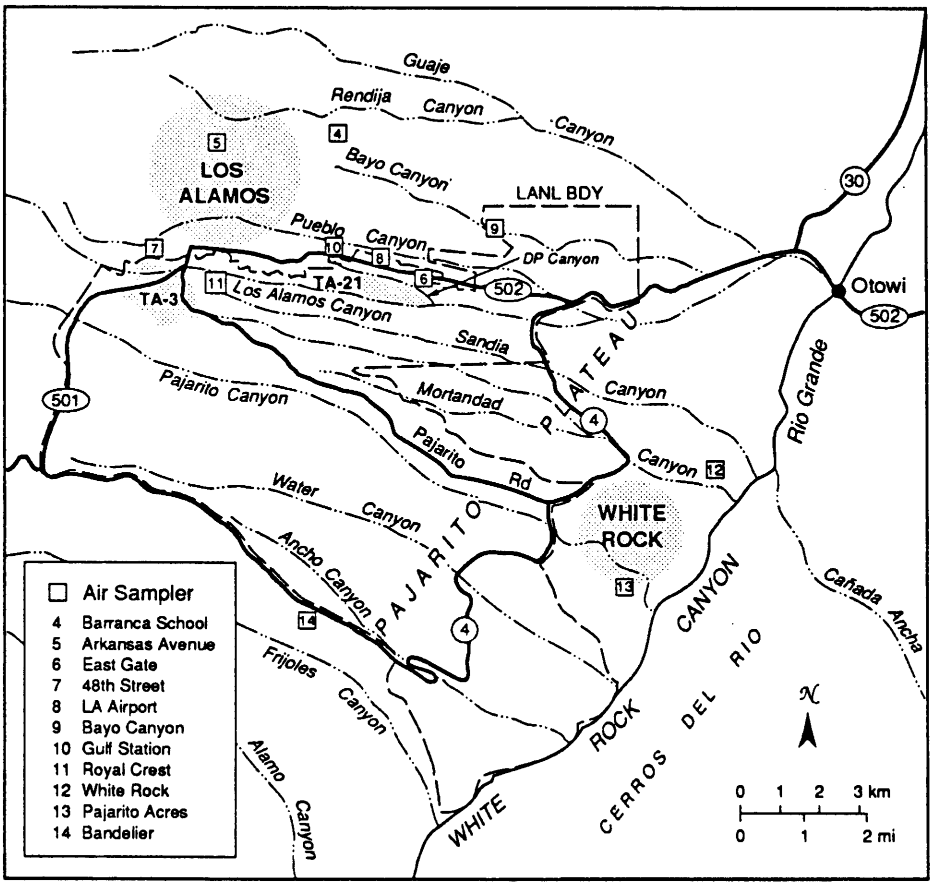


Fig. 4.2-5 Perimeter air sampler locations (ESG 1989).

Data needs. Based on knowledge of airborne contaminant levels near TA-21, as discussed in Chapter 5, the existing data are sufficient for background comparisons.

Other airborne contaminants. Because the Los Alamos area is remote from large metropolitan areas and major sources of air pollution, air monitoring for nonradioactive contaminants has not been conducted.

Data needs. No monitoring of air to determine background concentrations of other elements or chemicals is needed at this time.

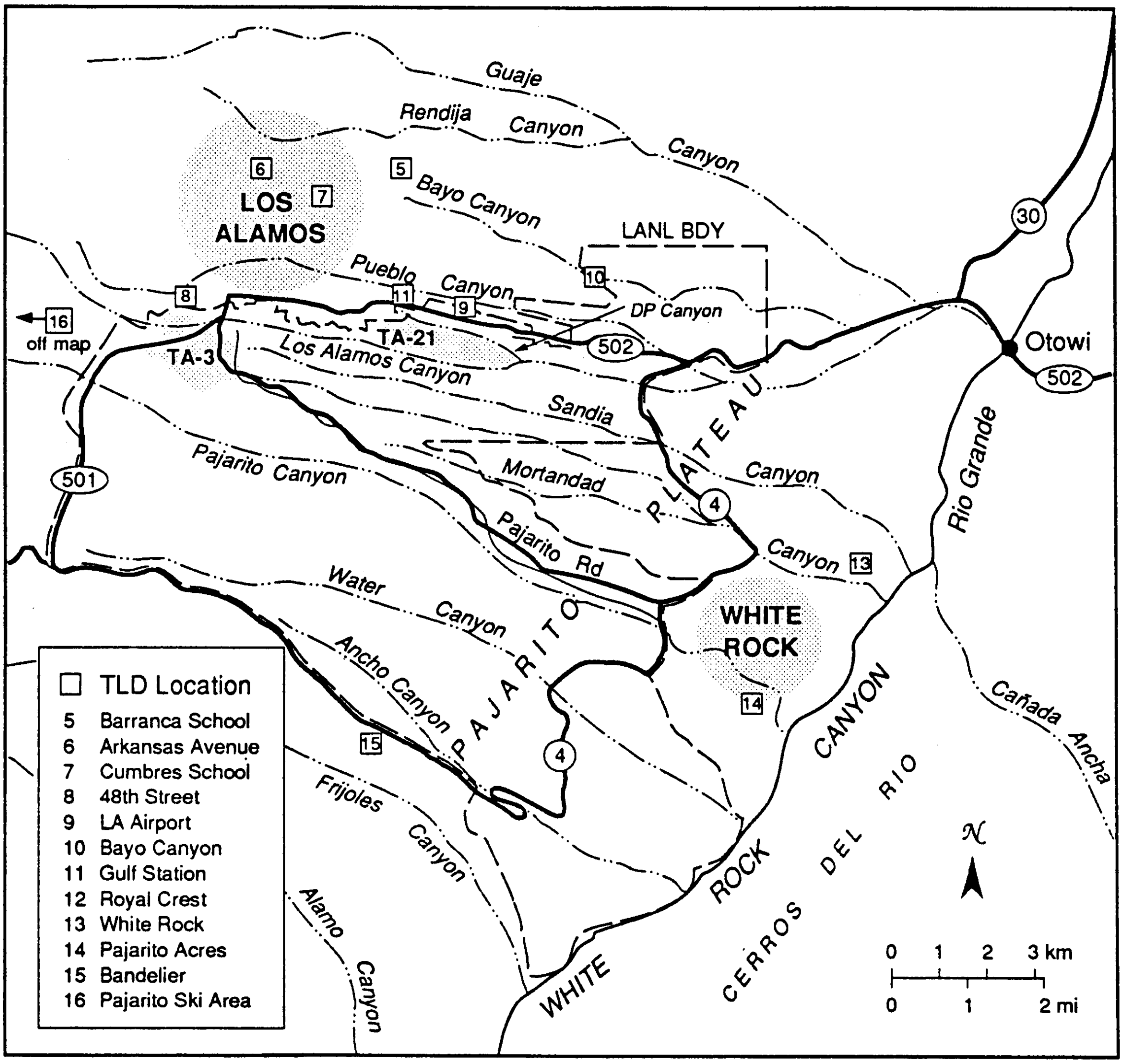


Fig. 4.2-6 Perimeter thermoluminescent dosimeter (TLD) locations (ESG 1989).

4.2.6. Ambient-Penetrating Radiation

Background gamma radiation levels are measured at four regional and twelve perimeter locations using thermoluminescent dosimeters (TLDs) (Fig. 4.2-6). A summary is included in Table 4.2-XVI.

Data needs. The available background data are sufficient for comparisons.

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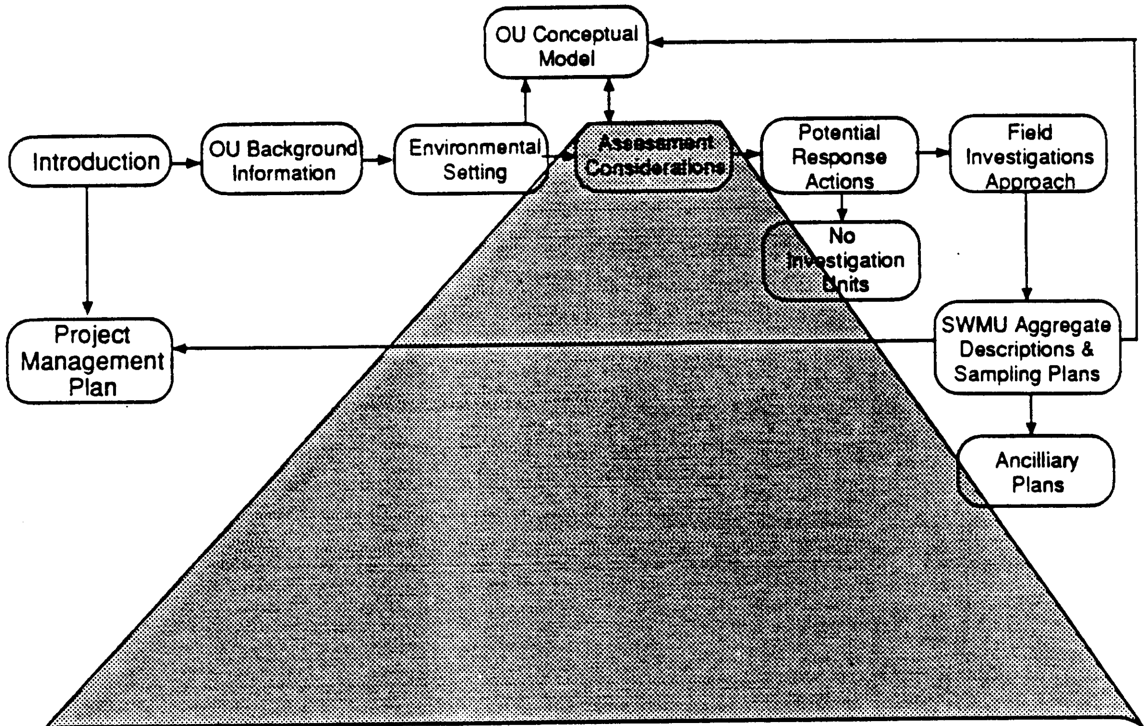
CHAPTER 5



Assessment Considerations

- Potential Contaminant Migration Pathways

5. POTENTIAL MIGRATION PATHWAYS

This chapter identifies the major potential environmental pathways for contaminant release from SWMUs at TA-21. It categorizes the TA-21 SWMUs, and presents available monitoring data pertinent to each pathway. This chapter has two sections. The first section, SWMU Conceptual Categories, defines four conceptual categories of SWMUs, defines the categories applying to each SWMU, and discusses the probable environmental contaminant release and transport mechanisms for each category.

The second section, Pathways Description, describes the environmental endpoints of the potentially important release and transport mechanisms identified in the first section. It summarizes available data regarding the presence of contaminants in the endpoint media for each environmental pathway at TA-21.

Throughout this chapter, an effort is made to identify additional data that are needed to assess the conditions and importance of the various environmental pathways. Identified data needs are summarized in Chapter 8, Data Needs.

5.1. SWMU Conceptual Categories

The large number (approximately 112) and diversity of the SWMUs at TA-21 have been indicated in Chapter 2. In an attempt to streamline the assessment of potential environmental pathways, this section gives a categorization of the SWMUs into four conceptual categories as listed below:

- deep liquid releases,
- near-surface liquid releases,
- subsurface solid waste disposals, and
- surface contamination areas.

These categories allow an emphasis on the current sources of contaminants in the environment, rather than on the multitude of original release types. This limits the discussion of environmental pathway networks to four situations.

Few TA-21 SWMUs can be characterized by only one of the conceptual categories. Table 5.1-I identifies all categories that apply to each SWMU. In Sec. 2.2.3, the SWMUs are grouped into five investigation groups, according to similarities of expected field investigations. The investigation groups are used as the major divisions in Table 5.1-I. While the investigation groups are not

TABLE 5.1-I
CROSS REFERENCE OF SWMUS TO CONCEPTUAL CATEGORIES BY INVESTIGATION GROUPS

Investigation Groups	SWMUs	Conceptual Categories
Surface Soil Contamination from Airborne Contamination Area		21-007 Salamanders Surface
Emissions (Chapter 13)	21-008 Incinerator	Surface Contamination Area
	21-009 Filter Houses/Exhaust Stacks	Surface Contamination Area
	21-020 Decommissioned Filter Houses	Surface Contamination Area
	21-021 Stack Emissions	Surface Contamination Area
Surface Units (Chapter 14)	21-002(b) Inactive Container Storage Areas	Surface Contamination Area
	21-003 PCB Container Storage Area	Surface Contamination Area
	21-004 Aboveground Tanks and Drain Lines	Surface Contamination Area Near-surface Liquid Releases
	21-013(a)–(f) Surface Disposal Areas	Surface Contamination Area Near-surface Liquid Releases
	21-026 Sewage Treatment Plant	Surface Contamination Area Near-surface Liquid Releases Deep Liquid Releases
	21-028 (d),(e) Active Container Storage Areas	Surface Contamination Area
	21-029 DP Tank Farm	Surface Contamination Area Near-surface Liquid Releases
Outfalls (Chapter 15)	21-004(d) Aboveground Tanks and Drainlines	Surface Contamination Area
	21-006(b) Seepage Pit (Outfall)	Surface Contamination Area
	21-011(k) New Industrial Liquid Waste Treatment Plant	Surface Contamination Area
	21-022(h) Acid Waste Lines and Sumps (Outfall)	Surface Contamination Area
	21-023(c) Decommissioned Septic Systems	Surface Contamination Area Near-surface Liquid Releases
	21-024(a)–(m) Inactive Septic Systems/Outfalls	Surface Contamination Area Near-surface Liquid Releases
	21-026(d) Wastewater Treatment Plant	Surface Contamination Area
	21-027(a)–(d) Surface Discharge	Surface Contamination Area
Material Disposal Areas (Chapter 16)	21-014 MDA A	Surface Contamination Area Subsurface Solid Waste Disposals
	21-015 MDA B	Surface Contamination Area Subsurface Solid Waste Disposals

TABLE 5.1-I (continued)
CROSS REFERENCE OF SWMUS TO CONCEPTUAL CATEGORIES BY INVESTIGATION GROUPS

Investigation Groups	SWMUs	Conceptual Categories
	21-016 MDA T	Deep Liquid Releases
		Subsurface Solid Waste Disposals
		Surface Contamination Area
	21-017 MDA U	Deep Liquid Releases
		Surface Contamination Area
	21-018 MDA V	Deep Liquid Releases
		Surface Contamination Area
	21-010 Industrial Liquid Waste Treatment Facility	Surface Contamination Area
		Near-surface Liquid Releases
	21-011 New Industrial Waste Treatment Plant	Surface Contamination Area
		Near-surface Liquid Releases
Subsurface Units (Chapter 17)	21-005 Acid Pit	Near-surface Liquid Releases
	21-006(b) Underground Seepage Pits	Near-surface Liquid Releases
		Deep Liquid Releases
	21-009 Waste Treatment Laboratory	Near-surface Liquid Releases
	21-012 Dry Wells	Deep Liquid Releases
	21-022(a),(f) Acid Waste Lines and Sumps	Deep Liquid Releases
SWMUs for Coordination with Building D&D (Chapter 18)	21-002(a) Inactive Container Storage Areas	Surface Contamination Area
	21-006(a),(c)–(f) Underground Seepage Pits	Near-surface Liquid Releases
		Deep Liquid Releases
	21-022(b)–(e), (g)–(j) Acid Waste Lines and Sumps	Near-surface Liquid Releases
		Deep Liquid Releases
	21-028(c) Active Container Storage Areas	Surface Contamination Area

directly based on the four conceptual categories, the SWMUs within an investigation group tend to fall into similar categories.

The descriptions below serve as simple models for each conceptual category of SWMU, identifying the nature of the waste, some typical SWMUs, and the major contaminant release and transport mechanisms of concern.

5.1.1. Deep Liquid Releases

Waste—Large volume, relatively deep releases of contaminated liquids to the subsurface. The present contaminant sources are absorption bed/seepage pit fill and subsurface soil and tuff.

Example SWMUs—The three liquid waste Material Disposal Areas (MDAs T, U, and V), several sumps and seepage pits, and a dry well.

Description—Units in this category have had substantial releases of contaminants or liquids to the subsurface, either for the purpose of material disposal or as a result of long term leakage.

Potentially Important Release/Transport Mechanisms

- Unsaturated flow of liquids in the vadose zone
- Vapor-phase transport in the vadose zone

Other Release/Transport Mechanisms

- Erosive exposure of subsurface-contaminated soils
- Mobilization of the liquid-borne contaminants by precipitation infiltration

5.1.2. Near-surface Liquid Releases

Waste—Shallow liquid releases of small volumes or low contaminant concentrations. Present contaminant source is surface and near-surface soil.

Example SWMUs—Septic systems, certain drain lines and outfalls, and larger liquid spills on the surface.

Description—The releases from SWMUs in this category are relatively shallow, less likely to have high concentrations of contaminants, and more likely to be associated with surficial soil materials than with deep penetration of liquids into the subsurface.

Potentially Important Release/Transport Mechanisms

- Erosion and wind dispersal of contaminated surface soils

- Storm water run-off erosion of contaminated surface soils
- Erosive exposure of contaminated subsurface soils, followed by wind and water erosion, as above

Other Release/Transport Mechanisms

- Liquid migration in the vadose zone
- Vapor migration in the vadose zone
- Precipitation infiltration and liquid migration in the vadose zone

5.1.3. Subsurface Solid Waste Disposals

Waste—Solid waste placed in subsurface disposals. Present source term is the waste disposed.

Example SWMUs—he two solid waste Material Disposal Areas (MDAs A and B) and the solid waste shafts at MDA T.

Description—This category is characterized by predominantly dry, solid wastes placed in waste trenches for disposal.

Potentially Important Release/Transport Mechanisms

- Vapor-phase movement within the waste and neighboring soils
- Precipitation infiltration and mobilization of otherwise-contained contaminants
- Unsaturated liquid movement in the vadose zone

Other Release/Transport Mechanisms

- Erosive exposure of wastes, followed by wind and water erosion.

5.1.4. Surface Contamination Areas

Waste—Contaminated surface soils. The present contaminant sources are deposited on, mixed with, or sorbed on surface soils.

Example SWMUs—Container storage areas, incinerators and stack releases, surface disposals, drainage channels, and some drain line outfall areas.

Description—This category includes SWMUs comprised primarily of contaminated surface soils resulting from airborne releases, solid waste spills, and surface liquid waste leaks or spills of limited volume. Most of the MDAs categorized above as deep liquid releases or solid waste disposal areas also have a component of surface contamination. Surface soils in the vicinity of the MDAs tend to be contaminated from past operations, spills, overflows, windblown dust releases and similar processes.

Potentially Important Release/Transport Mechanisms

- Surface erosion by precipitation run-off
- Dispersal of contaminated soils by wind

Other Release/Transport Mechanisms

- Transport into deeper soils with the infiltration of precipitation

5.1.5. Summary of Potentially Important Release/Transport Mechanisms

For the four conceptual categories of SWMUs, six primary contaminant release and environmental transport mechanisms have been identified. These are summarized in Table 5.1-II, where the media representing the environmental endpoints of the release/transport pathway are identified. The remaining sections of this chapter discuss available information on the transport of contaminants through the identified pathways and evaluate existing data on contaminant concentrations in the endpoint media.

5.2. Environmental Pathways

Five pathways of concern have been identified from the TA-21 OU environmental setting data presented in Chapter 4 and the discussion of major release/transport mechanisms and environmental endpoints summarized in Sec.5.1 (see Table 5.1-II). These pathways are

- atmospheric dispersion,
- surface water run-off,
- precipitation infiltration,
- migration in the vadose zone, and
- erosive exposure.

These pathways are summarized in Fig.5.2-1, and discussed in more detail in the following sections. Where available, TA-21 specific data are presented for a given pathway to give an idea of what is known of its importance at the TA-21 OU. However, because relatively little is known about potential contaminants present at TA-21 SWMUs (see Chapters 12–18), it is difficult to rank pathway importance for the TA-21 OU. Additional data needs are identified for each pathway.

Based on the information about the Laboratory's environmental setting presented in the IWP, and on the specific setting of the TA-21 OU presented in Chapter 4, it has been concluded that no

TABLE 5.1-II
SUMMARY OF MAJOR RELEASES/TRANSPORT MECHANISMS
AND ENVIRONMENTAL END-POINTS OF INTEREST

Release/Transport Mechanisms	Environmental End-Point of Interest
A. Wind entrainment and dispersal of surface soil	1. Contaminants deposited on surface soils. 2. Contaminants in air.
B. Surface water run-off carrying soil/sediment in suspension, contaminants in solution	1. Contaminants deposited in drainage sediments. 2. Contaminants released to surface waters. 3. Contaminated surface water infiltrating canyon bottom alluvium to alluvial aquifer.
C. Liquid movement in the vadose zone	1. Expanded contamination of subsurface soil and rock. 2. Immobilization in the subsurface. 3. Collection at, and movement along, unit contacts, fractures, and joints. 4. Releases at springs or seeps.
D. Vapor movement in the vadose zone	1. Expanded contamination of subsurface soil and rock. 2. Immobilization in the subsurface. 3. Preferential transport along joints and fractures leading to releases at surface or canyon walls.
E. Erosive exposure of subsurface wastes or contaminated soil	1. Feeds wind dispersal (A) and surface water run-off (B).
F. Infiltration of precipitation	1. Feeds liquid movement in vadose zone (C) and vapor movement in vadose zone (D).

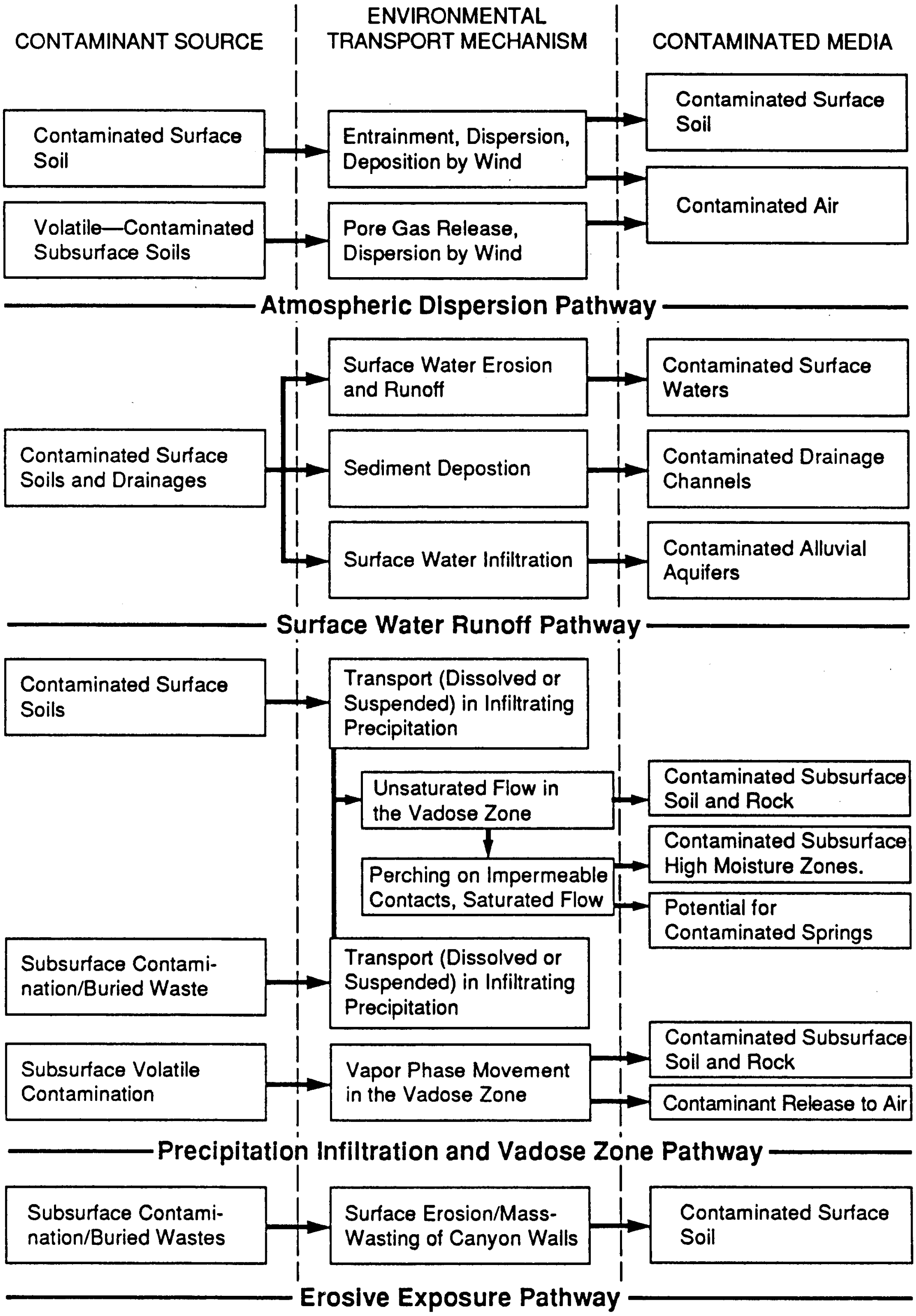


Fig. 5.2-1 Diagram of major contaminant transport pathways.

pathway exists for the migration of contaminants to groundwater beneath the Bandelier Tuff. Therefore, it is not considered further. In the unlikely event that site characterization data indicate it should be considered further, it will be addressed.

5.2.1. Atmospheric Dispersion Pathway

Release mechanisms for the air pathway include wind entrainment of contaminated soil (resuspension) and releases of volatile compounds and tritium from within the soil profile. A simple diagram identifying the major release mechanisms and resulting contaminated media is given in Fig.5.2-2. Wind speed, direction and stability class, plus vegetative cover, soil physical properties, soil moisture content and soil heat flux are important variables affecting resuspension and soil gas releases (Travis 1975; Abeele and Nyhan 1987).

Resuspension/deposition. Past airborne releases from facility stacks and other sources at TA-21 have resulted in elevated concentrations of radionuclides in soils on DP Mesa and surrounding areas. These elevated levels have been defined as SWMUs (see Chapter 13) and constitute one potential source of contaminants that may now be suspended and redeposited. In addition, numerous discrete SWMUs have had releases of contaminants to the surface soils that also constitute a part of the source term for resuspension, atmospheric dispersion, and deposition.

Few data are currently available documenting the distribution of contaminant levels in soils across TA-21. SWMU-specific data are discussed in Chapters 13–18, but these data were collected to document contaminant levels in immediate proximity to discrete SWMUs. They represent only a part of the contaminant distribution picture.

Data needs. Documentation of the current contaminant levels throughout the OU is needed. This will form the basis for defining the source term available for resuspension.

Release of Volatile Compounds and Tritium. Releases of tritiated water vapor and tritium gas from facilities at TA-21 and in waste streams disposed at the MDAs occurred for many years. Some releases still continue from the Tritium Systems Test Assembly (TSTA) (see Sec.3.1.2) and the TA-21 sewage treatment plant. Low levels of tritium are pervasive in the environment at TA-21. It is probable that common laboratory solvents and other volatile organic compounds were released to the MDAs and other SWMUs at TA-21.

As a result of subsurface releases to absorption beds or seepage pits, some distribution of volatile organic compounds and tritiated water is likely within the subsurface profile. Few data are

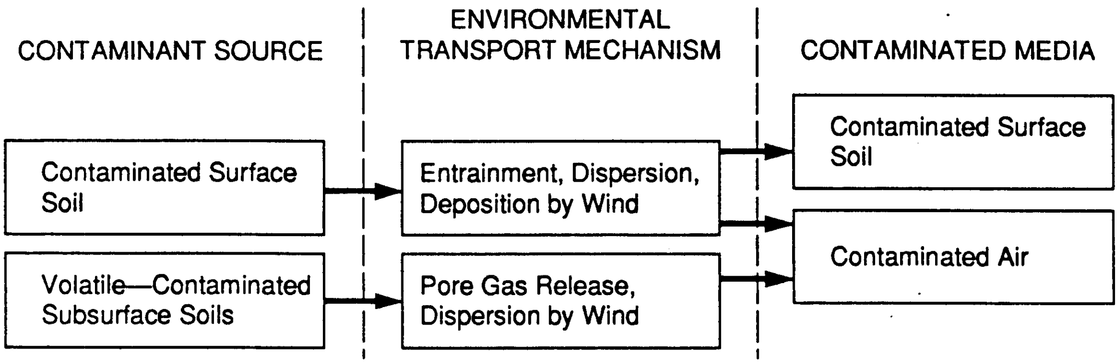


Fig. 5.2-2 Diagram of the atmospheric dispersion pathway.

available to document the subsurface distribution of contaminants that could be released in the gas phase from the soil.

Data needs. Characterize the subsurface source term for contaminants that could be released to the atmosphere in the gas phase. Quantify the presence of those contaminants in the air in and around the OU.

Airborne contaminants. Some measurements are available on contaminant concentrations in air in the vicinity of TA-21. The data focus on radionuclides and are summarized below.

Figure 5.2-3 identifies six air sampling locations in the vicinity of TA-21. Table 5.2-I summarizes the air monitoring data from these six stations and three regional stations (see Fig.4.2-1) for the five-year period from 1984 through 1988. Samples were collected and analyzed monthly for tritium and quarterly for total uranium and $^{239/240}Pu$.

For tritium, the perimeter and onsite stations in the vicinity of TA-21 appear elevated above regional levels, with the exception of the Bayo STP monitoring station. This is consistent with known elevated levels of tritium in soil at TA-21 from past operations and its potential for continuing release. TA-21 is not the only source of tritium in the area, however, and the observed values may not be directly attributable to releases from SWMUs or soil contamination at TA-21. One source of operational releases of tritium at the Laboratory is the TSTA, noted above. In addition, tritium is present in the permitted liquid effluent from TA-21's sewage treatment plant.

For $^{239/240}Pu$, the results from the onsite monitoring station at TA-21 are comparable to those from the regional stations. The perimeter stations in the vicinity of TA-21 have slightly higher values, but the significance of this observation is not known. The total uranium measurements for

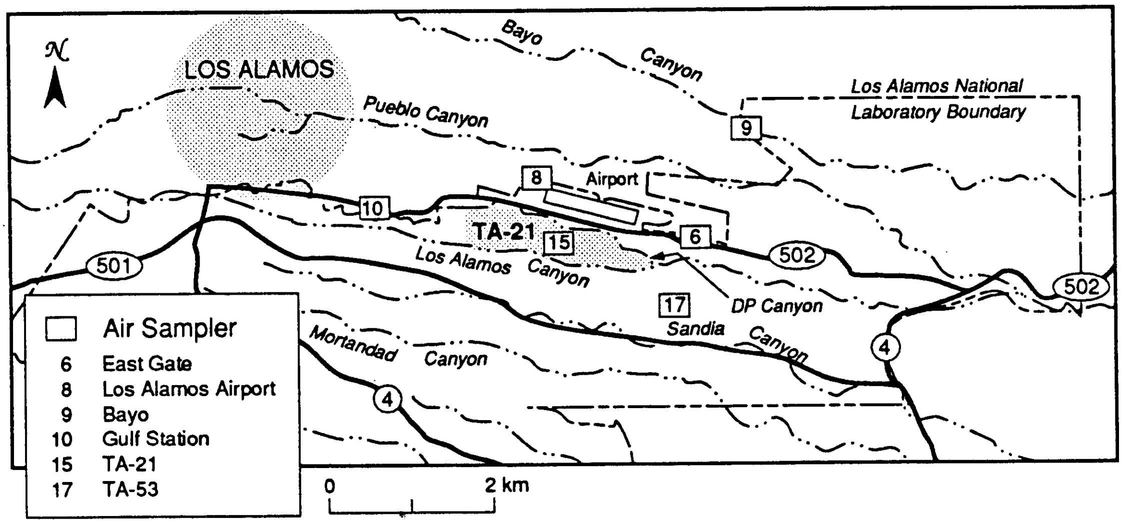


Fig. 5.2-3 Air sampling locations potentially susceptible to TA-21 emissions.

all stations were within the range expected for background in air.

The annual average concentrations of these radioactive materials are less than 0.1 % of their respective DOE-derived concentration guides (DCG) for uncontrolled areas. The DCGs are included in Table 5.2-I.

Data needs. For purposes of predicting transport of contaminants by air, more detailed information on the contaminant sources at the several SWMUs is needed. The need for, and design of, any SWMU-specific air monitoring program should be based on those data when they have been obtained and evaluated. As discussed in Sec.4.1.2, Climate, available meteorological data are sufficient. For resuspension/deposition and volatilization estimates, measurements of the physical properties of the soil will be needed.

5.2.2. Surface Water Run-off Pathway

The climate of the Pajarito Plateau (Sec.4.1.2, Climate) is characterized by snowfall in the winter with intermittent melt events and high-intensity, short-duration rainfall events in the summer. These factors often result in significant surface water run-off and soil erosion. A simple diagram of the major release mechanisms and resulting contaminated media is given in Fig.5.2-4. The release mechanism for the run-off pathway is erosion of contaminated surface soils. The environmental dispersal of contaminants by the run-off pathway has three major components as follows:

TABLE 5.2-I
AIRBORNE RADIOACTIVITY IN THE VICINITY OF TA-21[a]

Air Monitoring Station	Tritium pCi/m^3	$^{239/240}$Pu aCi/m^3 (10^{-18}µCi/mL)	Total U pg/m^3
Regional			
Espanola	4.7 ± 2.8	1.0 ± 0.8	75.8 ± 47.4
Pojoaque	6.4 ± 3.7	0.3 ± 0.5	96.7 ± 43.7
Santa Fe	3.2 ± 2.6	1.0 ± 0.6	54.8 ± 41.0
™x ± s	4.8 ± 3.3	0.8 ± 0.7	75.8 ± 47.3
Nearby Perimeter Stations			
6 East Gate	12.4 ± 7.5	1.3 ± 0.5	37.7 ± 6.6
8 LA Airport	11.4 ± 4.6	2.1 ± 1.8	60.0 ± 28.2
9 Bayo STP	4.4 ± 1.5	1.1 ± 0.8	43.9 ± 37.3
10 Exxon Station	11.0 ± 2.0	2.6 ± 1.1	45.6 ± 4.4
™x ± s	9.7 ± 5.6	1.8 ± 1.3	46.9 ± 25.7
™x ± s w/o Bayo	11.2 ± 5.5	2.0 ± 1.3	52.6 ± 26.0
Onsite Stations near TA-21			
15 TA-21	26.5 ± 16.5	1.0 ± 0.4	45.8 ± 11.5
17 TA-53	13.9 ± 5.4	0.9 ± 0.7	35.6 ± 11.0
DOE Derived Air Concentration (DAC) Guides.			
DAC:	1x10^5	1x10^4	1x10^5

[a]ESG (1985–1989).

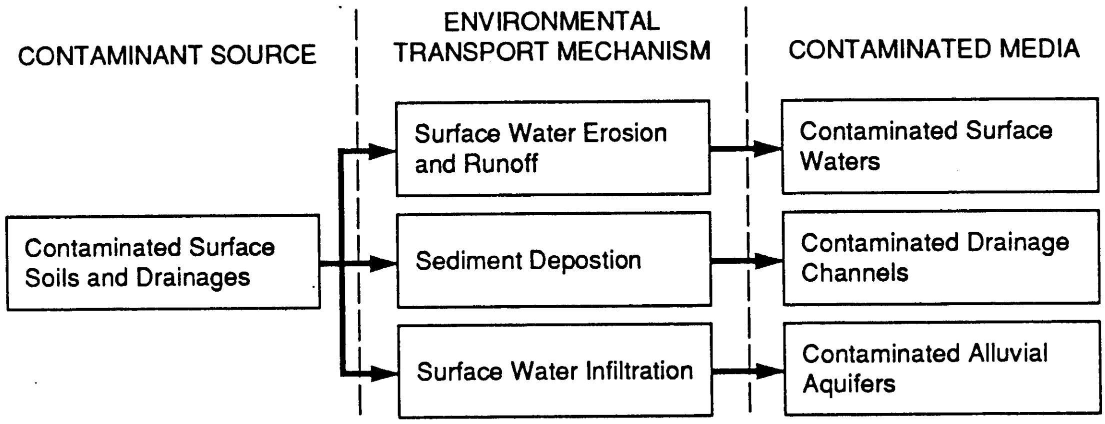


Fig. 5.2-4 Diagram of the surface water runoff pathway.

- deposition of contaminated sediments in drainage channels,
- contamination of surface water from the dissolved and suspended solids, and
- contamination of the shallow saturated zones in the alluvium of the canyon bottoms (alluvial aquifers).

At TA-21, the water and sediments discharged from the mesa top go to DP Canyon on the north and Los Alamos Canyon on the south, as described in Sec.4.1.4.1. At the eastern edge of the OU, DP Canyon merges with Los Alamos Canyon and Los Alamos Canyon joins the Rio Grande at Otowi, (see Fig.4.2-6, for example).

The organization of the ER Program at the Laboratory includes an OU specifically for investigation and remediation of all canyon systems, the Canyons' OU. Thus, while the TA-21 OU is bounded by the drainage channels of DP and Los Alamos Canyons, responsibility for characterization and assessment of those canyons belongs to the Canyons' OU. The focus of the TA-21 RFI work plan is on the present potential for releases from the TA-21 OU; in this case as contributions to the Canyons' OU. The discussions below review available data on contaminants in sediments, surface water, and alluvial aquifers for the TA-21 OU.

Data needs. For the purposes of the TA-21 RFI work plan, investigations are needed to determine erosion rates, contaminant levels and distribution in drainage channels within the OU, and the available source term for erosion by surface water run-off. Properties of the soils and drainages that affect erosion potential need to be characterized.

5.2.2.1. Surface Water

Surface water flow normally occurs in the canyons only in the upper reaches near the Jemez Mountains or for short distances downstream from Laboratory effluent sources such as the sewage treatment plant at TA-21, which discharges to DP Canyon. Many run-off events generate surface flow along portions of a canyon's length, but not the full length. This is particularly true of summer run-off events, which may reach the Rio Grande less frequently than once per year (Purtymun et al. 1990). The long duration of the spring run-off event can saturate the drainage channel and provide conditions supporting flow along the entire length of a canyon. In a study of spring run-off in Los Alamos Canyon covering seven years, flow reached the Rio Grande in five of the years (Purtymun et al. 1990).

Table 5.2-II gives data for plutonium in solution (and in sediments) during snowmelt run-off at a station (GS-2) in Los Alamos Canyon approximately 2 miles below the confluence with DP Canyon (Fig.5.2-5). The plutonium in solution is in the same range as background levels reported in deep groundwater wells (Sec.4.2.3, Groundwater).

TABLE 5.2-II
PLUTONIUM IN RUN-OFF WATER, SUSPENDED SEDIMENTS, AND BED SEDIMENTS IN LOS ALAMOS CANYON BELOW DP CANYON (STATION GS-2)

	Total Plutonium		
Year	Solution (pCi/L)	Suspended Sediments (pCi/g)	Bed Sediments (pCi/g)
1975[a]	0.03	1.16	0.18
1979[a]	0.01	4.56	0.40
1980[a]	0.01	5.37	0.17
1982[a]	0.05	11.1	0.31
1983[a]	0.01	4.97	0.24
1985[a]	0.03	5.47	0.82
1986[a]	0.01	1.84	0.29
1987[b]	0.021	2.05	—
1988[c]	0.004	3.32	—

aPurtymun et al. 1990.
bESG 1988 - ^{238}Pu and $^{239/240}$Pu concentrations were summed to give total plutonium.
cESG 1989 - ^{238}Pu and $^{239/240}$Pu concentrations were summed to give total plutonium.

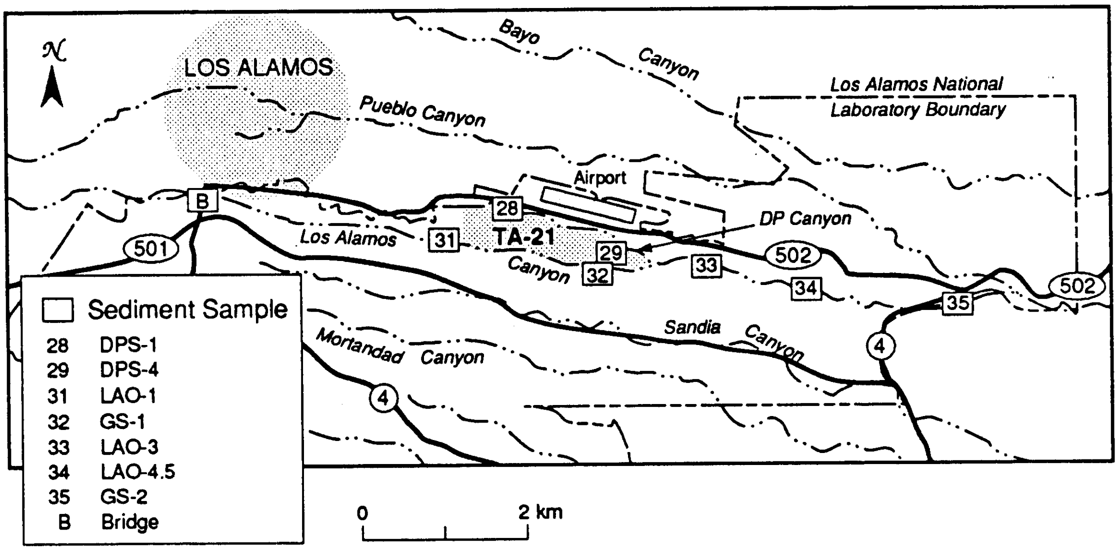


Fig. 5.2-5 Sediment sampling locations in DP and Los Alamos Canyons.

Two surface water sampling stations in Los Alamos and DP Canyons were among those sampled (including groundwater locations) for a broad suite of chemical analyses in 1986 (Purtymun et al. 1988). The locations are identified in Table 5.2-III and shown on Fig.5.2-6. With the qualifications in Table 5.2-III, no contaminants were present above detection limits.

Data needs. Measurements of fraction of precipitation, which runs off the TA-21 mesa top, drainage collection basins, water velocities, channel configurations, and the dissolved and suspended contaminant loading of surface water run-off at TA-21 are needed.

5.2.2.2. Sediments.

Sediment transport by surface water run-off includes soil carried in suspension and heavier particles moved by the force of the water along the bed of the drainage, depending on the properties of the soil and the velocity of the water. The quantity of various contaminants that may be transported depends on physical and chemical properties of both the soil and the contaminant. Contaminants originally released in solution may become chemically bound to and transported with soil particles. Contaminants released as airborne particulates may behave differently in the soil matrix, and water-soluble contaminants will be distributed and behave in yet another fashion.

Enhanced contaminant retention often occurs in the silt-clay fraction of the soil because of mineralogy and higher specific surface. The silt-clay fractions are readily transported in suspension once detached from the soil; thus surface water run-off can be an efficient contaminant

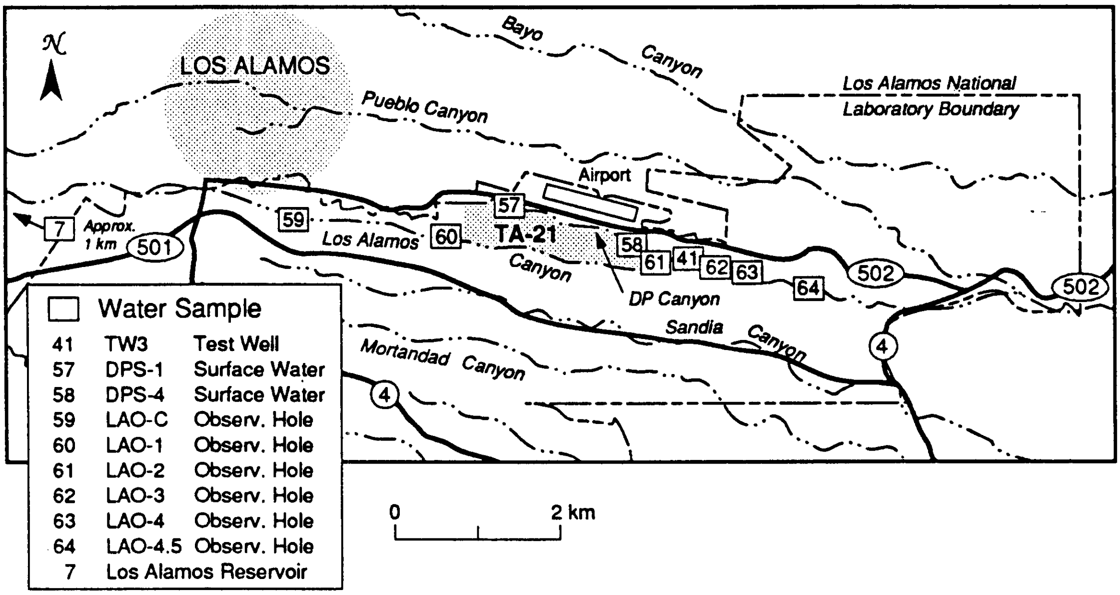


Fig. 5.2-6 Surface and groundwater sampling locations in DP and Los Alamos Canyons.

transport mode. For insoluble contaminants, such as plutonium, movement with sediment is the primary mode of surface water transport in arid and semiarid ecosystems (Hakonson and Nyhan 1980; Hakonson et al. 1979; Hakonson et al. 1981).

Table 5.2-II gives data on the plutonium concentrations in suspended sediments and bed sediments (and in solution) during run-off events for nine years in the period 1975 through 1988. The sampling location, GS-2, is shown in Fig.5.2-5. Table 5.2-IV gives results of analyses for several radionuclides in sediments collected when the channel was not flowing. These data cover the five-year period from 1984 through 1988. The samples were collected at eight locations, two in DP Canyon and six in Los Alamos Canyon, as shown in Fig.5.2-5. The data are also presented in Figures 5.2-7 and 5.2-8, where the concentrations are plotted as a function of the location in Los Alamos and DP Canyons. These data indicate an increase in radionuclide content of sediments in Los Alamos Canyon from TA-21 downstream. DP Canyon sediments generally have higher concentrations than Los Alamos Canyon, except for tritium and uranium. Both tritium and uranium are within the range of background in both canyons. Strontium-90 concentrations exceed the range of background in DP Canyon (twice and six times the background value) but not in Los Alamos Canyon. The other radionuclides (^{137}Cs, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am) are above background levels in both canyons, except at the furthest upstream point (see Figs. 5.2-7 and 5.2-8).

TABLE 5.2-III
ORGANIC COMPOUNDS IN SURFACE WATER AND ALLUVIAL AQUIFERS IN DP AND LOS ALAMOS CANYONS[a]

Stations	Type of sample (depth)	Volatile organics (35 Compounds)	Semivolatile organics (65 Compounds)	BNA Fraction	Pesticides (20 Compounds)	Herbicides (3 Compounds)	Polychlorinated Biphenyls (7 Compounds)	Cyanide
Los Alamos Reservoir	Surface Water	U	U	U	U	U	U	U
DDS-4	Surface Water	U	B	U	U	U	U	U
LAO-C	Alluvial Aquifer (9 ft)	U	U	C	U	U	U	U
LAO-1	Alluvial Aquifer (32 ft)	A	U	U	U	U	U	U
LAO-3	Alluvial Aquifer (32 ft)	U	U	U	U	U	U	U
LAO-4.5	Alluvial Aquifer (48 ft)							
TW-3	Groundwater (750/815 ft)	U	D	U	U	U	U	U

U: no compounds detected
A: chloroform 7 µg/L (detection limit 5 µg/L)
B: Bis(2-ethylexyl) phthalate 400 µg/L (detection limit 10 µg/L); this is a common analytical laboratory contaminant.
C: Unknown, scan number 1535, 40 µg/L [detection limit (estimated) 25µg/L]
Unknown, scan number 1700, 30 µg/L [detection limit (estimated) 25µg/L]
Unknown, scan number 1774, 40 µg/L [detection limit (estimated) 25µg/L]
D: Di-n-butyl phthalate 16 µg/L (detection limit 10 µg/L)

[a]Purtymun et al. (1988)

TABLE 5.2-IV
RADIONUCLIDE CONCENTRATIONS IN SEDIMENTS OF DP AND LOS ALAMOS CANYONS, 1984–1988[a]

Map Number	Location	Tritium[b,d] (pCi/mL)	$^{90}Sr^{c,e}$ (pCi/g)	$^{137}Cs^{e}$ (pCi/g)	U^{e} (µg/g)	$^{238}Pu^{e}$ (pCi/g)	$^{239/240}Pu^{e}$ (pCi/g)	$^{241}Am^{f}$ (pCi/g)
	DP Canyon							
28	DPS-1	1.8 ± 3.6	5.9 ± 5.9	6.9 ± 6.6	3.4 ± 2.0	0.897 ± 1.236	2.731 ± 3.761	7.96 ± 13.41
29	DPS-4	2.4 ± 0.8	1.7 ± 0.3	11.1 ± 3.9	2.4 ± 1.5	0.131 ± 0.048	0.418 ± 0.126	0.487 ± 0.419[g]
	Los Alamos Canyon							
	At bridge	2.4 ± 0.8	0.1 ± 0.2	0.2 ± 0.2	2.6 ± 1.1	0.000 ± 0.001	0.009 ± 0.015	-0.289 ± 0.658
31	LAO-1	2.6 ± 0.8	0.2 ± 0.2	0.8 ± 0.8	2.8 ± 0.9	0.006 ± 0.009	0.317 ± 0.166	0.433 ± 0.812
	GS-1	5.2 ± 1.2	0.5 ± 0.3	5.9 ± 5.5	4.0 ± 1.3	0.141 ± 0.107	0.695 ± 0.274	0.753 ± 0.880
	LAO-3	2.6 ± 0.8	0.5 ± 0.4	2.3 ± 2.7	4.1 ± 4.5	0.030 ± 0.030	0.241 ± 0.126	0.394 0.655
	LAO-4.5	2.7 ± 0.8	0.7 ± 0.4	9.6 ± 10.6	3.7 ± 1.1	0.134 ± 0.113	0.689 ± 0.558	0.575 ± 2.054
	At S.R. 4	3.4 ± 0.8	0.5 ± 0.2	3.6 ± 3.0	3.1 ± 1.2	0.080 ± 0.038	0.426 ± 0.260	0.816 ± 0.837

[a]ESG (1985–1989).
[b]Data from one year (1984) only.
[c]Data from four years (1984–1986, 1988).
[d]Measurement ± counting uncertainty.
[e]Mean of measurements ± standard deviation ($\bar{x} \pm s$).
[f]Data for four years (1984–1987).
[g]Data for three years (1984–1986).

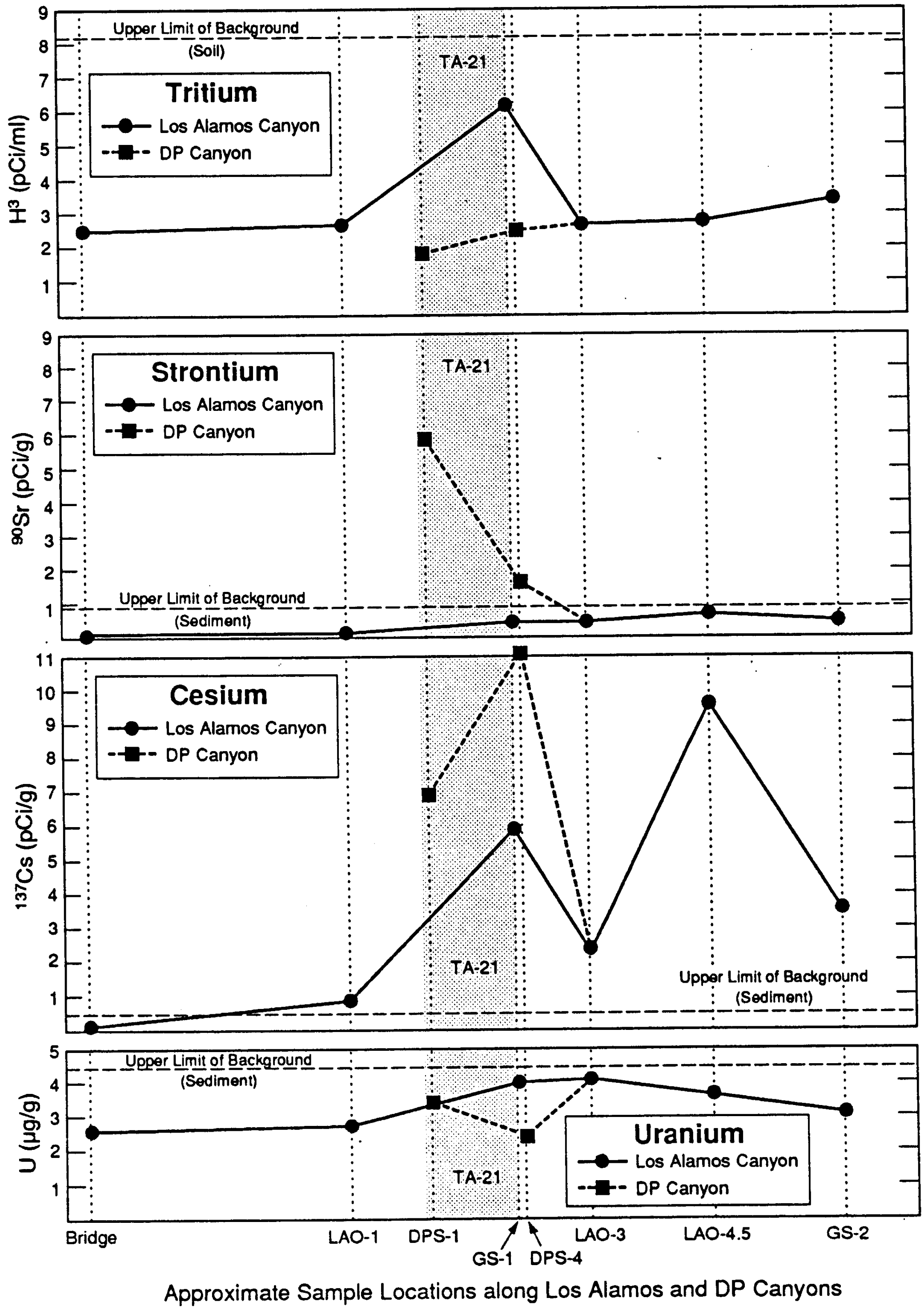


Fig. 5.2-7 Graphs showing concentrations of tritium, strontium, cesium and uranium in samples along Los Alamos and DP Canyons.

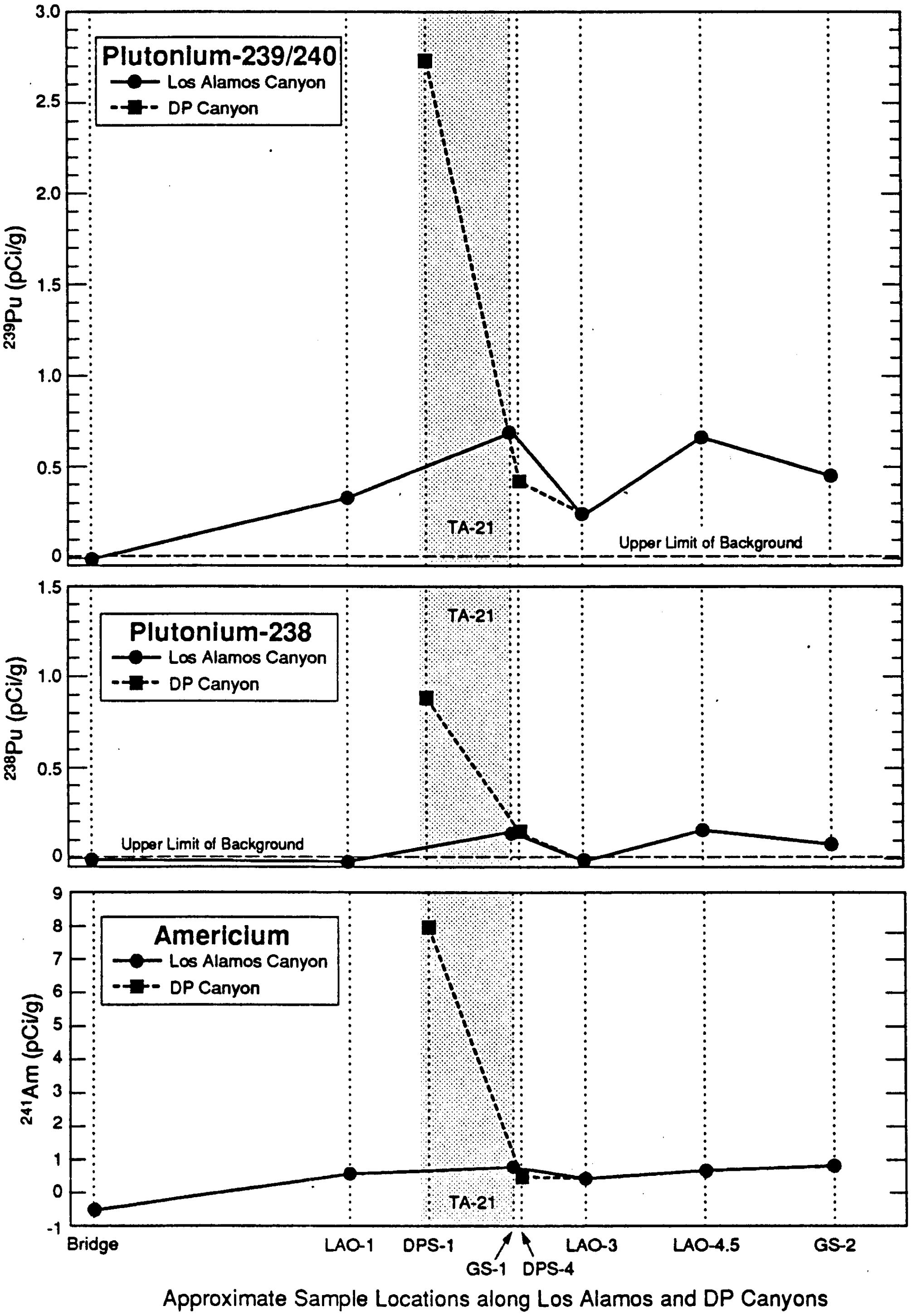


Fig. 5.2-8 Graphs showing concentrations of plutonium-238, -239/240, and americium in samples along Los Alamos and DP Canyons.

A large buildup of radionuclides has not occurred in sediments at the effluent outfall in DP Canyon because the sediments are moved downgradient with summer storm and spring snowmelt run-off.

An inventory of plutonium in sediments in Acid, DP, and Los Alamos Canyons indicated that only 8% of the plutonium was in the active channel; the remaining 92% was in the inactive channel and bank (Stoker 1981). A model (Lane 1985) placed 33% of the inventory in the active channel and 67% in the inactive channel and on its banks.

Stoker (1981) reported the plutonium inventory in the active channel in DP Canyon and Upper Los Alamos Canyon was 5.0 μCi in May 1968; 1.5 μCi in August 1968; 5.7 μCi in February 1970; and 3.7 μCi in October 1972. The inventory in May 1968 shows the build up of plutonium during the fall-winter-spring months and the August 1968 inventory represents the residual after the summer rainfall season.

The estimated inventory of ^{137}Cs on sediments in DP and Upper Los Alamos Canyon was about 154 mCi in 1972. About 84% was within 1.8 km of the outfall in DP Canyon (Stoker 1981). For DP Canyon, transport of radionuclides in summer storm run-off was studied by Purtymun (1974). Precipitation during the period of May through September 1967 resulted in 23 run-off events that carried about 88,000 kg of suspended sediments out of the canyon in about 36,800 m^3 of water. The suspended sediments carried out about 70μCi of gross alpha emitters and 11,300 μCi of gross beta emitters. The source of gross beta emitters is principally ^{90}Sr.

On the basis of available measurements, Stoker (1981) estimated that the typical amount of plutonium transported by run-off from Los Alamos Canyon into the Rio Grande is on the order of 1 mCi. If the 1 mCi of plutonium is distributed in the average annual suspended sediment load of 2.2×10^8 kg in the Rio Grande at Otowi, then the average plutonium concentration would be 0.0005 pCi/g.

Data needs. Estimates of soil erosion by surface water transport, the contaminant loading, and the available contaminant source term in the surface soils of TA-21 will aid in assessing the importance of this pathway.

5.2.2.3 Alluvial Aquifers

The surface water run-off pathway leads to the alluvial aquifers as a reservoir for one contaminated media, the shallow groundwater. In this context, the following discussions summarize pertinent information and indicate the impact prior surface water releases from TA-21 have had on the alluvial aquifers.

Los Alamos Canyon. The alluvial aquifer in Los Alamos Canyon extends from its upper reaches to below the confluence with DP Canyon. It is recharged by infiltration from the drainage channel during spring and late-summer run-off. Water levels decline in the winter and early summer when run-off is at a minimum (ESG 1989). Depletion occurs by evapotranspiration and infiltration into the underlying tuff. Contaminants in surface water may enter the alluvial aquifer and will move with or be removed from the water according to the chemical nature of the contaminant and the alluvium.

Six groundwater sampling locations in Los Alamos Canyon are shown in Fig.5.2-6. Five of these (the LAO- series) sample the alluvial aquifer in the canyon, the sixth (Test Well 3) samples groundwater in the Puye Formation at a depth of 750 to 815 ft below the canyon floor.

Table 5.2-III, presented earlier, gives the results of analyses for organic compounds for samples from the wells in Los Alamos Canyon. Generally, organic compounds were absent. In two alluvial aquifer wells (LAO-C and LAO-1) and a groundwater test well (TW-3), concentrations of one organic in each well were found above, but very close to, detection limits. These results are not believed to be significant; however, no subsequent sampling and analysis have been done to confirm the presence of these compounds.

Table 5.2-V summarizes data on radionuclides in water from the six wells during the five-year period 1984–1988. Conclusions are given below, based on background levels in well and spring water given in Sec.4.2.2, Surface Water, and Sec.4.2.3, Groundwater. All radionuclides are within the range of background level for the samples from the main aquifer (TW-3, see Fig.5.2-6)). In the alluvial aquifer, the levels of ^{137}Cs and ^{238}Pu are within the range of background at all sampling locations. Uranium is also in the range of background level, except at well LAO-2, which may be slightly elevated. This well is the first one sampled below the confluence with DP Canyon. From well LAO-2 downstream through the remaining wells sampled in Los Alamos Canyon, $^{239/240}Pu$ is slightly elevated above the range of background in water. Tritium is within the background level range at the furthest upstream well (LAO-C) but has elevated levels in all wells downstream from there. The elevated levels are present at well LAO-1, which is upstream of TA-21 and of the confluence with DP Canyon. This may indicate a tritium source other than TA-21.

Table 5.2-VI summarizes data from the same time period for chemical constituents. EPA Maximum Contaminant Levels (primary and secondary standards) for inorganic chemicals and radio-

TABLE 5.2-V
RADIONUCLIDE CONCENTRATIONS IN THE ALLUVIAL AQUIFER AND THE MAIN AQUIFER BENEATH LOS ALAMOS CANYON

	Tritium pCi/mL	^{137}Cs pCi/L	^{238}Pu pCi/L	$^{239/240}Pu$ pCi/L	Total U µg/L
Alluvial Aquifer					
LAO-C	0.4 ± 0.8	34.3 ± 36.1	0.006 ± 0.010	0.002 ± 0.009	1.0 ± 0.8
LAO-1	6.8 ± 8.0	0.0 ± 44.1	-0.000 ± 0.008	0.009 ± 0.012	1.1 ± 0.5
LAO-2	7.3 ± 11.4	33.6 ± 44.8	0.010 ± 0.009	0.069 ± 0.076	5.1 ± 9.5
LAO-3	8.2 ± 12.1	-24.7 ± 42.8	0.009 ± 0.014	0.037 ± 0.052	2.2 ± 1.4
LAO-4	3.9 ± 4.5	30.9 ± 65.5	0.022 ± 0.033	0.051 ± 0.054	1.4 ± 1.2
LAO-4.5	4.3 ± 5.4	5.2 ± 65.3	0.006 ± 0.013	0.049 ± 0.053	1.6 ± 1.1
Main Aquifer					
TW-3	0.3 ± 1.2	10.0 ± 25.4	0.006 ± 0.013	0.010 ± 0.018	1.1 ± 1.1
EPA MCL (primary std)	20.	200.	15.	15.	

TABLE 5.2-VI
CHEMICAL QUALITY OF WATER FROM THE ALLUVIAL AND MAIN AQUIFERS FROM BENEATH LOS ALAMOS CANYON (1984—1988)[a]

	SiO_2 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	CO_3 (mg/L)	HCO_3 (mg/L)	P (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	N (mg/L)[b]	TDS (mg/L)	Total Hardness (mg/L)	pH	Conductivity (mS/m)
Main Aquifer																
TW-3	43 ± 35	15 ± 5	4.7 ± 1.5	2.3 ± 0.5	11 ± 4	0	75 ± 32	0.3 ± 0.2	4 ± 1	4 ± 1	0.2 ± 0.2	0.4 ± 0.4	129 ± 49	55 ± 19	7.8 ± 0.2	55 ± 90[c]
Alluvial Aquifer																
LAO-C	34 ± 9	17 ± 11	3.9 ± 2.1	3.0 ± 0.7	33 ± 24	0	53 ± 32	0.2 ± 0.2	8 ± 6	51 ± 36	0.4 ± 0.3	0.22 ± 0.05	179 ± 80	58 ± 40	7.5 ± 0.3	27 ± 17
LAO-1	34 ± 7	17 ± 6	3.8 ± 1.8	6.6 ± 4.7	54 ± 20	0	76 ± 39	0.3± 0.1	15 ± 6	63 ± 40	1.1 ± 1.0	1.0 ± 0.9	239 ± 79	59 ± 19	7.6 ± 0.2	40 ± 16
LAO-2	30 ± 11	17 ± 6	3.6 ± 0.9	8.7 ± 4.9	59 ± 39	0	83 ± 39	0.3 ± 0.1	17 ± 7	57 ± 32	2.0 ± 2.0	1.2 ± 1.0	303 ± 109	57 ± 20	7.4 ± 0.3	43 ± 20
LAO-3	38 ± 4	22 ± 7	4.7 ± 1.3	12.3 ± 5.9	67 ± 33	0	86 ± 30	0.3 ± 0.1	21 ± 8	79 ± 46	1.6 ± 1.0	1.6 ± 1.0	296 ± 113	73 ± 26	7.3 ± 0.2	50 ± 21
LAO-4	36 ± 5	13 ± 3	3.6 ± 0.7	6.4 ± 3.7	42 ± 11	0	78 ± 35	0.3 ± 0.2	12 ± 3	40 ± 20	0.9 ± 0.7	0.6 ± 0.4	194 ± 27	46 ± 5	7.3 ± 0.1	31 ± 6
LAO-4.5	46 ± 14	14 ± 2	3.9 ± 1.0	5.9 ± 3.5	42 ± 11	0	77 ± 35	0.3 ± 0.2	12 ± 3	38 ± 17	0.9 ± 0.7	0.6 ± 0.6	205 ± 27	50 ± 8	7.3 ± 0.3	31 ± 6
EPA MCL									250 secondary	250 secondary	2 primary	10 primary	500 secondary		6.5—9.5 secondary	

[a]ESG (1985–1986).
[b]Data for four years (1985–1988). Prior to 1985, data reported were NO_3.
[c]A value of 215 mS/m appears anomalous; without that value $\bar{x} \pm s$ is 1.5 ± 5.

nuclides are given in the tables for reference (EPA 1976, 1979; ICRP 1977). There are no regulatory standards for the following cations and anions: sulfate, calcium, magnesium, potassium, sodium, carbonate, bicarbonate, phosphorus, sulfate, total hardness, or conductivity. When compared with the background data presented in Sec.4.2.3, it appears all parameters are at background levels in the main aquifer at TW-3. In the alluvial aquifer, all parameters except potassium, sodium, sulfate, and chlorine are within the normal range for local waters. The first three of these parameters are at background levels at the furthest upstream location in Los Alamos Canyon (LAO-C) and are slightly elevated at all downstream wells. For chlorine, all alluvial aquifer wells sampled in Los Alamos Canyon are elevated. In all cases, the elevated levels of these four chemicals are apparent upstream of TA-21 and at the confluence with DP Canyon.

Data needs. No additional data for the alluvial aquifer in Los Alamos Canyon are needed at present. Other investigations may be undertaken by the Canyons' OU.

DP Canyon. No wells have been placed in DP Canyon, and there is no direct evidence regarding the presence of an alluvial aquifer. DP Canyon has in the past received contaminated liquid effluents from several sources, accounting for the elevated levels of radionuclides observed in DP Canyon sediments. Past effluent volumes were much larger than current releases from the NPDES-permitted outfall of the TA-21 sewage treatment plant. The sewage treatment plant discharge, sampled in August 1990, contained tritium at 9 pCi/mL (see Table 5.2-VII).

TABLE 5.2-VII
TRITIUM AND LIMITED CHEMICAL DATA FOR DP SPRING AND TA-21
SEWAGE TREATMENT PLANT EFFLUENT

NO_3 DP Spring	Temp. C	pH	Tritium pCi/mL	B mg/kg	Cl mg/kg	mg/kg
5/30/90	8.4	7.5	2.8	<0.05	39.5	5.78
8/10/90	9.8	7.4	1.1	0.53	24.7	3.41
9/6/90	16.0	7.9	1.3	0.10	21.1	2.45
TA-21 Sewage Treatment Plant Outfall						
8/10/90	18.5	7.4	9.0	<0.05	38.1	153.

During reconnaissance geologic work in May 1990, a spring was discovered discharging from the north wall of DP Canyon about 1 km downstream (east) of TA-21. It has been named DP Spring. Well-established vegetation at the spring indicates an age of not less than 10 years. The discharge point occurs at the contact of colluvium of Bandelier Tuff resting on an old erosional surface cut into a lower unit of the upper Bandelier Tuff.

The spring rises on the opposite wall of the canyon from the sewage plant discharge but at a lower elevation in the canyon. A possibility exists for a hydrologic connection between the spring and the discharge. The discharge may infiltrate the alluvium of DP Canyon, perch in the old erosional surface, cross the canyon, and emerge on the opposite wall. This would imply the presence of at least a limited zone of saturation in the alluvium and could demonstrate one subsurface migration pathway, which has been considered speculative in the past. On the other hand, the spring may rise from unknown water sources on the mesa above it to the north.

This spring was sampled three times during the period May to September 1990. Although flow rate has been variable (2 to 20 L/min) during this time period, this spring has not gone "dry" to date. Analyses results for samples from this spring collected from May to September 1990 are shown in Table 5.2-VI. Tritium values averaged 1.7 pCi/mL for the three samples taken.

Data needs. Investigations to identify the origin of the water emerging at DP Spring are needed. The presence of an alluvial aquifer in DP Canyon needs to be determined.

5.2.3. Infiltration and Vadose Zone Transport

Within the OU at TA-21, migration of contaminants in the subsurface will be in the vadose zone of the Bandelier Tuff. This is in contrast to the alluvium of the canyon bottoms discussed above (part of the **Canyons** OU), where zones of saturation are known and saturated flow processes are possible. As diagrammed in Fig.5.2-9, three mechanisms are of importance in the vadose zone as follows:

- infiltration of precipitation, which can provide the water to serve as a contaminant-carrying transport media;
- movement of the contaminant-bearing water in the vadose zone via unsaturated flow processes; and
- movement of tritiated water vapor and vapors of volatile compounds through the vadose zone in the gas phase.

Section 4.1.7, Vadose Zone Hydrology, summarized available information regarding these modes

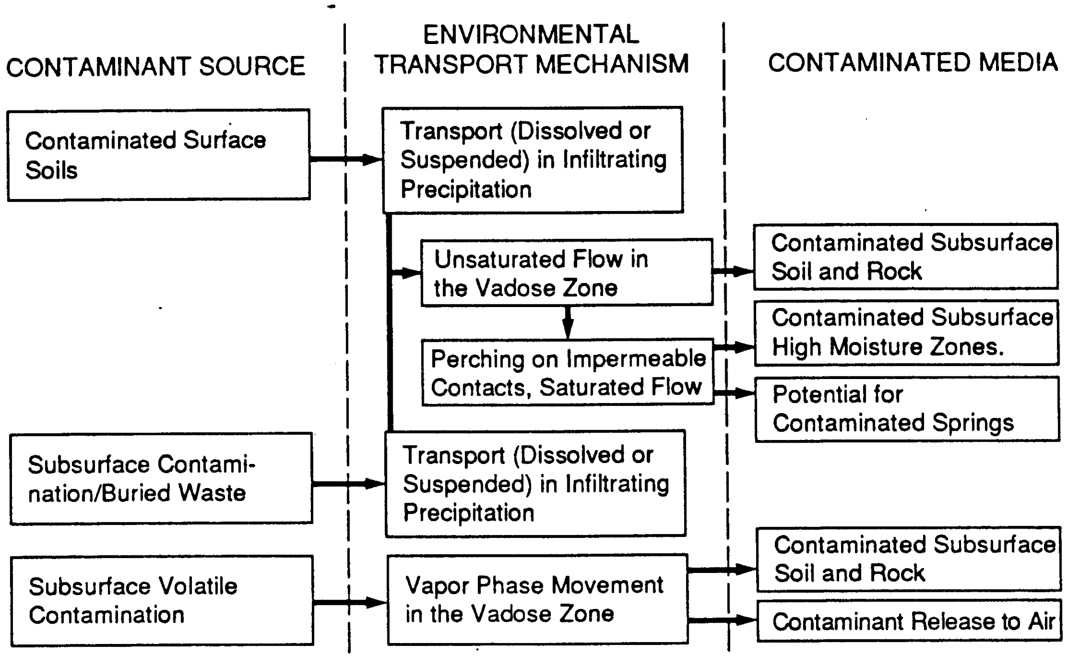


Fig. 5.2-9 Diagram of precipitation infiltration and vadose zone pathway.

of movement in the Bandelier Tuff. No additional data specific to TA-21 are available.

Liquid migration. The existing studies described in Sec.4.1.7 support the assessment that liquid-phase migration in the vadose zone may be a dead-end pathway in the Bandelier Tuff. That is, while some migration into the tuff may have occurred during the time when significant volumes of liquids were released, such migration ceased soon after the liquid releases ceased and cannot occur again in the absence of significant input of water. Those studies also indicated that infiltration of natural precipitation cannot provide the necessary quantities of water.

Uncertainties that remain include the role and importance of joints and fractures in the tuff that could act as enhanced routes for precipitation infiltration and the presence and importance of impermeable zones within the tuff (perhaps at unit contacts) where liquids input to the tuff may have perched and may potentially move horizontally to a release point on a canyon wall.

Data needs. Investigation of subsurface SWMUs at TA-21 that were formed by liquid discharges are needed to determine the distribution of contaminants in the subsurface and to address the status of the water in the contaminated zone. Specific attention should be given to identifying the presence of zones of elevated moisture content, especially in the context of paths for horizontal movement of water.

Vapor migration. Migration of tritium through tuff as tritiated water vapor has been documented near deep tritium disposal shafts at TA-54 (Purtymun 1973; Abeele et al. 1981). The subsurface distribution pattern indicates influences from the presence of open joints and fractures may be important. Migration of volatile organic compounds through tuff has been documented around chemical disposal pits, also at TA-54 (Devaurs 1985; Devaurs and Bell 1986). These studies are summarized in IWP Sec.2.6.3.4.4, Tritium Migration Studies, and Sec.2.6.3.4.7, Organic Plume Migration Studies (LANL 1990). No additional data are available for TA-21.

Depending on the magnitude of the source term for tritium and volatile organic compounds at the different SWMUs at TA-21, vapor phase migration may be a release pathway of interest. The importance of the pathway is dependent on the concentrations of contaminants moving as vapors and the availability of release points into the atmosphere.

Data needs. Investigations are needed to determine the source term for contaminants that may move in the vapor phase. Such investigations should evaluate the existing distribution of such contaminants in the subsurface and address the importance of joints and fractures as migration paths.

5.2.4. Erosive Exposure of Subsurface Contamination

Two major mechanisms exist for the long-term exposure of subsurface contaminated soils or buried wastes at TA-21, as identified in Fig.5.2-10. These are

- loss of surface soil cover by wind and water erosion and
- mass-wasting of canyon walls leading to the exposure of wastes from the side.

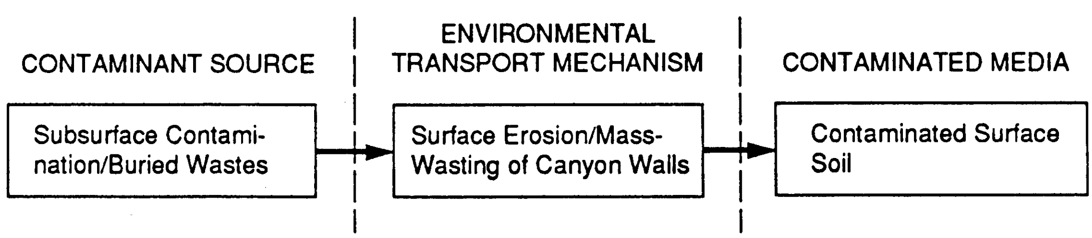


Fig. 5.2-10 Diagram of erosive exposure pathway.

These mechanisms would lead to contaminated surface soils that could be dispersed in the environment by the other transport pathways described above. The surface erosion mechanism is being investigated as part of cover-design pilot studies conducted Laboratory-wide and specifically at MDA B at TA-21 (see Sec.10.4.1, Capping). Mass-wasting of canyon walls is a very long-term process, which is also of interest Laboratory-wide. The continuing presence of 600- to 800-year-old prehistoric Indian cave dwellings in the mesa walls of the Pajarito Plateau is one indication of the time scale for this process.

Data needs. Data relevant to erosive exposure processes at TA-21 will be obtained from studies conducted Laboratory-wide by the ER Program. Continuation of pilot studies at MDA B will be needed for this purpose.

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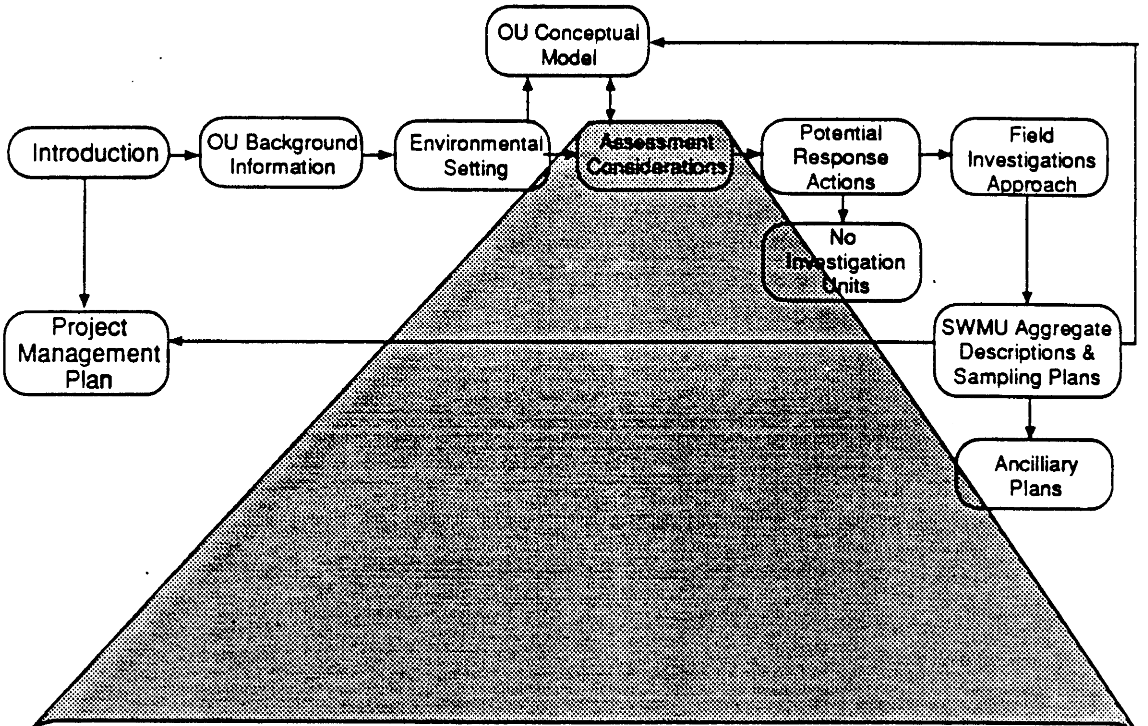
CHAPTER 6



Assessment Considerations

- Identification of Potential Receptors

6. IDENTIFICATION OF POTENTIAL RECEPTORS

The identification of populations representing potential receptors for contaminants released from SWMUs at TA-21 is based on the pathways described in Chapter 5, Potential Migration Pathways. Several subjects are addressed in this section as follows:

- local human populations are identified, including on-site workers at TA-21;
- potential exposure routes are determined;
- pathway-specific receptors are considered; and
- present and future land use patterns are discussed.

This chapter presents available information and identifies additional data needed for assessing threats to human health or the environment. The identified data needs will be acquired during the facility investigation. In future activities, these data will be used to assess the need for interim corrective measures, to perform baseline risk assessments for evaluation of no-action alternatives, and to evaluate the relative benefits of competing remedial alternatives.

6.1. Local Populations

The IWP (LANL 1990) describes the population distribution within a 50-mile radius of the Laboratory (Sec. 2.5.4, Population Distribution). The IWP presents a table documenting population density in 9 distance intervals for 16 compass directions, based on 1989 projections from 1980 census data.

The closest residents to TA-21 are located within 1 km to the north-northwest, in an area of Los Alamos referred to as the Eastern Community. Residences are also located within 1 km to the northwest. In this area are located several businesses, churches, recreational facilities (community pool and park), and a nursing home. The rest of the town of Los Alamos lies within a radius of 6 km in the quadrant from due north to due west. The IWP gives the population of Los Alamos as 12,100.

The town of White Rock lies within Los Alamos County approximately 7 km to the southeast. The IWP gives the population of White Rock as 7,200. Several isolated rental dwellings are located at Totavi, approximately 8.5 km east of TA-21 in the lower reaches of Los Alamos Canyon.

More than 100 Laboratory employees currently have offices and laboratories at TA-21, which remains an operational facility. The Laboratory's long range plans call for decontamination and decommissioning of DP West (see Sec. 2.4.1); therefore, the number of Laboratory employees at TA-21 will decrease in the future.

Data needs. A more refined distribution of population close to TA-21 is needed. Identification of sensitive population groups, maximally exposed groups, and other similar categories is needed.

6.2. Land Use

Land use in the vicinity of the Laboratory (including TA-21) is described in IWP Sec. 2.5.1, Land Use Patterns. For the TA-21 OU, land use in the immediate vicinity is unlikely to change while present social and political institutions continue to function. Land presently occupied by TA-21 and the neighboring canyons is expected to remain under DOE/Laboratory control. Outside of the immediate vicinity of TA-21, land use patterns can be expected to remain within the constraints imposed by the environment: little large-scale agriculture is anticipated, home gardens are typical, residences will be primarily in developed areas, low-intensity cattle grazing will occur in the lower reaches of the canyons on Indian land to the east.

Because the primary purpose of the town of Los Alamos is to support the Laboratory, the land would probably revert to National Forest or National Park Service (Bandelier National Monument) control if the Laboratory ceased to exist (i.e., loss of institutional control). In this case, recreational users and direct contact would need to be considered.

Data needs. An assessment of potential land use scenarios needs to be developed. This should address land use options that are tied to specific remedial alternatives. For example, future land use options may differ depending on whether a material disposal area is capped in place or removed. Detail is required on present land uses. This detail should include estimates of the intensity of recreational use of canyon areas and identification of specific areas used for cattle grazing.

6.3. Routes of Exposure

Under the current land use patterns in the vicinity of the TA-21 OU, no pathways or receptors are of concern. However, if land use patterns change in the future (i.e., loss of institutional control), exposure pathways would be of concern. For each contaminated medium identified in Chapter 5, routes of exposure for potential receptors have been identified (Fig. 6.3-1). For airborne contaminants, both inhalation and dermal contact have been identified. Tritium may be absorbed through the skin, and that is a route of exposure for some chemicals. For contaminated soil surfaces,

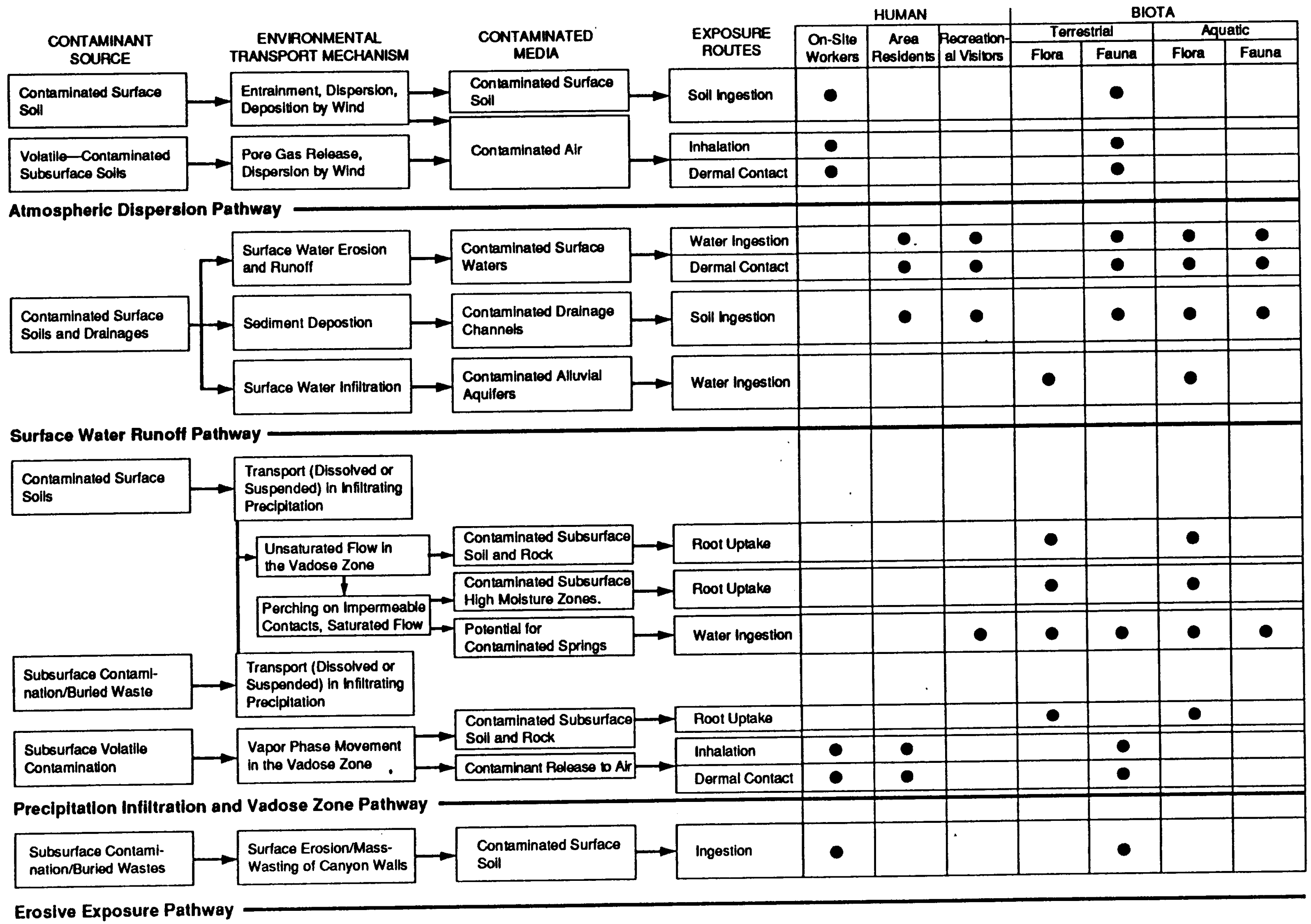


Fig. 6.3-1 Exposure routes and potential receptors for each contaminant transport pathway.

ingestion has been cited as the potential route of exposure to account for accidental ingestion of soil by adults and the often intentional ingestion by children. Ingestion of water is listed as a potential exposure route for running surface water as well as seeps and springs, although the potential for such ingestion is considered small. Ingestion is also a possible exposure route for the alluvial aquifers although, again, little potential exists. No human exposure routes for contaminants held in deep soil and rock were identified; only deep rooted plants are considered to have access to such contaminants.

Data needs. For several routes of exposure, there is a need to identify specific points of exposure and critical population groups that may have access to those locations. The exposure points may change depending on assumptions regarding future land uses. Identification of contaminants being transported in specific environmental pathways is an important data need — several pathways and exposure routes have been postulated on a conceptual basis and may not in fact be operable pathways.

6.4. Pathway Specific Receptors

For each contaminated medium and route of exposure, potential receptors have been identified in Fig. 6.3-1. The human populations exposed to airborne contaminants and contaminated surface soils include both onsite workers and area residents. Human receptors exposed to surface water run-off and drainage sediments are probably limited to those living downstream (Totavi) or persons hiking along the drainages. In the absence of institutional controls, the exposed human population would consist primarily of recreational users and possible residents. No human receptors could be identified for the contaminated alluvial aquifer or for contaminants retained in the liquid or vapor phase in subsurface rock and soil. A remote potential exists for human ingestion of contaminated water from seeps or springs. This route would be limited to persons hiking along a drainage.

Biota are also identified as potential receptors. Terrestrial biota are predominant because of the climate and the ephemeral nature of flow in the drainages. An exception is a small marshy area with aquatic vegetation in DP Canyon where the discharge from the sewage treatment plant reaches the canyon floor. Deep-rooted flora are the only potential receptors for contaminants in subsurface soil and rock. Small mammals, birds, reptiles, and insects are common terrestrial fauna throughout the area near TA-21.

Data needs. These receptors have been identified on the basis of conceptual evaluations of the pathways and limited available information regarding contaminant distribution at TA-21. As results of contaminant source and distribution studies are assessed, the focus on particular receptors may need to be reconsidered. A particular data need is for specific information on the presence of contaminants at points of exposure. Detailed exposure scenarios need to be developed based on identified exposure points, specific populations having access to the exposure points, and the identified contaminants of concern. For biota, a baseline biological survey of flora and fauna is needed.

6.5. Risk Assessment Issues

The considerations described above set the groundwork for health risk assessments that may be used to identify a need for immediate corrective actions or to assess the relative benefits offered by several remedial alternatives. To conduct such risk assessments, additional information is required that is independent of the facility investigation.

Data needs. Data are needed on the physiochemical nature of the contaminants that are determined to be migrating in the environment and available, or potentially available, at points of exposure. Action levels and other regulatory levels should be identified for those contaminants (some action levels have already been identified in the IWP), as well as the reference doses, slope factors, and other parameters required to estimate health risks from the particular radiological and chemical contaminants. An additional need is for the development of a standard method for combining radiological and chemical risk estimates to allow comparable decisions to be based on risks from either type of contaminant.

6.6. Current Risk Estimates

As a part of the Laboratory's annual environmental surveillance activities, estimates are made of the radiation exposures and health risks presented by Laboratory operations to local populations. These estimates are based on known releases from operating facilities and on the data collected at the environmental monitoring stations on and around the Laboratory. Data from some of those stations that are close to TA-21 are discussed in Sec. 4.2, Background Environmental Data and Sec. 5.2, Environmental Pathways. Although the estimates are prepared for the Laboratory as a whole, they are summarized here to provide a perspective on potential risks related to the TA-21 OU, which is small part of the Laboratory.

The environmental surveillance report documenting activities for 1988 (ESG 1989), indicates that the DOE Radiation Protection Standard (RPS), under which the Laboratory operates, limits radiation doses (effective dose equivalent) to 100 mrem/yr from all exposure pathways. In addition, exposure by the air pathway is limited to 25 mrem/yr in accordance with EPA requirements. The report states that the estimated dose to the maximum individual was 6.2 mrem in 1988 and was delivered primarily by the air pathway. The primary source of the airborne radioactivity was the Los Alamos Meson Physics Facility (LAMPF) located 1 km southeast of TA-21. For comparison, the average background radiation exposure to individuals living in Los Alamos is approximately 336 mrem/yr from all sources.

The environmental surveillance report estimates that the incremental risk of cancer to residents of Los Alamos due to 1988 Laboratory operations was 1.2×10^{-8} (ESG 1989). Of that risk, the TA-21 OU can represent only a small part.

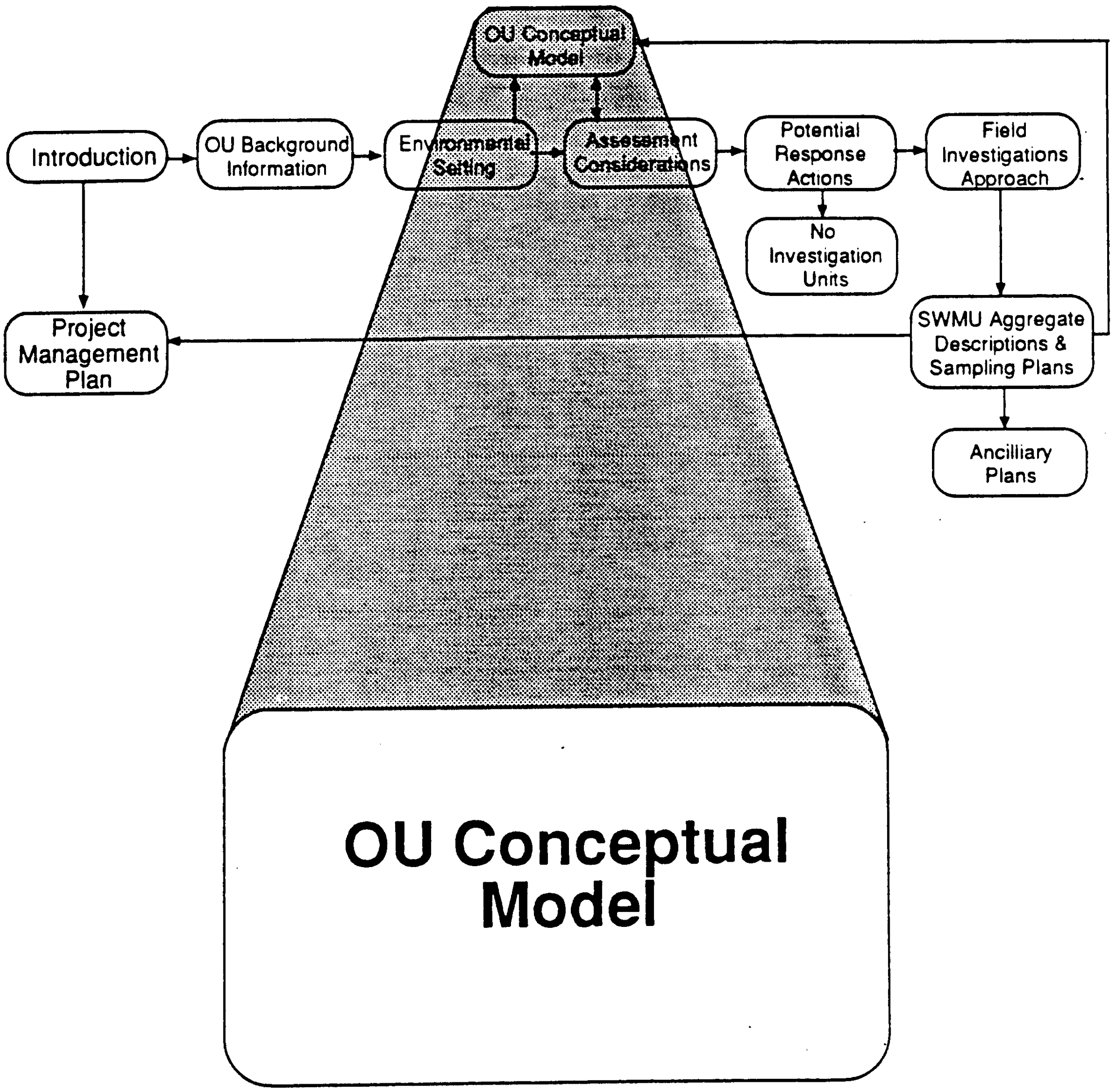
The risk assessment data needs described in preceding sections of this chapter are pertinent even in the light of the small risks currently estimated. Those data are required to assess risks for chemicals in addition to radionuclides, and they are needed to assess exposure scenarios that differ from the current land uses.

References

ESG*, June 1989. Environmental Surveillance at Los Alamos During 1988, Los Alamos National Laboratory Report LA-11628-ENV, Los Alamos, New Mexico.

LANL (Los Alamos National Laboratory), November 1990. "Installation Work Plan for Environmental Restoration," Los Alamos National Laboratory Report LA-UR-90-3825, Los Alamos, New Mexico.

CHAPTER 7


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
SWMU Aggregate Descriptions & Sampling Plans
Ancilliary Plans
Project Management Plan
OU Conceptual Model

7. CONCEPTUAL SITE MODEL

7.1. Development of the Conceptual Model

A conceptual site model has been developed through the discussions in the preceding three chapters and is summarized here. In diagram form, the conceptual model of contaminant release and transport and potential routes of exposure is presented in Fig. 7.1-1. The model is based on the present understanding of the TA-21 environment as presented in Chapter 4. The major pathways included in the model are based on present knowledge of the types of SWMUs present at TA-21 (four conceptual categories are identified in Sec. 5.1). The pathways descriptions include the primary release mechanisms, the environmental transport process, and the resulting contaminated media for each pathway (four pathway networks are described in Sec. 5.2). Exposure routes and potential receptors for the contaminated media resulting from each pathway are described in Chapter 6.

The data acquired from the field investigations planned in this RFI work plan will provide needed information to allow assessment of conditions at each SWMU. It is expected that initial assessments of the data will allow the current list of SWMUs to be reduced to those that actually have had releases of contaminants and those with source terms with the potential to migrate. The field investigations will also identify the magnitude of contaminant transport along each pathway and will allow the relative importance of the various pathways to be assessed. When these assessments have been made, the need for quantitative, mathematical models to describe contaminant transport will be determined.

At present, the site model is conceptual and serves to focus the investigations on the contaminant sources, contaminant properties, and environmental processes believed to be important at TA-21. If acquired data demonstrate that a different focus is appropriate, the conceptual model will be revised and the new focus will be pursued in subsequent investigations.

7.2. Elements of the Conceptual Model

Key concepts for each element of the conceptual model are summarized in the following paragraphs and amplified in Table 7.2-I. Figure 7.1-1 illustrates the overall conceptual model for TA-21.

Under the current land use patterns in the vicinity of the TA-21 OU, no pathways or receptors are of concern. However, if land use patterns change in the future (i.e., loss of institutional control),

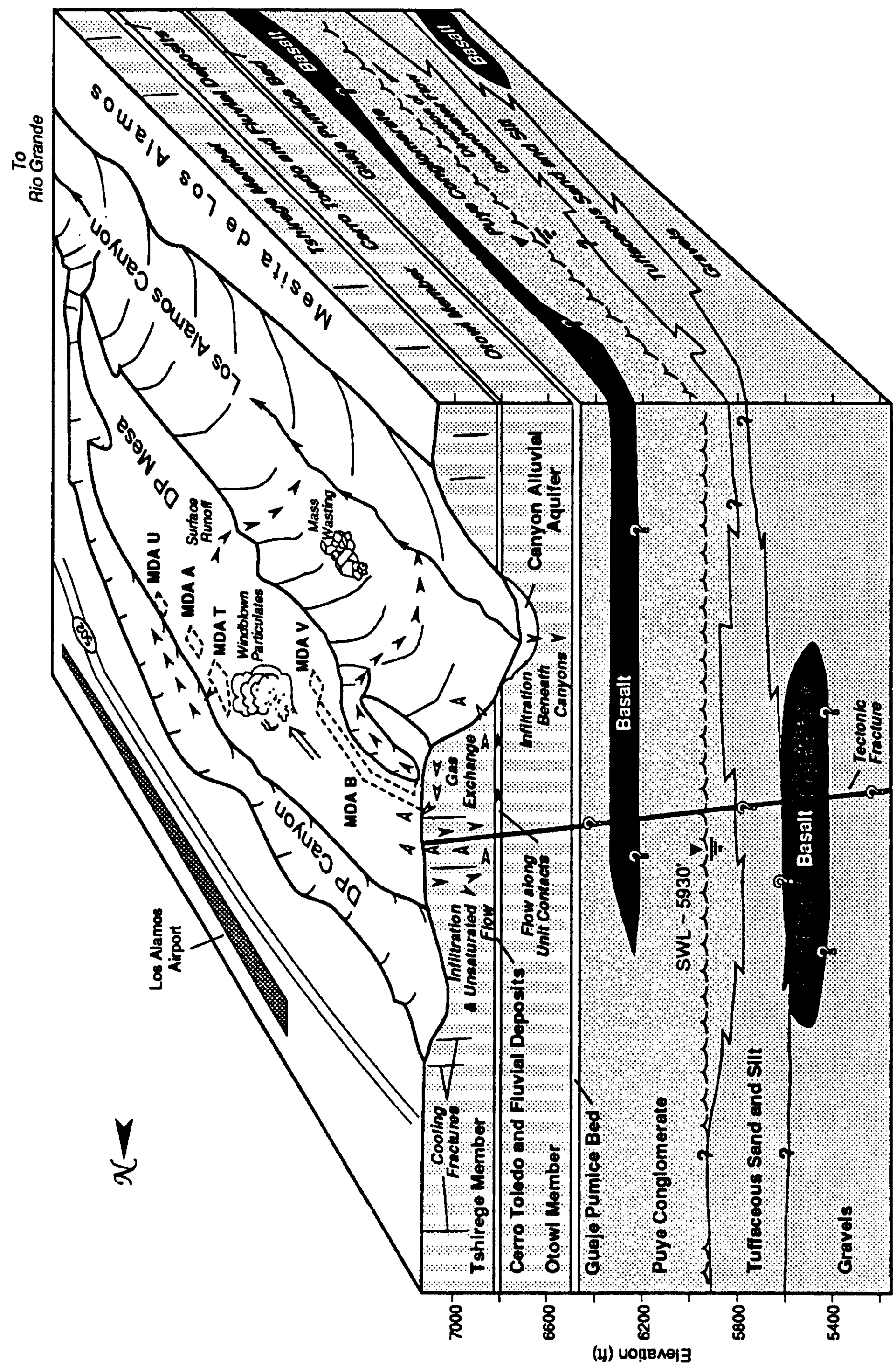


Fig. 7.1-1 Three-dimensional conceptual model of TA-21.

the primary exposure pathways of concern would be

- surface run-off and sediment transport and
- erosion and surface exposure.

Both unsaturated zone transport (in both the liquid and vapor phase) and the groundwater pathway are not of direct concern, based on the great depth and no known pathway to the main aquifer system.

Surface run-off and sediment transport. Water is perceived as the key component for contaminant migration at TA-21. Precipitation infiltration, run-off and soil erosion, and the subsequent movement and fate of the water and transported contaminants in the TA-21 environs constitute the basic components for understanding the system at TA-21.

Erosion and surface exposure. Erosive exposure processes are long-term release mechanisms serving to expose to the environment previously contained contaminants or to provide access of water to previously protected wastes. An understanding of these processes is necessary primarily for the design of certain remedial measures.

Should loss of institutional control occur, direct contact as a result of either recreational use or gardening will become the primary potential exposure rate.

Although not believed to be a significant pathway, wind entrainment of soil-borne contaminants, tritiated water vapor, or volatile organic compounds can be a pathway for widespread dispersal of contaminants. Dispersal is limited to surficial deposits, and gases and vapors exchanged to the atmosphere from soil pore-gas.

7.3. Conceptual Model Refinement

Site characterization data will enable further refinement of the conceptual model by providing data that either support the current model or redefine the site conceptual model. Not all data to support the conceptual model refinement will be collected at TA-21. The ER Program is currently developing regional characterization studies. Results of these studies will be integrated into the TA-21 OU conceptual model development.

Correctly defining the conceptual model is an integral part of building an accurate picture of the site processes and pathways important to contaminant migration. As appropriate, mathematical models will be derived from the conceptual model to guide later data collection, to test hypothesis, and to support the CMS.

TABLE 7.2-I SUMMARY OF CONCEPTUAL MODEL ELEMENTS

Pathway/Mechanism	Concepts/Hypotheses
Atmospheric Dispersion	
Particulate Dispersion	• Entrainment is limited to contaminants in surface soils. • Entrainment and deposition are controlled by soil properties, surface roughness, vegetative cover and terrain, as well as atmospheric conditions. • Atmospheric conditions affecting entrainment, dispersal and deposition include wind speed, direction, stability class, and precipitation.
Gas/Vapor Dispersion	• Gas exchange between the subsurface and atmosphere provides the release mechanism for volatile contaminants, such as tritium or volatile organic compounds. • Gas exchange between the rock and atmosphere is a function of temperature gradients and barometric pumping. • Fractures may be facilitators of gas exchange between the rock and the atmosphere. • Atmospheric conditions affecting dispersal include wind speed, direction, stability class, and precipitation.
Surface Water Run-off	
Surface water	• Precipitation that does not infiltrate will become surface run-off. • Surface run-off is concentrated by natural topographic features, or man-made diversions, and flows towards the canyons. A topographic low can cause the water to pond on the mesa top, but in most cases the water will flow into the canyon. • Contaminant transport by surface run-off can occur in solution, sorbed to suspended sediments, or as mass movement of heavier bed sediments. • Surface run-off may carry contaminants beyond the TA-21 OU boundary. • Contaminated surface run-off may infiltrate the canyon bottom alluvium.

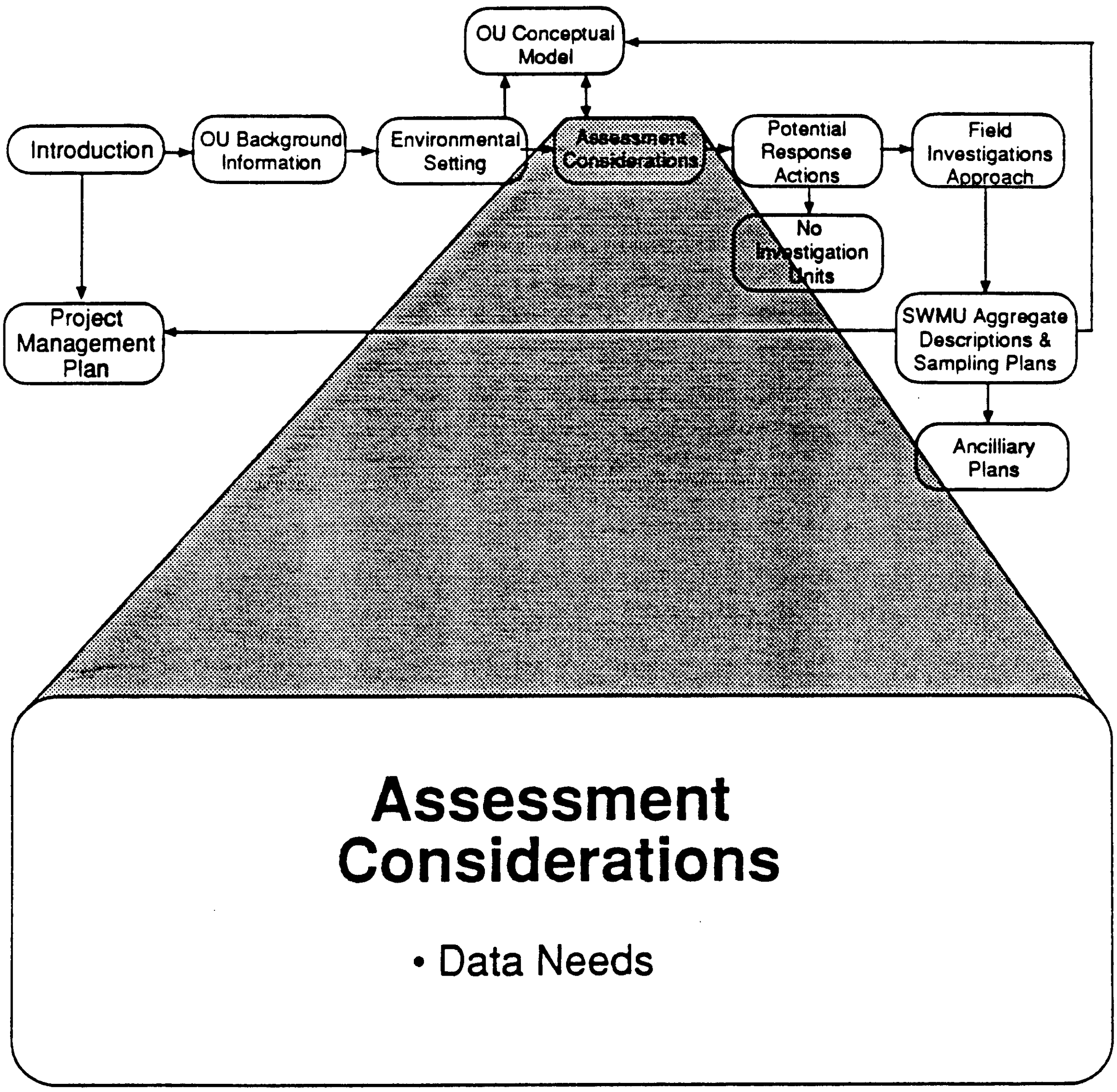
Sediments	• Surface soil erosion and sediment transport is a function of run-off intensity and soil properties. • Contaminants dispersed on the soil surface can be collected by surface water run-off and concentrated in sedimentation areas in drainages. • Erosion of drainage channels can extend the area of contaminant dispersal in the drainage way.
Alluvial aquifers	• Surface run-off discharged to the canyons may infiltrate into sediments of channel alluvium. • Flow in the alluvial aquifer under saturated conditions will be down channel, and can be represented by a porous media continuum model. • Retardation of contaminants will be primarily by sorption in the alluvium or on organic material that is present in the alluvium. • Water in the alluvial aquifer may enter the underlying tuff. The process will depend on the properties of the interface between the saturated alluvium and unsaturated tuff.

Infiltration and Vadose Zone Transport.

Infiltration	• Infiltration into surface soils depends on the rate of precipitation or snowmelt, antecedent soil water status, depth of soil, and soil hydraulic properties. • Infiltration into the tuff depends on the unsaturated flow properties of the tuff. • Joints and fractures in the tuff may provide additional pathways for infiltration to enter the subsurface regime.
Unsaturated flow - liquid phase	• Movement of liquids in the Bandelier Tuff is dominated by unsaturated flow processes. • Transient rather than steady state conditions may describe the hydraulic character of the near-surface tuff. The influences include surface water infiltration and evapotranspiration. • Liquid water flow under ambient conditions can be represented by a porous media continuum model. • A condition of non-flow may be present in the tuff below the influence of transient surface moisture effects. • The movement of contaminants by liquids in the unsaturated zone may be in solution or as suspended solids.

	• Retardation of contaminants will be primarily due to sorption on the tuff or organic material that is present on the tuff. • Fractures may affect liquid transport. Their role is hypothesized to be dependent on the soil water content. Above a critical water content, fractures are expected to facilitate flow and transport. Below the critical water content, rock matrix properties will dominate the hydraulic response.
Unsaturated flow - vapor phase	• Vapor phase processes are important as a transport process for certain contaminants. Matrix influences include porosity, permeability, moisture content and other properties of the tuff. • The exchange of pore gas with atmospheric air is a release mechanism for vapor phase contaminants, and is influenced by temperature gradients and atmospheric pressure changes. • Fractures may be facilitators of gas exchange both within the rock and with the atmosphere.
Lateral flow at unit contacts	• Contrast in hydraulic properties between layers or due to inclusions may divert flow laterally, or may cause a perched water zone to develop. • Laterally diverted flow may find surface expression as springs or seeps. • Perched water zones may provide localized areas where saturated flow conditions may occur.
Erosive Exposure	
Soil Erosion	• The erosion of surface soils is dependent on soil properties, vegetative cover, slope and aspect, exposure to the force of the wind, and precipitation intensity and frequency. • Erosion may be controllable by natural or man-made surface features. • Depositional areas as well as erosional areas exist, and erosive loss of soil may not occur in all locations.
Mass Wasting	• The loss of rock from the canyon walls is discontinuing, observable process. • The rate of the process is extremely slow.

CHAPTER 8


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
Project Management Plan
SWMU Aggregate Descriptions & Sampling Plans
Ancilliary Plans
Assessment Considerations
• Data Needs

8.0 DATA NEEDS

This chapter succinctly summarizes the overall data needs for the TA-21 OU generated from discussions of available information on the environmental setting, potential migration pathways, and risk assessment in Chapters 4 through 6, respectively (Table 8-I). Specific plans for obtaining the needed data are presented in the field sampling plans (Chapters 12–18). The SWMU-specifi, contaminant-related data needs are also identified in Chapters 12-18, and summarized in Table 8-II.

TABLE 8-I. SUMMARY OF DATA NEEDS FOR THE TA-21 OU RFI WORK PLAN

Objective	Data Need
Characterize Site Hydrogeology	
1. Determine site stratigraphy, depth and nature of unit contacts for upper vadose zone.	• Select locations across entire OU for subsurface characterization investigations. • Borehole coring and lithological logging to identify units and characterize unit contacts in the upper 300 ft of tuff.
2. Determine physical, mineralogic and hydrologic properties important to unsaturated and vapor phase migration for upper units of the Bandelier Tuff.	• Mineralogic analysis of borehole cores. • Physical/hydrological measurements on borehole core samples. • Downhole logging of boreholes to identify changes in moisture, density, mineralogy with depth. • Downhole video to inspect fractures, joints, unit contacts. • Downhole air permeability tests.
3. Investigate rate of water/vapor migration using dating of native water in tuff.	• Isotope ratios on water extracted from bulk tuff and fractures/joints.
4. Investigate nature of joints and fractures in the tuff as potential barriers or migration routes	• Measurements of moisture content and mineralogical differences. • Evidence of impermeable layers and elevated moisture zones. • Measurements of air permeability differences *in situ.* • Geochemical characterization of core samples.
Characterize Site Morphology	
1. Identify surface geology, unit contact expressions, expressions of paleo-erosional surfaces.	• Geologic map of entire OU. • Measurements of exposed units in DP and Los Alamos Canyon cliffs.
2. Characterize morphology of drainages.	• Locations of erosional and depositional areas, drainage paths. • Measurements of chemical and radiological contaminant levels in sediment samples.
3. Investigate presence of fault expressions and fracturing to confirm or refute projection of a possible fault beneath MDA V.	• Field studies and drilling to determine location and character of possible fault beneath MDA V.

4. Determine if faults affect the distribution of subsurface units, or provide potential pathways for contaminant migration.	• Field investigations, fracture mapping, observation of contact offsets to identify any expression of faulting in the upper units of the tuff.

Characterize Mesa-wide Surface Contamination

1. Characterize contaminant levels in surface soils across the entire OU to form a basis for comparison.	• Establish a grid for mesa-wide investigations. • Establish a grid for mesa wide investigations. • Collect surface soil samples (6 in.) for chemical and radiological analysis, use same sample interval as will be used for all SWMU investigations. • Make measurements with radiological survey instruments to determine ambient readings across the mesa.
2. Characterize contaminant levels in near-surface soils across the entire OU to form a basis for comparison.	• Collect near-surface soil samples for chemical and radiological analysis, use same sample intervals (6 in,) and typical depth (24 in.) as will be used for individual SWMU investigations.
3. Characterize contaminants in a thin layer at the soil surface as an indication of wind deposited contaminants from past stack releases.	• Use site wide grid. • Collect deposition layer samples (1 in.) for comparison to thicker surface soil samples (6 in.) to identify if contaminants are confined to a thin layer on the soil surface.

Characterize Contaminant Sources

1. Identify the presence of contaminants at each SWMU.	• Sampling at release points. • Field screening at point of collection for health and safety, and to flag grossly contaminated samples. • Use field laboratory analyses to aid in directing field work.
2. Identify the contaminants.	• Laboratory analyses using standard methods for radiological contaminants. • Laboratory analyses using SW-846 methods for chemical contaminants.

Characterize Nature and Extent of Contamination

1. Identify any evidence of migration of contaminants away from each SWMU.	• Sampling along preferential paths of migration. • Additional sampling to document other avenues of migration and extent of generalized contaminant spreading (boreholes at radial increments, surface grids).

	• Field screening as above. • Field laboratory measurements as a screening tool for identified contaminants to reduce analytical laboratory burden, and to aid in guiding field work.
2. Identify mobile contaminants.	• Laboratory analysis to identify the contaminants that are migrating. • Analysis methods as above.
Provide Data for Baseline Risk Assessment	
1. Identify potential receptors for each pathway.	• Exposure points for each major pathway. • Population distribution, access to exposure points. • Future land use scenarios.
2. Determine contaminant fate and transport.	• Data on the physiochemical processes associated with site contaminants based on the literature and site specific information.
3. Assess contaminant levels against action levels and other guides.	• Action levels or other regulatory levels for contaminants at the site.
4. Assess threat to public health and the environment from the no action remedial alternative.	• Reference doses and slope factors for contaminants at the site. • Exposure scenarios.
5. Assess potential remedial measures.	• Data regarding the effectiveness of each remedial alternative. • Reference doses and slope factors for contaminants at the site. • Exposure scenarios.
Provide Data for Assessing Remedial Alternatives	
1. Assess potential remedial measures.	• Information on migration pathways to be blocked. • Information on effectiveness of the remedial measure. • Information on ease of implementation, long term effectiveness, cost.

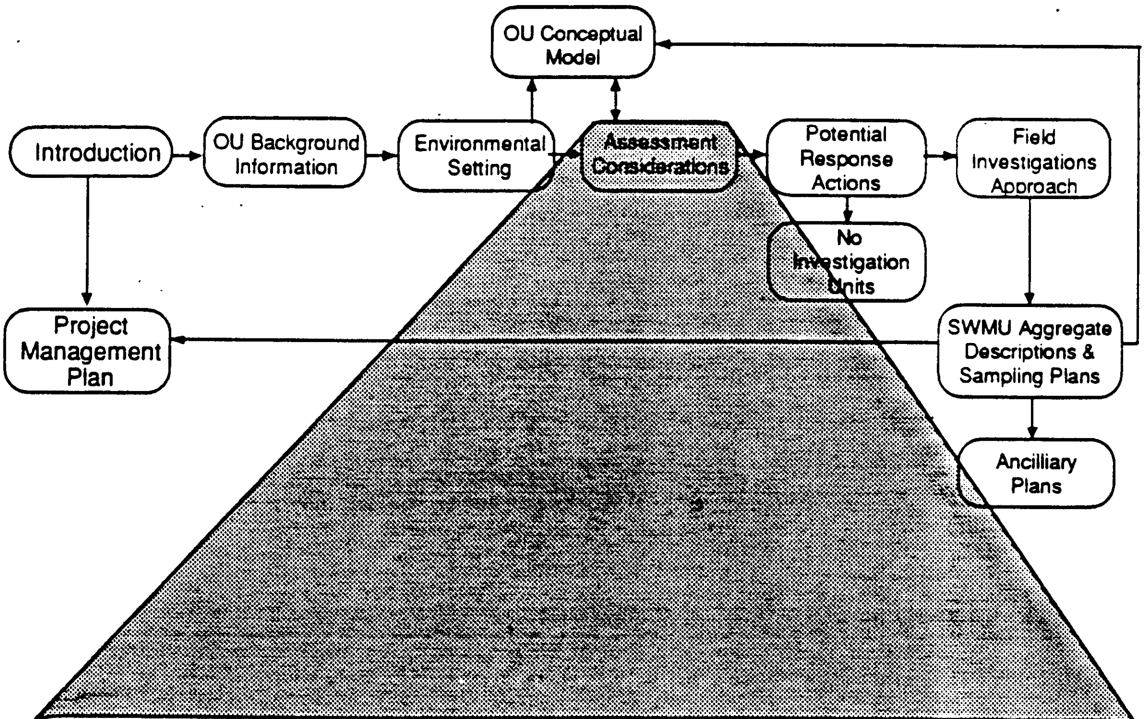
TABLE 8-II. SUMMARY OF SWMU-SPECIFIC DATA NEEDS

Investigation Unit	SWMU #	Determine location of unit	Identify presence/absence of contaminants in unit	Establish contaminant suite related to unit	Determine lateral extent of contamination	Identify depth of contamination	Estimate source volume/concentration	Estimate contaminant plume volume/concentration	Assess interaction of contaminants with air pathway	Assess interaction of contaminants with surface water pathway	Assess interaction of contaminants with groundwater pathway	Assess interaction of contaminants with biotic pathway	Determine direction and rate of transport by air	Determine direction and rate of transport by surface water	Determine direction and rate of transport by groundwater	Determine direction and rate of transport by biota	Estimate potential impact on human health	Estimate potential impact on environment	No further action
Storage Areas and Tanks	-002	x	x	x	x	x		x		x		x		x		x	x		x
	-003		x	x	x	x		x		x		x		x		x	x		x
	-004		x	x	x	x		x	x		x		x		x	x		x	x
	-028 (d),(e)		x	x	x	x		x	x		x		x		x	x		x	x
	-029		x	x	x	x		x		x		x		x		x	x		x
Surface Disposals	-013 (b)–(f)	x	x	x	x	x	x	x		x		x	x		x		x		x
Stack Emissions	-007, -008 -019, -020 -021		x	x	x	x	x	x		x		x		x		x	x		x
No Investigation Units	-025																		x
	-012(a)																		x
	-028(e)																		x
	-029(b)																		x

TABLE 8-II (continued)

Investigation Unit	SWMU #	Determine location of unit	Identify presence/absence of contaminants in unit	Establish contaminant suite related to unit	Determine lateral extent of contamination	Identify depth of contamination	Estimate source volume/concentration	Estimate contaminant plume volume/concentration	Assess interaction of contaminants with air pathway	with surface water pathway	with groundwater pathway	with biotic pathway	Determine direction and rate of transport by air	by surface water	by groundwater	by biota	Estimate potential impact on human health	on environment	No further action
Outfalls	-023(c), -024 -027, & outfalls	x	x		x	x	x	x		x		x		x		x	x		x
MDAs	-014 to -018, -001, &028(a)		x		x	x	x	x		x		x		x		x	x		x
Subsurface Units	-005, -006(b)		x		x	x	x	x		x		x		x		x	x		x
	-009		x		x	x	x	x		x		x		x		x	x		x
	-012		x		x	x	x	x		x		x		x		x	x		x
D & D Units	-006(a),(c)–(f)	x	x		x	x	x	x		x		x		x		x	x		x
	-022				x	x	x	x		x		x		x		x	x		x
	-023(a),(b),(d)	x	x		x	x	x	x		x		x		x		x	x		x
	-028(b),(c)		x		x	x	x	x		x		x		x		x	x		x
Areas of Concern		x	x		x	x	x	x		x		x		x		x	x		x

CHAPTER 9



Assessment Considerations

• Data Quality Objectives

9. DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the type, quality, and quantity of data collection needed to guide the decisions that will achieve the objectives of the RFI (EPA 1987). In Chapter 2 (see Sec 2.3.2, TA-21 Objectives and Approach) the SWMU-specific and OU-wide objectives of the TA-21 OU RFI were established as follows:

- Identify contaminants (if any) present at each SWMU.
- Determine the nature and extent of contamination for each SWMU.
- Identify pathways of contaminant migration from each SWMU and for the operable unit as a whole.
- Characterize the TA-21 environment sufficiently to allow quantitative migration pathway and risk assessment analyses, as necessary.
- Provide necessary data for initial assessment of remedial alternatives.
- Provide the basis for planning detailed corrective measures studies.

In the course of planning each aspect of the facility investigation, specific data needs were identified for achieving the objectives. These data needs have been listed in each section of Chapters 4–7 and 12–18, and have been summarized in Chapter 8, Data Needs. In Chapter 11, Methods, and in Appendix A, TA-21 Quality Assurance Project Plan, the analytical or other methods required to provide the needed level of data quality have been identified in specific detail.

This chapter documents in summary form the results of the application of the DQO process to the planning of investigations at TA-21. The summary addresses these issues as follows:

- The definition of required data quality for each data type to achieve the objectives and data needs given in Chapter 8. This is addressed by specifying the methods to be used to provide data sufficient for the intended use.
- Definitions of data quality levels (DQO Levels) to be used as abbreviated descriptions of data quality in the field sampling plans (Chapters 12–18).

9.1. DQOs for Identified Data Types

The purpose of the DQO process is to provide a method for determining the amount and quality of data required to support decisions during the RFI. The data requirements are integrated with the development of field sampling plans and are represented there by specifying the number and analytical level of data points required at individual SWMUs (Chapters 12–18). This section summarizes, by data type and intended data use, the level of quality needed to meet the objectives of investigations at each SWMU and the overall data needs and data use objectives given in Chapter 8.

Table 9.1-I summarizes data types for OU-wide characterization activities. As can be seen in Table 9.1-I, high quality data are required for all OU-wide characterization activities. Two reasons account for the emphasis on higher quality data over less expensive types of information as follows:

- OU-wide measurements of hydrogeological parameters provide the basis for contaminant transport modeling and may be instrumental in health risk analyses.
- Surface and subsurface "background" contaminant levels will be established OU-wide. These values will be used as a basis of comparison for identifying SWMU-related contaminant levels. These data need to be of high quality because they are used as a basis for the decision to take no further action at an individual SWMU.

For SWMU-specific investigations, four general types of data will be collected: field screening, field survey, field laboratory, and analytical laboratory (see Chapter 11 for detail). The intended data usage and required data quality for these data types are summarized in Table 9.1-II, and fall into several categories as follows:

- Field identification of sources of contamination
- Health and Safety-related information
- Early identification of grossly contaminated samples
- Delineation of contaminated zones prior to sampling for high quality analysis

- Guidance for making decisions regarding the effectiveness of the sampling plan during the course of field operations
- High-confidence-level analysis for contaminant species

9.2 Definition of Analytical Level DQOs

Four analytical data quality levels (DQO Levels) are used as abbreviated statements in describing SWMU-specific, contaminant-related data needs in the field sampling plans (Chapters 12–18). Characteristics of the four categories (EPA 1987) are given in Table 9.2-I. As defined for use in this document, the categories include:

- Level I — data from survey methods used to identify contaminants *in situ* or field sample screening methods to be used at the point of sample collection.
- Level II/III — field laboratory measurement methods used to provide rapid quantitative or semiquantitative sample analyses during the course of field operations.
- Level III/IV — analytical laboratory methods used to provide accurate, precise, defensible data.

TABLE 9.1-I DATA TYPES FOR TA-21 OU-WIDE CHARACTERIZATION ACTIVITIES

Data Type	Intended Uses	Required Data Quality
OU-Wide Subsurface Characterization		
Mineralogy/geochemistry (e.g., clay mineral content , zeolite mineralogy, cation exchange capacity, sulfate mineral content, etc.)	Predict contaminant movement through tuff.	Standard laboratory methods. Standard operating procedures. The intended use is consistent with normal use of these data, thus standard methods provide appropriate data quality.
Hydrogeological parameters (e.g., moisture content, bulk density, porosity, permeability, moisture characterization curve, hydraulic conductivity)	Estimate flux through vadose zone.	The required data uses can be supported by data provided by standard laboratory methods. Excessive variability in early data may require additional sampling/analysis to identify source of variability.
	Estimate velocity in vadose zone.	
	Estimate contaminant movement in vadose zone.	
	Input to a flow and transport model.	
Pore gas sampling (e.g., straddle packer tests, isotope characterization at water extracted from bulk tuff)	Delineate depth of migration of water that has infiltrated into the subsurface below DP Mesa.	Standard field and laboratory methods are to be used. These were developed for the intended data uses and provide data of sufficient quality.
	Determine absolute ages of pore water in vertical hydrostratigraphic section of 300 ft deep boreholes.	
	Characterize vapor transport pathways by determining in situ permeability.	

TABLE 9.1-I DATA TYPES FOR TA-21 OU-WIDE CHARACTERIZATION ACTIVITIES

Data Type	Intended Uses	Required Data Quality
OU-Wide Surface Characterization		
Geomorphology (e.g., geologic base map, drainage patterns, sediment deposition areas)	Identify surface geologic features that may influence contaminant movement, contaminant distribution, and the capping/stabilization-in-place remedial option.	Standard geological field methods will be used. Procedures used will be documented. This will provide sufficient quality for the identified uses.
	Determine potential contaminant collection areas.	
	Determine if overland or channel flow can result in offsite transport, and if flow patterns identify contaminant transport pathways.	
Fault/fracture mapping	Determine the potential for contaminant transport via faults and fractures.	Standard geological field methods will be used. Procedures used will be documented. This will provide sufficient quality for the identified uses.
	Determine potential impact on site stability and feasibility of stabilization-in-place remedial options.	
Surface contaminant characterization.	Provide a basis for comparison to determine whether individual SWMUs are contaminated.	Analytical laboratory analyses providing Level III/IV data are required.

TABLE 9.1-II DATA TYPES FOR SWMU-SPECIFIC CHARACTERIZATION ACTIVITIES

Data Type	Intended Uses	Required Data Quality
Field surveys (e.g. gross gamma, phoswich, geophysical)	Direct reading/recording instruments to scan land surface and measure in situ conditions.	Level I data are acceptable for identifying sources of contamination.
Field screening (e.g., gross gamma, gross alpha, organic vapor, lithological logging)	Point of collection sample measurements.	Level I data are acceptable for identifying contaminated samples and other intended data uses.
	Identify grossly contaminated samples.	
	Document sample lithology.	
	Support Health and Safety operations.	
Field laboratory measurements (gross alpha, gamma spectrometry, tritium, volatile organics, PCBs, soil moisture)	Guidance to field operations (i.e., borehole stopping criteria)	Primarily Level II data will be used since a significant number of confirmatory analytical laboratory measurements will be obtained.
	Aid in selecting judgmental sampling locations (e.g., to select "hot" samples for contaminant identification, or to select "no detect" samples for analytical laboratory confirmation)	Some of the techniques may be Level I or Level III, as well.
	Analytical sample load reduction.	
Analytical laboratory measurements (SW846, radiochemistry)	Provide the fundamental high quality, defensible data.	Level III and IV data are considered to be appropriate for these uses. In some circumstances, well-supported Level II data may be acceptable.

TABLE 9.1-II DATA TYPES FOR SWMU-SPECIFIC CHARACTERIZATION ACTIVITIES

Data Type	Intended Uses	Required Data Quality
	Give a broad list of identifiable species.	
	Accurate, precise quantitation.	
	Regulatory agency acceptance.	
	May be used for risk assessment purposes.	

TABLE 9.2-I. SUMMARY OF ANALYTICAL LEVELS APPROPRIATE TO DATA USES[a]

Data Uses	Analytical Level	Limitations	Type of Analysis	Data Quality
Site characterization, monitoring during implementation	Level I	Field screening for organic vapor and radiological detection using portable instruments	Instruments respond to naturally occurring compounds	If instruments calibrated and data interpreted correctly, can provide indication of contamination
		Field test kits		
Site characterization, evaluation of alternatives, engineering design monitoring during implementation	Level II	Variety of organics by GC, inorganics by AA, XRF	Tentative identification	Dependent on quality assurance/quality control steps employed
		Tentative identification, analyte specific	Techniques/instruments limited mostly to volatiles, metals, some radionuclides	Data typically reported in concentration ranges
		Field laboratory analyses for some radiological constituents	Tentative identification and quantification	Dependent on quality assurance/quality control steps employed
		Detection limits vary from low ppm to low ppb		
Risk assessment, site characterization, evaluation of alternatives, engineering design, monitoring during implementation	Level III	Organics/inorganics, using EPA procedures other than CLP, can be analyte specific	Specific identification; tentative identification in some cases	Similar detection limits to CLP
		RCRA characteristic tests	Can provide data of same quality as Level IV	Less rigorous quality assurance/quality control
		Radiological constituent	Specific identification; detection limits below background; with suitable QC, gives comparable quality to SW846 methods	Quality assurance/quality control is comparable to SW846 methods
Risk assessment, evaluation of alternatives, engineering design	Level IV	TCL/TAL organics/inorganics by GC/MS, AA, ICP	Tentative identification of non-TCL parameters	Goal is data of known quality
		Low ppb detection limit	Some time may be required for validation of packages	Rigorous quality assurance/quality control
Risk assessment	Level V	Nonconventional parameters	May require method development modification	Method-specific
		Method-specific detection limits	Mechanism to obtain services requires special lead time	
		Modification of existing methods		

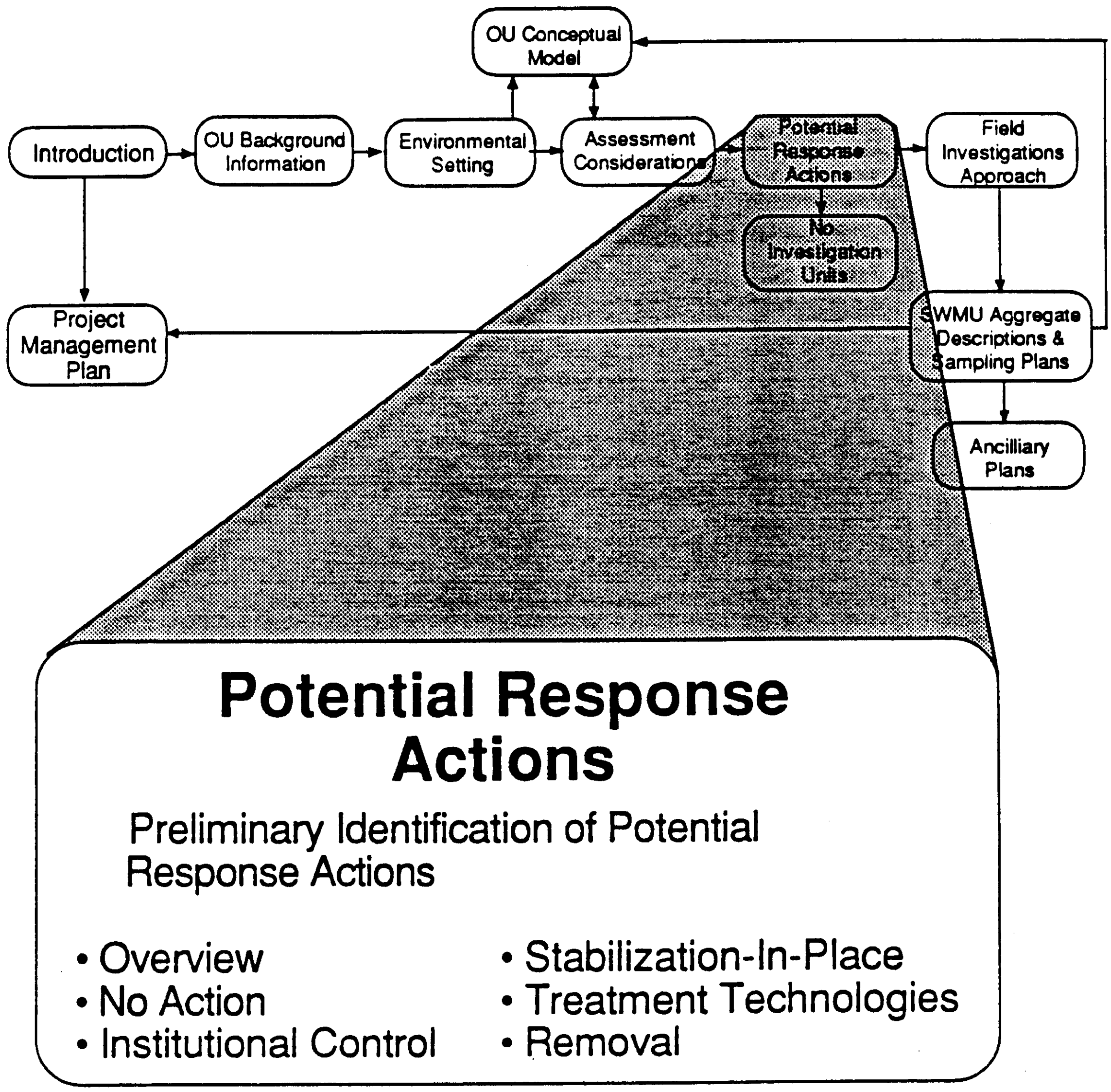
GC - gas chromatography; ICP - inductively coupled plasma; AA - atomic absorption
EPA - Environmental Protection Agency; XRF - X-ray fluorescence; CLP - Contract Laboratory Program
MS - mass spectrometry; RCRA - Resource Conservation and Recovery Act; TAL - Target Analyte List
TCL - Target compound list

[a]EPA (1987).

References

EPA (US Environmental Protection Agency), March 1987. "Data Quality Objectives for Remedial Response Activities, Volume I: Development Process," EPA 540/G-87/003, OSWER Directive No. 9355.0-7B, prepared by CDM Federal Programs Corporation, Washington, DC.

CHAPTER 10



OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
Project Management Plan
SWMU Aggregate Descriptions & Sampling Plans
Ancilliary Plans
Potential Response Actions
Preliminary Identification of Potential Response Actions
• Overview
• No Action
• Institutional Control
• Stabilization-In-Place
• Treatment Technologies
• Removal

10 PRELIMINARY IDENTIFICATION OF POTENTIAL RESPONSE ACTIONS

10.1 Overview

The IWP Sec. 3.5.2.3 (LANL 1990) details the Laboratory's approach to the RFI to focus field investigations to determine whether a CMS is necessary and to support the performance of a CMS or the design and implementation of a corrective measure. The staged investigative approach being employed for the RFI at TA-21 encourages identification of key data needs as early in the process as possible (see Chapter 8) to ensure that data collection is always directed toward providing information relevant to selection of a remedial action. This chapter provides a preliminary development and screening of technologies and alternatives for TA-21 SWMUs, but detailed screening and analysis cannot be performed until additional data are collected.

Following RCRA Subpart S guidelines and the observational approach, it is appropriate to identify response actions that are probable based on existing data as early as possible in the site characterization process. This helps focus RFI activities to collect data to support and evaluate possible remedial alternatives. After initial site characterization sampling is conducted, potential remedial alternatives for corrective action will be re-evaluated. Any subsequent sampling may differ according to the results of this initial evaluation.

Although uncertainty with regard to both the nature and extent of potential contaminants present at TA-21 SWMUs varies, as detailed by SWMU or SWMU aggregates in Chapters 12 to 19, the following general response actions are believed to be technically feasible and appropriate for use at TA-21 SWMUs, as summarized in Table 10-I:

- no action,
- institutional control (monitoring, fencing, deed control),
- stabilization-in-place (containment such as capping),
- treatment, and
- removal (excavation to RCRA mixed-waste or radioactive-waste landfill).

This section does not give an all-inclusive list of potential remedial alternatives. It focuses on the most likely response actions for TA-21 SWMUs based on existing data. As additional data are collected as part of the RFI, applicable remedial action technologies will be re-evaluated by SWMU or SWMU aggregate. These data will provide for a thorough comparative evaluation of the technologies with respect to implementation, effectiveness, and cost, and allow for informed decisions to be made with respect to selection of remedial alternatives.

10.2. No Action

The no-action category signifies complete inaction at a given site. It allows conditions and processes currently occurring at the site to continue.

The no-action alternative may be applicable if field investigation results indicate the following conditions:

- not a SWMU;
- no contaminants are present;
- contaminants are present but at concentrations below regulatory action levels; or
- risk assessment demonstrates that the extent of contamination and the associated exposure pathways result in no risk or acceptable risk using the risk assessment methodology to be developed and implemented in the RFI report and the CMS work plan and report.

The no-action alternative also serves as a basis for comparison with other alternatives.

To undertake no action is to refrain from intervening in the fate and transport of contaminants. No action does not necessarily perpetuate the status quo because natural processes may be transforming a site. In this context, the no-action alternative is known as passive remediation. Passive remediation recognizes the effects of natural processes such as biodegradation, volatilization, photolysis, leaching, and absorption that may have beneficial effects on contaminants present at a specific site.

At the majority of TA-21 SWMUs listed in Table 10-I, the no-action alternative may apply for varying reasons detailed in the field sampling plans. The outfall sampling strategy (see Chapter 15) assumes that the no-action alternative is most likely. It is also likely to apply to most surface SWMUs discussed in Chapter 14 and to the ER sampling sites in Chapter 19. If surface soil contamination from stack emissions (Chapter 13) is below action levels or poses no risk to human health and the environment, no action may be required. If risk assessment shows subsurface units pose either no risk or an acceptable risk, it may also apply to Chapter 17 SWMUs.

10.3 Institutional Control

If field investigation results indicate that contaminants are present in concentrations above regulatory action levels or if waste is left in place at a given site, other response actions or combinations of response actions, such as monitoring, fencing, or deed control, may be required. For example, the site could be fenced and monitored to evaluate migration of contaminants over time.

10.3.1 Monitoring

Monitoring involves no substantial action on contaminated media, but it does provide information about the status of contaminants. In situations where no other action is taken, monitoring can serve not only to document passive remediation but also to provide early warning in the event that passive remediation fails to adequately protect human health and the environment. Monitoring may also be needed in situations where containment, collection/removal, or treatment actions are undertaken. Its purpose in these situations would be to document the effectiveness of the remedial actions and to provide early warning in the event the remedial action fails.

The monitoring technology applies to the perched aquifer systems, surface drainage within the area canyons, and the MDAs (see Table 10-I). Monitoring of these entities has already been performed, to varying degrees. At the MDAs, the most likely remedial alternative is believed to be stabilization-in-place followed by long-term monitoring. Additional site-specific monitoring at other SWMUs is technically feasible and may be warranted following evaluation of SWMU-specific data.

10.3.2 Restrictive Use

No technology is required to implement restrictive access (i.e., fencing or deed restrictions). Fencing exists at certain SWMUs, such as the MDAs. Additionally, most community developments near the Laboratory are confined to the mesa tops. The surrounding land is largely undeveloped, with large tracts north, west, and south of the laboratory site held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east. Because most of the surrounding land is controlled by government entities, with the exception of San Ildefonso Pueblo, land use restrictions have been applied and can be enforced.

Restrictive use may apply to those SWMUs to be addressed in coordination with building D&D, depending upon what D&D/ER decisions are made about future use and cleanup levels once the buildings are removed.

10.4 Stabilization-In-Place

10.4.1 Capping

Capping entails placing a horizontal, low-permeability cover over an area of surficial or below-ground contamination. Engineered caps are designed to reduce infiltration, biointrusion, run-off, and erosion and to physically isolate contaminants from the above-ground environment and prevent direct contact by man or biota.

Past and ongoing research at the Laboratory has developed an enhanced capping design using cobble-gravel biobarriers that is applicable to the arid setting of the Laboratory (Hakonson et al. 1986; Nyhan et al. 1984; Nyhan 1989a, 1989b, and 1989c; Nyhan and Barnes 1989; and Nyhan et al. 1989a, 1989b, and 1989c). The ER Program capping pilot study program is discussed in greater detail in the IWP, Appendix Q (LANL 1990).

Capping studies at MDA B at the TA-21 OU were installed in 1987 to evaluate the design and performance of different soil and rock materials in landfill cover systems. In 1990, ER Program support of the MDA B cover demonstration study was initiated as a pilot study. This study demonstrates the interactive effects of surface mulches, vegetative cover, and soil profile design on site water balance.

Analyses of 1987–89 MDA B data suggest a balance of erosion control and desirable soil water storage dynamics can be achieved by manipulating both the soil profile characteristics and the species mix in the vegetative cover. Gravel mulches are effective in reducing run-off and erosion on a waste site, at least during summer months. Soil moisture throughout the soil profile can be reduced by using deeper rooting shrubs in addition to the grass cover usually emplaced on a site. Sediment transport rates from winter snowmelt run-off events are much lower than rates observed in summer.

Given the knowledge and experience with capping technology at the Laboratory, this technology presently provides a response action potentially applicable to the TA-21 environment, particularly at the MDAs. The MDA B pilot study will be invaluable for evaluating capping-in-place as a remedial alternative for all five TA-21 MDAs. At the MDAs, the most likely remedial alternative is believed to be stabilization-in-place followed by long-term monitoring (see Table 10-I).

10.4.2 Additional Containment Technologies

Additional containment alternatives, such as vertical barriers, bottom sealing, or surface management technologies, may be applicable at TA-21 OU SWMUs. However, additional site characterization data for individual SWMUs and better definition of potential migration pathways are required to determine whether these alternatives are appropriate and merit further consideration. If applicable they will be addressed during the CMS.

10.5 Treatment Technologies

There are numerous technologies associated with general response actions involving treatment of soils or water, either *in situ* or combined with removal. Examples of *in situ* contaminated soils treatment technologies that may be applicable at the TA-21 OU are immobilization, soil flushing, vapor extraction, vitrification, and biological treatment. With available data, groundwater treatment technologies are not believed to be applicable.

Insufficient SWMU data are available to determine which of these technologies may be applicable. However, treatment may be a remedial alternative at the majority of TA-21 SWMUs, as identified in Table 10-I. For example, treatment may be required at liquid waste MDAs, particularly MDA T, before stabilization-in-place can be implemented. As appropriate, treatment technologies will be evaluated during the CMS. Analytical laboratory and pilot scale tests will be used as needed to confirm feasibilities of treatment technologies.

10.6 Removal

Removal would be paired with either treatment and/or disposal. Removal/disposal without site characterization is applicable for SWMUs that are inactive, small units, such as septic tanks. With existing data, removal is a possible remedial alternative for the majority of TA-21 SWMUs (see Table 10-I). However, it is most likely to be applied as removal/disposal for inactive septic tanks and perhaps for other relatively small SWMUs. Additionally, surface soil contamination from stack emissions could be remediated by removing contaminated soil. Although possible for large SWMUs such as MDAs, removal is not advantageous because of the large volumes of radioactive and/or mixed waste.

TABLE 10-I
PRELIMINARY REMEDIAL ALTERNATIVES FOR SWMUS AT TA-21

Chapter	SWMU Number	Not a SWMU	No Action	Institutional Controls	Monitor	Cap-in-Place	Treatment	Remove and Dispose	Remove and Treat
13	21-007		X					X	X
	21-008		X					X	X
	21-019		X					X	X
	21-020(a,b)		X					X	X
	21-021		X					X	X
14	21-002(b)	X	X						
	21-003						X	X	X
	21-004(a-c)	X	X						
	21-028(d-e)	X	X						
	21-029	X	X						
	21-013(b-g)	X	X						
	21-026(a-c)		X	X	X				
	21-013(a)		X	X	X		X	X	X
15	21-004(d)		x						
	21-006(b)	X	X						
	21-010					X	X	X	X
	21-011					X	X	X	X
	21-011(k)		X				X	X	X
	21-022(h)		X				X	X	X
	21-023(c)		X				X	X	X
	21-024(a,g,l)		X				X	X	X
	21-024(b-e,i)		X				X	X	X
	21-024(l)	X	X						
	21-024(h)	X	X						
	21-024(j,k)	X	X						
	21-024(m)	X	X						
	21-024(n,o)		X				X	X	X
	21-026(d)		X				X	X	X
	21-027(a)		X				X	X	X
	21-027(b)	X	X						
	21-027(c,d)		X				X	X	X
	NPDES Systems	X	X						

TABLE 10-I
PRELIMINARY REMEDIAL ALTERNATIVES FOR SWMUS AT TA-21

16	21-010					X	X	X	X
	21-011					X	X	X	X
	21-014				X	X	X	X	X
	21-015				X	X	X	X	X
	21-016				X	X	X	X	X
	21-017				X	X	X	X	X
	21-018				X	X	X	X	X
17	21-005	X	X						
	21-006(b)		X	X			X	X	X
	21-009	X	X						
	21-012(b)	X	X						
	21-022(a,f)		X	X			X	X	X
18	21-002(a)	X	X						
	21-006(a, c-f)	X	X				X	X	X
	21-022(b-e,g,h-j)	X	X				X	X	X
	21-023(a,b,d)		X					X	X
	21-028(c)	X	X						
19	Areas of Concern	X	X					X	
20	21-012(a)	X	X						
	21-025	X	X						
	21-028(b,e)	X	X						

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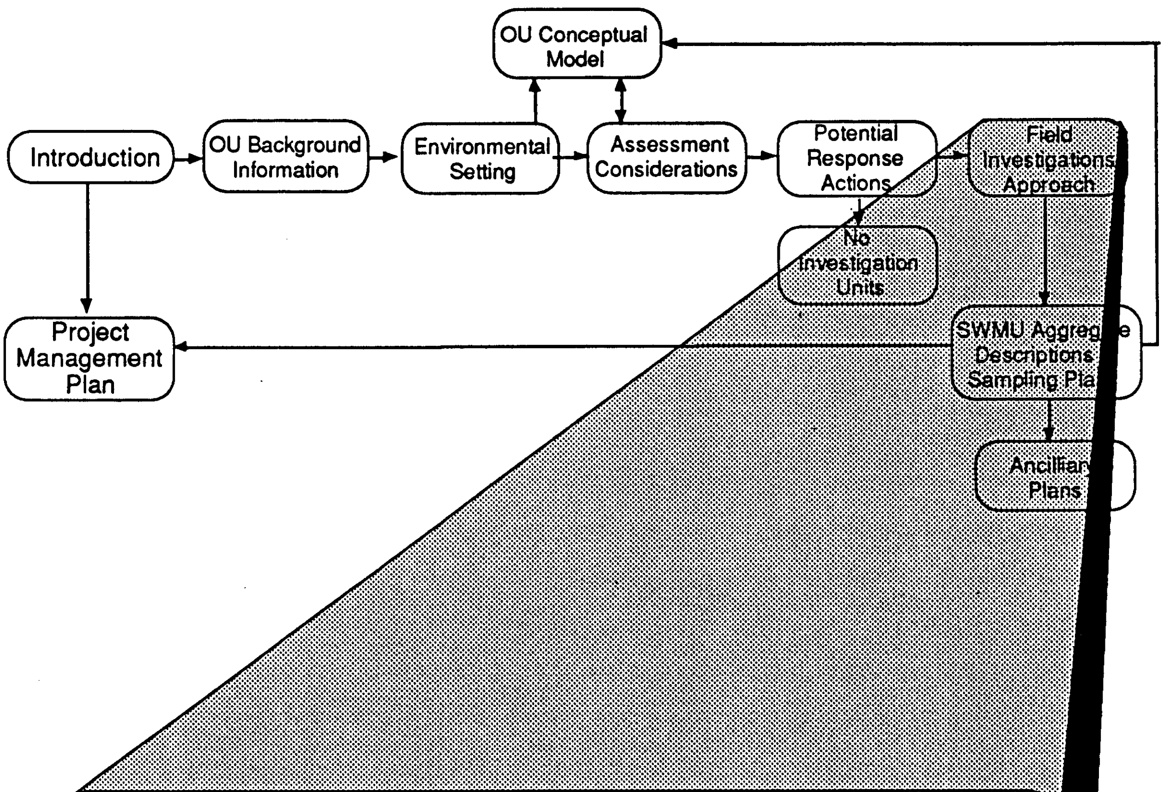
CHAPTER 11



Field Investigation Approach

- Field Operations
- Standard Survey, Screening, and Analytical Table
- Field Surveys
- Sampling Methods
- Field Screening
- Field Laboratory Measurements
- Analytical Laboratory Methods
- Data Analysis

11. METHODS

11.1 General

This chapter has been prepared to describe, in one place, the common elements that apply to the conduct of field investigations at all TA-21 SWMUs. The intent of pulling this information together in a single discussion is to reduce the repetition in each sampling plan of certain details that must be present but are the same for most of the plans. As discussed in Sec. 2.5.2, the large number of individual units to be addressed in this work plan has led to the use of several measures to streamline this document. This chapter represents one of those measures.

The objectives and technical approach for investigations at the TA-21 OU are described in Sec. 2.3, TA-21 RFI Approach. Key concepts presented there that are supported by the sampling plans include the following:

1. OU-wide investigations focus on general environmental characteristics and ambient levels of certain contaminants.
2. SWMU-specific characterizations focus on contaminant identification, extent, and migration of contamination.
3. OU-wide characterization data serve as a framework within which SWMU-specific contaminant data will be evaluated.
4. Explicit phases of investigation are identified and planned for (sequential sampling).
5. Evaluation of analytical data and reassessing data needs at intermediate stages is expected (decision analysis and observational approach).

Several general concepts apply to all of the field investigations presented in the following chapters. They include the following:

1. Radiological contamination is a general characteristic of TA-21 and a primary focus of SWMU-specific investigations. Releases of radioactive materials may have occurred without release of hazardous constituents.
2. For most SWMUs, the release of any hazardous constituents would have been associated with the release of radioactive materials.
3. Field surveys and field screening of samples can be used to identify gross contamination and to serve as Level I data.
4. Field laboratory analyses can be used to quickly provide Level II/III data to help guide field operations.

Field Operations. This chapter identifies several aspects of the Laboratory's implementation of the field sampling process that are not mentioned again in the SWMU-specific field sampling plans. Such aspects include the standard activities that will be used to support field operations (see Sec. 11.2, Field Operations) as follows:

- health and safety aspects of field operations;
- Laboratory-required preliminary activities and support procedures;
- identifying and documenting locations that have been sampled;
- sample handling and laboratory coordination procedures;
- equipment decontamination procedures; and
- management of wastes generated by sampling activities;

Investigation Methods. The primary focus of this chapter is on field investigation methods. It is tiered to the field sampling methods section of the Laboratory's Installation Work Plan (IWP), as presented in Sec. 3.5.3 of that document (LANL 1990). The methods presented in this chapter are specific examples of the options identified in the IWP. In addition, this chapter references the Laboratory's ER Program Standard Operating Procedures (SOPs) (LANL 1991). Each of the brief method descriptions given herein refers to the applicable SOPs for detailed methodology. The methods described in this chapter include (see Secs. 11.4–11.8)

- sampling methods;
- field survey methods to identify contaminants *in situ* (Level I);
- field sample screening methods to be used at the point of sample collection; (Level I);
- field laboratory measurement methods to provide rapid quantitative or semi-quantitative sample analyses Level II/III); and
- analytical laboratory methods (Level III/IV).

The method descriptions are simple and brief and provide some of the specific information that defines the application of the method. The specific information on each method is provided by the individual field sampling plan (such as sampling location or target depth of a borehole). Significantly, the method descriptions presented here are not intended to supplant or reduce the importance of the Quality Assurance Project Plan (Appendix A) and the governing SOPs (LANL 1991).

Data Analysis. The final section of this chapter gives a general discussion of data analysis concepts that will be applied in assessing the meaning of collected information. These concepts include (see Sec. 11.9)

- comparisons to local ambient contaminant levels, to background levels, and to action levels;
- decisions to conduct additional sampling or to stop sampling;
- role of the decision analysis and observational approaches; and
- statistical methods.

11.2 Field Operations

As indicated in the project schedule (Chapter 21), several investigations will be conducted concurrently because of the large area of TA-21 and the number of investigations to be completed. The organizational structure for each field investigation team is identified in Fig. 11.2-l. Each team will have individual responsibilities for health and safety, sample identification, sample handling and chain of custody, and related activities. Other operations may be shared across field teams, such as the field laboratory or an equipment decontamination facility. One field laboratory will be operated to perform all field laboratory analyses required by the Field Sampling Plans in Chapters 12–18. The field laboratory will be managed independently to assure rigorous QA/QC.

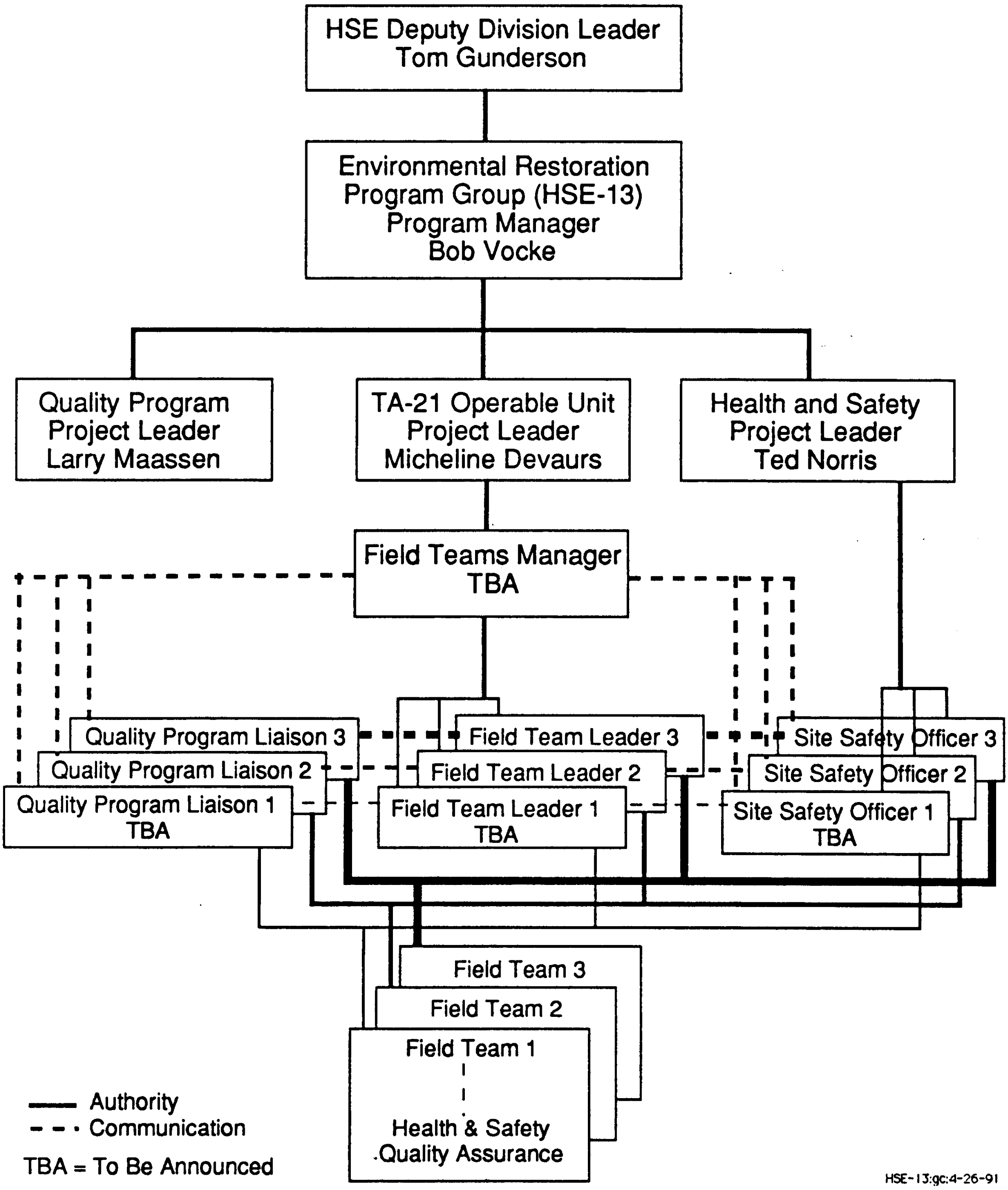
In this section, several aspects of field operations are described that will hereinafter be assumed to occur as a part of all field operations. This assumption will be implied and not restated in each sampling plan in Chapters 12–19.

11.2.1 Health and Safety

Appendix B presents the Health and Safety Plan for all field activities within the TA-21 OU. The plan gives SWMU-specific information regarding known or suspected contaminants and personnel protection required for different activities. Samples acquired under this RFI work plan will be screened at the point of collection to identify the presence of gross contamination or conditions that may pose a threat to the health and safety of field personnel. The techniques listed in Sec. 11.6, Field Sample Screening will be used. In particular, gross alpha and gross gamma radiation

FIG. 11.2-1

TA-21 Operable Unit Field Work Organization, Showing Health and Safety and Quality Assurance Responsibility



surveys and organic vapor surveys will always be conducted. Open excavations and borehole headspace will also be routinely monitored using organic vapor instruments and combustible gas and oxygen detectors. Applicable SOPs are contained in The ER Program SOP, Chapter 2, Health and Safety in the Field (LANL 1991) as follows:

- Health and Safety Monitoring of Organic Vapors with a Photoionization Detector
- Health and Safety Monitoring of Organic Vapors with a Flame Ionization Detector
- Health and Safety Monitoring of Combustible Gas Levels
- Total Alpha Surface Contamination Measurements
- Measurement of Gamma Radiation Using a Sodium Iodide Detector

11.2.2 Archaeological, Cultural, and Ecological Evaluations

Archaeological and ecological evaluations will be performed in all areas where the surface is to be disturbed, vegetation is to be removed, or invasive sampling is to be performed prior to initiation of field work as part of the Laboratory's ES&H Questionnaire process. Dependent upon the results of the archaeological and ecological evaluations, a DOE Environmental checklist for either categorical exclusion or an environmental assessment will be completed.

11.2.3 Support Services

Physical services support during the field investigation will be provided by Laboratory support groups ENG-3, ENG-5, Johnson Controls, or contractors. Existing job ticket procedures will be used. The services these groups will provide include, but are not limited to, back-hoe and front-end loader excavations, moving pallets of drummed auger cuttings and decontamination solutions, and setting up signs and other warning notices around the perimeter of the working area.

11.2.4 Excavation Permits

As part of the ES&H Questionnaire process, excavation permits are required by the Laboratory prior to any excavation, drilling, or other invasive activity. Acquisition of the permits will be coordinated with HSE-3 and Johnson Controls. Acquisition of excavation permits will be scheduled as appropriate for each phase of field work. All areas intended for excavation, drilling, or sampling deeper than 18 in. will be marked in the field for formal clearance prior to the work.

11.2.5 Sample Control and Documentation

Guidance for sample handling is provided in the IWP's Sec. 3.5.5 and Annex IV. Sample packaging, handling, chain of custody, and documentation procedures are provided in the ER Program SOPs as follows:

- General Instructions for Field Personnel
- Containers, Sampling and Preservation
- Guide to Handling, Packaging and Shipping of Samples
- Sample Control and Documentation

11.2.6 Sample Coordination

A sample coordination facility has been established by the ER Program in HSE-9 to provide consistency for all investigations. The system is detailed in the IWP's Sec. 3.5.5 and Appendix O, respectively. The applicable SOP is

- Sample Control and Documentation

11.2.7 Quality Assurance Samples

Field quality assurance (QA) samples of several types are collected during the course of a field investigation. The definition for each kind of sample and the purpose it is intended to fulfill are given in Appendix A, Quality Assurance Project Plan (QAPjP). The frequency with which each type of field QA sample is to be collected is detailed in the Field Sampling Plans in Chapters 12–18.

11.2.8 Equipment Decontamination

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross contamination among samples and helps maintain a clean working environment for the safety of personnel. Sampling tools are decontaminated by washing, rinsing, and drying. The effectiveness of the decontamination process is documented through rinsate blanks submitted for laboratory analysis. Steam cleaning is used for large machinery, vehicles, auger flights, and coring tools used in borehole sampling. Decontamination fluids, including steam cleaning fluids, are considered wastes and must be collected and contained for proper disposal. The applicable SOP is

- General Equipment Decontamination

11.2.9 Waste Management

This discussion is based on the guidance provided in Sec. 3.5.4 and Appendix B of the IWP. Wastes produced during characterization sampling activities may include borehole auger cuttings, excess sample, excavated soil from trenching, decontamination and steam-cleaning fluids, and disposable materials such as wipes, protective clothing, and spoiled sample bottles. In different areas of TA-21, several of the following waste categories have the potential to be encountered: hazardous wastes, low-level radioactive wastes, transuranic waste, and mixed waste (either low-level or transuranic mixed waste). Requirements for segregating, containing, characterizing, treating, and disposing of each type and category of waste are provided in the applicable SOP

- RFI-Generated Waste Management

11.3 Standard Survey, Screening and Analytical Table

In all sampling plans of this RFI work plan, a standard table has been used to identify certain field operations as well as sample analytical requirements. Table 11.3-I is an example of the standard table. It will be referred to in several remaining sections of this chapter. It contains four columns to identify each sample and sampling method and four groups of measurement or analysis identification columns.

11.3.1 Samples and Sampling Methods

The four columns on the left side of Table 11.3-I identify the SWMU, the sampling or activity to be conducted, the sampling location, the depth interval (as appropriate), and provide space for recording the sample identification number. The sampling methods or activities identified in the first column are specifically defined below in Sec. 11.5, Sampling Methods.

11.3.2 Survey, Screening and Analysis Methods

Very precise language has been adopted in this work plan to refer to four categories of measurements. Some of the terms defined below often are used interchangeably; however, in this plan they are used consistently, as defined below, to avoid confusion regarding the type of measurement being discussed. The four measurement types are defined as follows:

Table 11.3-I

STANDARD SURVEY, SCREENING AND ANALYSIS TABLE.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
Example site #1																																		
Vertical Borehole	1	0.0 - 5.0 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				
		5.0 - 10.0 ft						X	X		X	X	X	X	X	X	X																	
		10.0 - 15.0 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				
		15.0 - 20.0 ft						X	X		X	X	X	X	X	X	X																	
		20.0 - 25.0 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																											X	X	X	X				
		25.0 - 30.0 ft						C	C		C	C	C	C	C	C	C					C	C	C	C		C	C	C	C				
		30.0 - 35.0 ft						C	C		C	C	C	C	C	C	C																	
		35.0 - 40.0 ft						C	C		C	C	C	C	C	C	C					C	C	C	C		C	C	C	C				
Example Site #2																																		
Area Survey	1			X	X																													
Trench Excavation	1					X	X				X	X																						
Near Surface sample	1	0.0 - 6.0 in						X	X													X	X	X	X		X	X	X	X				
		6.0 - 12.0 in						X	X																									
		12.0 - 18.0 in						X	X																									
Shallow Borehole	1	0.0 - 2.5 ft						X	X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X	X				
		2.5 - 5.0 ft						X	X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X	X				
		5.0 - 7.5 ft						X	X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X	X				
Surface Sample	1	0.0 - 6.0 in						X	X					X	X	X	X					X	X	X	X		X	X	X	X				
	2	0.0 - 6.0 in						X	X					X	X	X	X					X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
Trip Blank																												X						

1. **Field Surveys** (or "surveys"). Direct reading or recording instruments are used to scan the land surface to make measurements of *in situ* conditions. Typically, surveys provide Level I data. Gamma radioactivity is a common target of field surveys. Land surveys and borehole logging are included in this category.

2. **Field Screening** ("field sample screening" or "screening"). Instruments or observations are applied to samples at the point of collection to measure the presence of contaminants or determine other properties of the sample. Usually, screening provides Level I data. Alpha radioactivity and organic vapors are common targets of field screening. Lithological logging of core samples is included in this category.

3. **Field Laboratory Measurements** (or "field laboratory analyses"). These are sample analysis methods that require minimal sample preparation and use desk top analysis equipment. They measure contaminants or other sample properties at better detection limits, with better precision, or for different contaminants than can be obtained with field screening techniques. Level II data are common, although Level I and Level III techniques are also used. Gamma spectrometry on dried soil samples placed in a fixed, shielded geometry is a typical example.

4. **Laboratory Analysis** (or "analytical laboratory analyses"). This category represents the primary analysis for which samples are collected, preserved, and sealed. Level III or IV data are usually expected. Commonly provided by offsite analytical laboratories.

Each of these four categories of measurements is shown in Table 11.3-I. For each category, several measurement techniques are identified by vertical columns. These represent the techniques that will be used most commonly at TA-21 for the majority of the SWMUs. The individual measurement techniques represented by each vertical column are identified in the sections that follow: Sec. 11.4, Field Surveys; Sec. 11.6, Field Screening; Sec. 11.7, Field Laboratory Measurements; and Sec. 11.8, Laboratory Analysis.

Figure 11.3-1 is a generic flow diagram that presents the interaction between the four categories of measurement during the performance of field investigations. The diagram presents logic flow from initiation of field investigations. The exact logic flow and categories of measurements implemented in an individual field investigation may vary from the generic logic flow presented in Fig. 11.3-1. However, the structure that controls interaction between measurement types is uniformly applied in all field investigations. Flow diagrams for the actual plan to be implemented at a given field investigation are presented in each of the field investigation chapters. In individual field sampling plan flow diagrams, only those decision flow paths used are diagrammed.

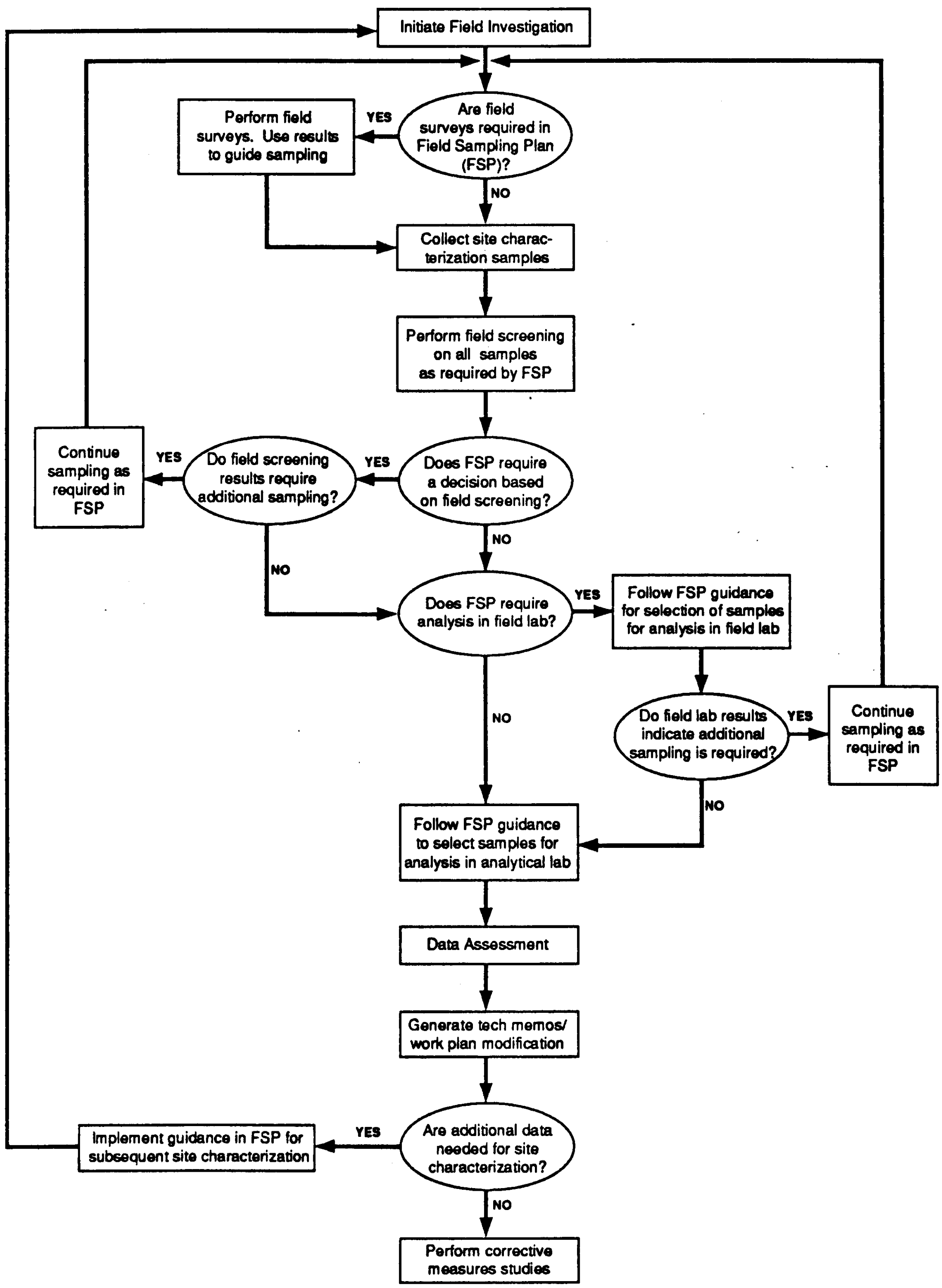


Fig. 11.3-1 Logic flow for field investigations.

11.3.2.1 Use of the Standard Screening and Analysis Table

The standard survey, screening, and analysis table serves two major purposes. First, it clearly and concisely summarizes the details of a sampling plan. It gives locations; indicates sampling methods and intervals; identifies the survey, screening, and analysis measurements for each sample detailed in Chapters 12–18; explicitly identifies the collection and analysis of field quality assurance samples; and gives a representation of certain options and uncertainties in the plan. Second, the table provides the detail needed to estimate the costs of the investigation.

As used in the individual sampling plans given in Chapters 12–19, the table identifies three types of sample selections. These are illustrated in Table 11.3-I and defined below:

- **X.** Planned sample screening and analysis are marked with an X at the intersection of the sample row with the analysis column.
- **E.** An example selection of samples is marked with an E in the table. This is used for cases where a plan allows an option or provides guidance to field personnel for selecting the particular samples to be submitted for analysis. The particular samples selected in the field may differ from those indicated by an E, but the number selected should be the same as the number marked. Where a sample marked E has an associated field QA sampling requirement, the QA requirement will be applied to the actual sample selected.
- **C.** A C is marked in the table for sample analyses that are provided by the plan as a contingency against foreseeable uncertainties that may be encountered in the field. For example, the drilling of boreholes will continue beyond the nominal depth set in the plan if contaminants are still detectable in cores. It can be expected that this will occur in an unknown fraction of the boreholes. Explicit inclusion of contingency samples to account for such occurrences has been used in some of the plans. While the contingency samples are usually marked in conjunction with particular boreholes, they may be used as needed in any portion of the plan.

11.3.2.2 The "Full Suite" of Analyses

In many of the sampling plans, the lack of past data from a SWMU leads to a need to evaluate the presence or absence of a wide spectrum of possible contaminants. In many cases, the analytical suite is simply specified as a "full suite of analytes." In the context of this plan, this means the following list of analytical laboratory methods will be applied to the samples. The specific analyses are defined in Sec. 11.8, Laboratory Analysis:

- gamma spectrometry
- tritium

- total uranium
- isotopic plutonium
- strontium-90
- volatile organic compounds (SW 8240)
- semivolatile organic compounds (SW 8270)
- metals (SW 6010)

As appropriate, additional laboratory analyses (e.g., PCBs, isotopic thorium) will be conducted on samples as detailed in Sec. 11.8.

11.3.2.3 Additional Analyses

For certain SWMUs, additional analyses are appropriate beyond those listed above. Some of the common additional analyses are shown in Table 11.3-I. Blank columns are provided in the table for listing other additional analyses required at particular SWMUs. Analyses identified in those columns are also described in the appropriate section of this chapter, below.

11.4 Field Surveys

Field surveys were defined in Sec. 11.3, above. These are primarily walking scans of the land surface using direct reading or recording instruments. For this work plan, these surveys include gamma radiation surveys and electromagnetic geophysical surveys. For convenience, land surveys to identify and mark locations from old drawings are included here. Field survey data other than that from land surveys are used to identify the presence of contaminants or structures in the field. In some plans, these techniques are used to identify locations for biased sampling. In some plans, these techniques are used as a preliminary assessment for areas where contaminants are not expected. While negative results from field surveys are not conclusive evidence of the absence of contaminants, positive results obtained at an early stage can allow timely redirecting of a sampling plan.

11.4.1 Radiological Surveys

11.4.1.1 Gross Gamma Survey. Several instruments are available that are suitable for these surveys: micro R meters, NaI detectors of various sizes with ratemeters or scalers, and Geiger-Muller detectors. The preferred instruments are microR meters with the ability to measure to 5 μR/hr, and 2-in. by 2-in. NaI detectors with a ratemeter capable of displaying 100 cpm. Some discrete-measurement or continuous-measurement recording instruments are also available using the same detectors. Surveys are conducted by carrying the instrument at waist height at a slow walking pace and observing and recording the ratemeter response. Measurements may also be made at the ground surface to aid in identifying the presence of localized contamination. The applicable SOP is

- Measurement of Gamma Radiation Using a Sodium Iodide (NaI) Detector

11.4.1.2 Low-Energy Gamma Survey. Two instruments are commonly used for these surveys, the FIDLER and the PHOSWICH. Both are optimized for the detection of low energy photons, such as the 60 keV gamma emission from ^{241}Am or the x-rays that accompany the decay of most heavy radionuclides, such as uranium, thorium, plutonium, and other transuranic radionuclides. Either instrument may be used for this work plan. Discrete- or continuous-measurement recording options are available. Surveys are conducted by carrying the instrument close to the ground surface and observing the ratemeter or scaler. Measurements may also be made at the ground surface to aid in identifying the presence of localized contamination. The applicable SOPs are

- Near Surface and Soil Sample Screening for Low-Energy Gamma Radiation Using the FIDLER
- Near Surface and Soil Sample Screening for Low-Energy Gamma Radiation Using the PHOSWICH

11.4.2 Geophysical Surveys

11.4.2.1 Electromagnetic Surveys

Field surveys will be performed with an electromagnetic instrument to confirm the location of buried structures that contain metal and to trace the path of buried metallic waste lines. The selected geophysical instrument will be able to detect all types of metal (ferrous and nonferrous). It will be of a design that will detect a 2-in.–diameter metal line buried at a depth to 5 ft. The instrument will provide a direct meter readout of changes in the electromagnetic response. The instrument will also have an RS-232 port, so that the electromagnetic response may be recorded electronically in an automated data recorder.

A geophysical survey to locate buried metal lines is typically performed by continuously observing the instrument meter response while walking along traverse lines that cross at a right angle over the suspected trend of the buried line. An appropriate spacing of the parallel traverse lines is 20 ft. A geophysical survey to locate buried metal structures is typically performed by taking measurements on a grid established over the suspected location of the structure. The spacing for measurements is determined by the size of the structure; the required spacing may be as close as measurements taken at nodes on a 2.5- by 2.5-ft grid. Applicable SOP is

- General Surface Geophysics

11.4.3 Land Surveys

Land surveys will be used for two purposes: first, to document all sampling locations and second to locate either former or buried structures where needed. Only land surveys to find former structure locations are identified on the analytical table described in Sec. 11.3, because this surveying will only be done for certain units. However, because sampling location surveying will be done for all sampling, it is not specifically identified in the analytical table. In all cases, the documentation requirements for the surveys are the same: plus or minus 1-ft horizontal and plus or minus 0.1-ft vertical. The conventional survey procedures used are documented by Facilities Engineering personnel.

11.5 Sampling Methods

11.5.1 Introduction

For the field sampling plans used in this work plan, a suite of specific sampling methods has been selected, and the details of their use and application in the field have been carefully defined. For example, a "surface soil sample" in this document is specifically defined as representing a 0- to 6-in. layer of soil collected by a hand scoop (see Subsec. 11.5.2.1), and a "vertical borehole core sample" is specifically defined as a 5-ft core interval taken with a particular length and diameter split-barrel sampler (see Subsec. 11.5.3.2).

Setting these common definitions and using them uniformly in all of the field sampling plans provides several benefits: consistency of field operations, comparability of sample analysis results from location to location at TA-21, and the ability to have each sampling plan refer to a method definition in this chapter without reproducing the information in each plan. For each method identified below, the specifically defined portion is detailed. However, complete specification of the method requires additional information that is referenced to the applicable SOP or provided in the field sampling plan (e.g., nominal or target depth for a borehole).

11.5.2 Soil Sampling Methods

11.5.2.1 Surface Soil Sample

Surface soil samples are defined as samples taken from the first 6 in. of soil. This type of soil sample will be gathered using a stainless steel or Teflon scoop. Care will be used to take the sample to a full 6-in. depth and to cut the sides of the hole vertically to ensure equal volumes of soil are taken over the full 6-in. depth. Applicable SOP is

- Spade and Scoop Method

11.5.2.2 Near-Surface Soil Sample

The spade-and-scoop method will be used to obtain near surface soil samples from depths to 30 in. Sample collection from depths greater than 30 in. can become labor-intensive. Collection of samples is accomplished with spades, shovels, and scoops. Spades and shovels are used to remove surficial material to the required depth. Then a stainless steel or Teflon scoop is used to collect the sample. Care will be used to take the sample to a full 6-in. depth and to cut the sides of the hole vertically to ensure equal volumes of soil are taken over the full 6-in. depth. Unless otherwise specified, the sample interval will be 6 in. Devices plated with chrome or other materials are not acceptable for sample collection. The applicable SOP is

- Spade and Scoop Method

11.5.2.3 Undisturbed Surface Soil Sample

Undisturbed soil samples will be gathered from the first 6 in. of soil using the ring sampler method. This method involves driving a 4-in.-diameter stainless steel tube (ring sampler) vertically into the area to be sampled. The soil around the ring sampler is then excavated so that the tube can be removed. An undisturbed core sample is obtained by pushing out the soil in the ring sampler. The applicable SOP is

- Stainless Steel Surface Soil Sampler

11.5.2.4 Deposition-Layer Soil Sample

Deposition-layer soil samples are those samples collected from the first 1 in. of soil. The method is used to collect samples that represent wind- or air-deposited contaminants on the soil surface (i.e., contaminants dispersed and deposited from stack emissions). They will be collected using a stainless steel or Teflon trowel to scrape off the upper 1 in. of soil. The applicable SOP is

- Spade and Scoop Method

11.5.2.5 Manual Shallow Core Sample

Small volume soil samples can be recovered from depths approaching 10 ft with a hand auger or with a thin-wall tube sampler. The thin-wall tube sampler provides a less disturbed sample than that obtained with a hand auger. However, it may not be possible to force the thin-wall tube sampler through some soil or tuff, and sampling with the hand auger may be the more viable alternative. It is usually not practical to use a hand auger or thin-wall sampler at depths below 10 ft. Applicable SOP is

- Hand Auger and Thin-Wall Sampler

11.5.3 Borehole Core Sampling Methods

Split-barrel core sampling will be accomplished using an auger rig that drives a 4.25-in. internal diameter hollow-stem auger with 7.5-in. outer diameter auger flights. Soil samples will be collected using a 3.125-in. internal diameter, 5-ft continuous, split-barrel sampler. In each sampling plan, a nominal depth for each borehole is given. The borehole will be sampled to at least the nominal depth. If contamination is detected by field screening or field laboratory measurements in either of the last two core intervals above the nominal depth, drilling will continue until background concentrations are detected in two successive sample intervals. This stopping criterion will be applied to all boreholes as a means of ensuring that the maximum information on contaminant depth is acquired. Each sampling plan specifies an analytical plan for cores down to the nominal depth. The pattern set by the analytical plan will be followed for the complete depth of the borehole as determined by the stopping criterion just described.

11.5.3.1 Shallow Boreholes

A number of the sampling plans call for core samples to be collected from limited depths to investigate subsurface migration of contaminants where little potential for deep migration exists. This shallow borehole method is intended for boreholes of limited depth; 30 ft is a reasonable maximum. Because these boreholes are primarily used for areas where minimal penetration of contaminants into the soil is expected, a major feature of this method is the specification of a 2.5-ft core interval as a sample. For ease of setup and rapid drilling, the use of the light-weight drilling rig may be preferred for all shallow boreholes, regardless of site access.

The stopping criterion described in Sec. 11.5.3 will be used, and the applicable SOP is

- Hollow-Stem Auger

11.5.3.2 Vertical Boreholes.

This is the standard hollow-stem auger, split-barrel core sampling method. A 5-ft core interval is specified as the standard sample. Drilling equipment is specified in Sec. 11.5.3, Borehole Core Sampling Methods. The stopping criterion described in Sec. 11.5.3 will be used. The applicable SOP is

- Hollow-Stem Auger

11.5.3.3 Angled Boreholes

Angle drilling is employed to access contaminant locations when placement of the rig directly over the point of interest is not feasible. As for vertical core sampling, a 5-ft core interval is specified as the standard sample. The auger rig used in this type of investigation should have mechanical specifications comparable to a Failing F-10 or CME-85, with angle drilling capability. In setting up for angle drilling, the drill rig will begin a borehole at a location specified in the sampling plan. The drilling angle and direction specified in the sampling plan will direct the auger string beneath the area to be investigated at the desired depth. The stopping criterion described in Sec. 11.5.3 will be used. The applicable SOP is

- Hollow-Stem Auger

11.5.3.4 Deep Core Sampling

For tuff coring deeper than 150–200 ft., a drilling rig is needed with capabilities greater than those used for the hollow-stem auger methods described above. Initial plans presented in Chapters 12–19 call for very few boreholes greater than 200 ft. Selection of rig and drilling method are matched to the goals of the investigation, according to the applicable SOP, which is

- Air Rotary Drilling

11.5.3.5 Rock Coring

Rock samples can be recovered from indurated rock formations with the use of a diamond-studded bit. In this method, the diamond bit cuts a small diameter core of rock 5 or 10 ft in length. As the rock is cut, it is pushed into an inner barrel of the drill string and retrieved by a wire-line apparatus. This method works best in rock that is hard, relatively free of bedding planes, lithology changes, and fractures. This method will be used in the lower reaches of deep boreholes beneath the relatively soft Bandelier Tuff. The applicable SOPs are

- Air Rotary Drilling
- Cable Tool Drilling

11.5.3.6 Shallow-Angled Boreholes. Several investigations specific to the MDAs require core sampling of boreholes placed at shallow angles beneath the disposal pits. Such boreholes cannot be drilled with the standard hollow-stem auger rigs specified above. For these holes, air rotary drilling with continuous coring will be used. The stopping criterion described in Sec. 11.5.3 may be used. The applicable SOP is

- Air Rotary Drilling

11.5.4 Trenching

Trenching is used in this work plan for several purposes: to identify the location of buried structures prior to drilling, to expose buried structures to be sampled, and to expose deeper soils for investigation or sampling. Trenching will be performed by a back-hoe or track-hoe capable of excavating to a depth of 15 ft. The bucket width and type will be determined by the equipment operator based on the structure to be exposed and the soil conditions. The trench must be wide enough for soil sampling and field surveys and screening to be safely performed. If the trenching is at a depth of 4 ft or greater, OSHA standards, 29 CFR 1926.650, for shoring and sloping will be followed (OSHA). Because the tuff at TA-21 is in a stable rock, shoring and sloping will generally not be necessary, but each trench should be inspected by a competent engineer to ensure that there is no sign of potential cave-ins. The maximum depth of a trench will be 15 ft. The applicable SOP is

- Excavating Methods

11.5.5 Tank Sampling Methods

11.5.5.1 Liquids

Samples of liquids contained in tanks will be gathered by filling sample bottles from a spigot or valve draining the tank. If a tank drain does not exist or cannot be used, then the tank must be opened and a sample gathered using a weighted bottle or COLIWASA (an acronym for

COmposite LIquid WAste SAmpler). At a minimum, two samples will be gathered from each tank to be investigated. One sample will be of any precipitate and associated liquid at the bottom of the tank. The other sample will be of the liquid contained in the tank. If there is evidence of vertical stratification (such as viscosity changes), then a liquid sample from each layer will be taken. Applicable SOPs are

- COLIWASA Sampler for Liquids and Slurries
- Weighted Bottle Sampler for Liquids and Slurries in Tanks

11.5.5.2 Dry Tanks

An extendible telescoping probe will be used to access the inside of dry tanks for sampling. A standard filter paper swipe will be attached to the end of the probe to sample the inside walls and bottom of the tank. Three replicate swipes will be taken on the inside of the tank. Whenever possible, swipes will be taken from an area of 100 cm^2. When it is not possible to cover this area, an estimate of the surface area sampled will be made in cm^2. For convenience, 100 cm^2 can be approximated by a square that is 4 in. on each side. Sufficient pressure should be used on the swipe to pick up loose contamination without tearing or separating the swipe. Applicable SOP is

- Sampling for Removable Alpha Contamination

11.5.6 Surface Water Sampling Methods

A Geotech Model 0700 peristaltic pump, or its equivalent, will be used to collect surface water samples. The Geotech Model 0700 allows the union of the filtration assembly with the pump and the sample container so that collection of a representative sample is simplified and the possibility of sample contamination is reduced. In this method, surface samples are filtered and collected directly with minimal elapsed time.

An alternate method is to collect surface water as grab samples. This method involves dipping a beaker, flask, or some other transfer device into the surface water to retrieve samples. The water sample can also be collected directly by dipping the sample container into the water and filling, removing, and capping it. This method is less useful when sampling shallow waters such as seeps, springs, or shallow streams. Applicable SOP is

- Surface Water Sampling

11.5.7 Well Installation and Groundwater Sampling

The installation and sampling of groundwater wells is included in the general characterization of the TA-21 OU. Due to the depth to groundwater and the relatively unlikely chance that contamination has migrated to such depths, the number of wells is limited. If perched water zones are encountered in any drilling at TA-21 OU, they will also be sampled. The applicable SOPs for these investigations are

- Well Installation
- Well Development
- Purging of Wells for Representative Sampling of Ground Water
- Field Analytical Measurements on Ground Water Samples

11.6 Field Screening

Field screening is defined in Sec. 11.3, above. Screening measurements are applied at the point of sample collection, in borehole headspace, and in excavations to identify gross contamination and to assess conditions affecting the health or safety of field personnel. Application of screening for personnel health and safety is detailed in the Appendix B Health and Safety Plan. Individual sampling plans may not explicitly identify the use or role of sample screening measurements; however, the standard analytical table for each investigation will show the methods to be used. In general, every sample taken at TA-21 will be screened for gamma and alpha radioactivity, and all excavations and boreholes will be monitored for combustible gases, organic vapors, and tritiated water vapor. In addition, a noninstrument form of sample screening, lithological logging, will be performed for all borehole samples.

In addition to the role of sample screening in monitoring for gross contamination or situations of concern for health and safety, certain sampling plans use the sample screening information explicitly as Level I data for making decisions on further sampling or for selecting sample analysis options.

11.6.1 Radiological Screening

11.6.1.1 Gross Gamma

Field screening of samples for gamma radioactivity will be done using a hand-held NaI detector probe and ratemeter. The detector is held close to the sample or core and is capable of identifying elevated concentrations of certain radionuclides as an increased ratemeter reading above instrument background levels. Quantification of the response is difficult and is best interpreted as a gross indicator of potential contamination. The applicable SOP is

- Measurement of Gamma Radiation Using a Sodium Iodide (NaI) Detector

11.6.1.2 Gross Alpha

Field screening of samples for gross alpha contamination is conducted using a hand-held alpha scintillation detector and a ratemeter. The detector is held close to contact with the sample or core and is capable of detecting on the order of approximately 100-200 pCi/g for a damp soil sample. The instrument cannot identify specific radionuclides. The applicable SOP is

- Total Alpha Surface Contamination Measurements

11.6.2 Nonradioactive Screening

11.6.2.1 Organic Vapor Detectors

Organic vapor detectors will be used to screen borehole cores and soil samples at the point of collection. Two purposes are addressed: personnel safety and the identification of grossly contaminated samples. Two types of detectors, PID and FID, will be used to improve the probability of detecting a wide range of vapors.

PID. A Model PI 101 photoionization detector (PID), or its equivalent, will be used. It is a general survey instrument capable of detecting real-time concentrations of many complex organic compounds and some inorganic compounds in air. The instrument can be calibrated to a particular compound; however, it cannot distinguish between detectable compounds in a mixture of gases. Applicable SOP is

- Health and Safety Monitoring of Organic Vapors with a Photoionization Detector

FID. A Foxboro Model OVA-128, or its equivalent, will be used. It is a flame ionization detector (FID), which can be used as a general screening instrument to detect the presence of many organic vapors. Its response to an unknown sample is relative to the response to a gas of known composition to which the instrument has been calibrated. Applicable SOP is

- Health and Safety Monitoring of Organic Vapors with a Flame Ionization Detector

11.6.2.2 Combustible Gas/Oxygen Detector

A Gastech Model 1314, or its equivalent, will be used to determine the potential for combustion or explosion of unknown atmospheres during drilling and intrusive activities. A typical combustible gas indicator (CGI) determines the level of organic vapors and gases present in an atmosphere as a percentage of the lower explosive limit (LEL) or lower flammability limit (LFL). The Gastech Model 1314 also contains an oxygen detector to determine atmospheres that are deficient or enriched in oxygen. The CGI will be used to monitor atmospheres during all intrusive activities for health and safety purposes. Applicable SOP is

- Health and Safety Monitoring of Combustible Gas Levels

11.6.2.3 Lithological Logging

Lithological logging of drill core will be performed to describe the physical nature of borehole cores. Lithological logging will be performed by a geologist capable of describing subsurface lithologies and differentiating the various strata of the Bandelier Tuff. Applicable SOP is

- Lithological Logging of Borehole Cores

11.7 Field Laboratory Measurements

The scope and nature of field laboratory measurements to be used in support of investigations at TA-21 are defined in Sec. 11.3. The field laboratory will provide fast turn-around analysis of samples for a limited number of analytical methods. The techniques used in the field laboratory give primarily Level II data, although some are Level I or near Level III as noted for the particular analysis method below. The field laboratory methods provide better quality information or lower detection limits than can be obtained with field screening. In some cases, they provide a type of information that cannot be obtained with field screening techniques. The intended uses of the field laboratory results vary from one sampling plan to the next. Three major uses dominate as follows:

1. **Guidance to Field Operations.** To provide fast turn-around results to aid in directing the course of field work. This use of the field laboratory can increase the efficiency of field operations. An example is the use of field laboratory measurements to determine when to cease drilling a borehole after it has exited a contaminant plume.

2. **Biased Sample Selection.** To focus analytical efforts on samples best suited to achieving investigation objectives. Depending on the goals of the investigation, samples having particular characteristics can be selected: select those with no detectable contaminants to assess the edge of a plume; select those with the highest levels to identify contaminants during source characterization. Knowledge-based sample selection can enhance the effectiveness of the investigation.

3. **Analytical Sample Load Reduction.** To provide the ability to quickly and inexpensively assess a large number of samples for easily detectable contaminants. In this case, the few samples submitted to the analytical laboratory can be supported by a broad base of lower quality measurements providing some assurance that the few high quality measurements are representative and sufficient for decisionmaking. This can limit the number of samples that must be sent for more costly analysis at an analytical laboratory.

The selection of samples to be submitted to the analytical laboratory on the basis of field laboratory results is required by several of the field sampling plans. The criteria to be used for making this selection depend on the focus and goals of the particular investigation. Three criteria are used as follows:

1. Where the goal of the investigation is primarily to identify contaminants by characterization at the source, the samples selected for submission in an analytical laboratory should primarily be those in which contaminants were identified in the field laboratory.

2. Where the goal is to determine the extent of contamination, the selection should be made from the samples at the edges of a contaminated zone, those with low concentrations as determined in the field laboratory, and those with results below the detection limits of the field laboratory instruments that would consist of the first samples outside the contaminated zone.

3. If the goal is to document the absence of contamination, the first priority is to select for analysis any sample for which the field laboratory results indicate the presence of a contaminant. In addition to this, a random or uniform (unbiased) selection from among all other samples should be made.

Situations can be envisioned that complicate the application of these criteria. Such situations might include samples from a borehole that sequentially passes through the contaminant source, a contaminant plume, and uncontaminated substrata. In such situations, all three criteria may apply, and in order for a sufficient number of samples to be submitted in each category, the percentage specified in the plan may need to be overridden by the field team leader in consultation with the OU project leader.

In the field sampling plans, a percentage of samples to be submitted for further analyses is recommended. The percentage is commonly 25 to 30% but may be as low as 10% or as high as 50%. The distinction between 25 or 30% is not intended to be significant and is often used to give a more easily implemented sampling scheme (i.e., 25% may be used to select one sample from each borehole that generates four samples, or 30% may be used to select one of the three near-surface samples from each 18-in.-deep near-surface investigation).

When 10% is used, it is commonly to provide a minimal level of confirmation regarding a contaminant that is considered only remotely possible to be present.

Higher percentages, such as 50%, may be specified when only a small number of samples are collected in order to increase the number of results from the analytical laboratory. This would be used only when there seems to be little need for analytical laboratory confirmation on all samples and is primarily used only if the potentially present contaminants are easily detected in the field laboratory.

A common expectation for many SWMUs at TA-21 is that any release of contaminants will have included radionuclides. Because these are relatively easily detected at reasonably low-detection limits in a field laboratory, more use of the field laboratory as a decision tool has been employed in this plan.

In the event that the confirmatory analyses in the analytical laboratory indicate that decisions made on the basis of field laboratory measurements could be misleading (i.e., contaminants of interest are found that were not detected in the field laboratory), then the role of the field laboratory, or the techniques used therein, will be modified for subsequent investigations. To provide for this confirmation, there is no circumstance in this work plan where field screening or field laboratory data are used without a percentage confirmation in the analytical laboratory.

The text of the individual sampling plans may not explicitly identify the use of field laboratory measurements. However, the standard analytical table for each investigation will show the methods to be used.

11.7.1 Radiological Measurements

11.7.1.1 Gross Alpha

Measurements of gross alpha radioactivity can be used to assess the presence of plutonium, uranium, and thorium in samples, although identification of the individual radionuclides is not possible. The alpha emissions from ^{238}Pu are indistinguishable from those of ^{241}Am. A typical method uses dried soil samples in a fixed geometry to detect alpha-emitting radionuclides at concentrations on the order of 25 to 40 pCi/g. These Level II measurements can be used to guide field operations or to bias sample selection. Following the drying of the soil, a measurement time of approximately 15 to 20 min is typical. Large area ZnS alpha scintillation detectors and a scaler are used. An instrument such as a Ludlum Model 2200 with a Model 43-10 alpha scintillation detector, or the equivalent, is appropriate. The applicable SOP is

Screening Soil Samples for Alpha Emitters

11.7.1.2 Gamma Spectrometry

Gamma radiation spectrometry can be used to quantify particular radionuclides present in soil samples such as ^{137}Cs, ^{60}Co,^{234}U, ^{235}U, and ^{238}U. Additionally, the 59 keV gamma from ^{241}Am can be detected. Such identification is important for guiding field work or biasing the selection of samples for laboratory analysis. Rapid turn-around analysis can be Level II or close to Level III quality using personal computer-based, multichannel analyzers (MCA) and NaI or germanium photon detectors. An example is a Canberra MCA with a Ludlum 44-10 NaI detector; and many equivalent instruments are available. Dried soil samples in fixed geometries can be analyzed in approximately 20 to 30 min with detection limits on the order of 5 pCi/g for radionuclides such as ^{137}Cs. The applicable SOP is

- Use of Gamma Spectrometry Systems as a Screen for Gamma Ray-Emmitting Radionuclides in Soil Samples

11.7.1.3 Tritium by Liquid Scintillation

Level II, overnight turn-around measurements of tritium in soil moisture or water samples can be obtained by liquid scintillation techniques. These measurements are needed for guiding field operations, primarily drilling operations. The distillation of soil moisture from soil samples is done in a ventilated hood in the field laboratory, as part of the process of drying soil samples for gross alpha measurements. Liquid scintillation measurements will be done by either HSE-1 or HSE-9 using documented laboratory procedures for this measurement of tritium in soil moisture.

11.7.2 Organic Chemical Measurements

11.7.2.1 Volatile Organic Compounds

Rapid turn-around analysis for volatile organic compounds with Level II quality is needed to guide field operations, primarily drilling. An instrument with the ability to distinguish between various organic compounds is preferable. The Laboratory's transportable purge-and-trap GC/MS can provide qualitative and quantitative analyses of most volatile organic compounds with boiling points below 200°C that exhibit low or slight solubility in water. Volatile water-soluble compounds can also be detected with higher detection limits. Applicable SOP is

- Portable Gas Chromotography for Field Screening of Volatile Organic Compounds

11.7.2.2 PCBs

Documented PCB contamination at TA-21 is limited to the vicinity of a single building and storage pad. The extent and variability of the contamination is unknown. An inexpensive, fast turn-around measurement technique at levels less than the regulatory limit (25 ppm) is needed. It will be used to define the areal extent of contamination with numerous Level II analyses and to minimize analytical laboratory Level III data. A 10 ppm detection level is achievable with available analytical techniques that provide quick turnaround in a field laboratory and is below regulatory requirements. A DEXSIL L2000 PCB/Chloride Analyzer or an alternative method with suitable detection limit can be used. The L2000 uses a chloride-specific electrode to quantify PCBs in oil or soils. Sample preparation involves extracting the PCBs from the soil and reacting the sample with a sodium reagent to transform the PCBs into chloride, which can be quantified by the instrument. Oil samples take about 5 min to prepare and soils about 10 min. Documented field laboratory procedures for measurement of PCBs in soil will be used.

11.8 Laboratory Analysis

Section 11.3 gives the definition of laboratory analysis as used in this work plan. These are intended to be the highest quality (Level III/IV) data acquired. As described in Sec. 11.2, samples to be submitted to an analytical laboratory will be coordinated, handled, and tracked by the ER Program Sample Coordination Facility.

Certain sampling plans rely entirely on Level III/IV data to support their objectives. Other plans rely heavily on Level I/II data for field guidance and use the higher quality results from an analytical laboratory for limited purposes. As discussed in Sec. 11.3, the standard survey, screening and analysis table identifies the analyses for which each sample is submitted. Identification of the methods listed as headings in the standard table follows. The common full suite of analytes is discussed first, followed by constituents identified in the table that are called out as required analyses in the field sampling plans infrequently.

Gamma Spectrometry. Quantification of radionuclides by measurement of photon emissions. Standard commercial laboratory procedures will be modified as described in Appendix A.

Tritium. Measurement of tritium in soil moisture. Soil moisture is distilled from soil, and the low energy beta emission from tritium is measured by liquid scintillation techniques. Standard commercial laboratory procedures will be modified as described in Appendix A.

Total Uranium. Analysis done by LANL HSE-9 methods following sample digestion using EPA method 3050.

Strontium-90. Radiochemical separation using multiple selective precipitation and counting of beta activity by gas proportional detectors.

Isotopic Plutonium. Radiochemical separation of plutonium from soil is followed by alpha spectrometry to quantify each isotope of plutonium. Standard commercial laboratory procedures will be modified as described in Appendix A.

If special counting techniques with modern detectors and software are developed to provide plutonium isotopic data in soil and sediment at low activity levels, as appropriate, these techniques will be substituted for radiochemistry.

Volatile Organics (SW 8240). EPA standard method for quantification of volatile organic compounds. The standard list of analytes and quantitation limits is given in Appendix A.

Semivolatiles (SW 8270). EPA standard method for quantification of semivolatile organic compounds. The standard list of analytes and quantitation limits is given in Appendix A.

Metals (SW 6010). EPA standard method for quantification of metals and cyanide. The standard list of analytes and quantitation limits is given in Appendix A.

The following four analyses are called out in selected field sampling plans for reasons detailed therein but are not part of the common full suite of analyses.

- **PCB (SW 8080)**. EPA standard method for quantification of PCBs and pesticides. Only the PCB results are of interest for this work plan. The standard list of analytes and quantitation limits is given in Appendix A.
- **TCLP Metals**. EPA standard method for defining a hazardous waste. The TCLP method includes metals and other compounds; only the metals are of

interest for this work plan. The standard list of analytes and quantitation limits is given in Appendix A.

- **Isotopic Uranium.** Radiochemical separation of uranium from soil is followed by alpha spectrometry to quantify each isotope of uranium. Standard commercial laboratory procedures will be modified as described in Appendix A.
- **Isotopic Thorium.** Radiochemical separation of thorium from soil is followed by alpha spectrometry to quantify each isotope of thorium. Standard commercial laboratory procedures will be modified as described in Appendix A.

11.9 Measurements at Geohydrologic Characterization Boreholes

Boreholes to characterize the site geohydrology are planned for eight locations (see Fig. 11.9-1). Five of the boreholes are located in background areas away from sources of contamination. In addition, separate boreholes are located near each of the three MDAs that received liquid wastes. An additional borehole may be located at each of the three MDAs as an option dependent upon the findings at the initial borehole.

The measurements to be taken in the site geohydrologic characterization program are grouped into five categories (see Table 11.9-I) and presented in Table 11.9-II. A description of each measurement type listed in Table 11.9-II follows.

11.9.1 Hydrogeological Measurements

Gravimetric water content. Quantitative measurement of water content in undisturbed core by weighing moisture loss due to oven drying. ASTM method (ASTM D-4531-86)

Bulk density. Calculated value from gravimetric water content test data. ASTM method (ASTM D-4531-86)

Dry density. Calculated value from gravimetric water content test data. ASTM method (ASTM D-4531-86)

Porosity. Calculated value from gravimetric water content test data. ASTM method (ASTM D-4531-86)

Porosity (He injection). Quantitative measurement of porosity in undisturbed core sample. American Petroleum Institute Method (API 40,Sec. 3.58)

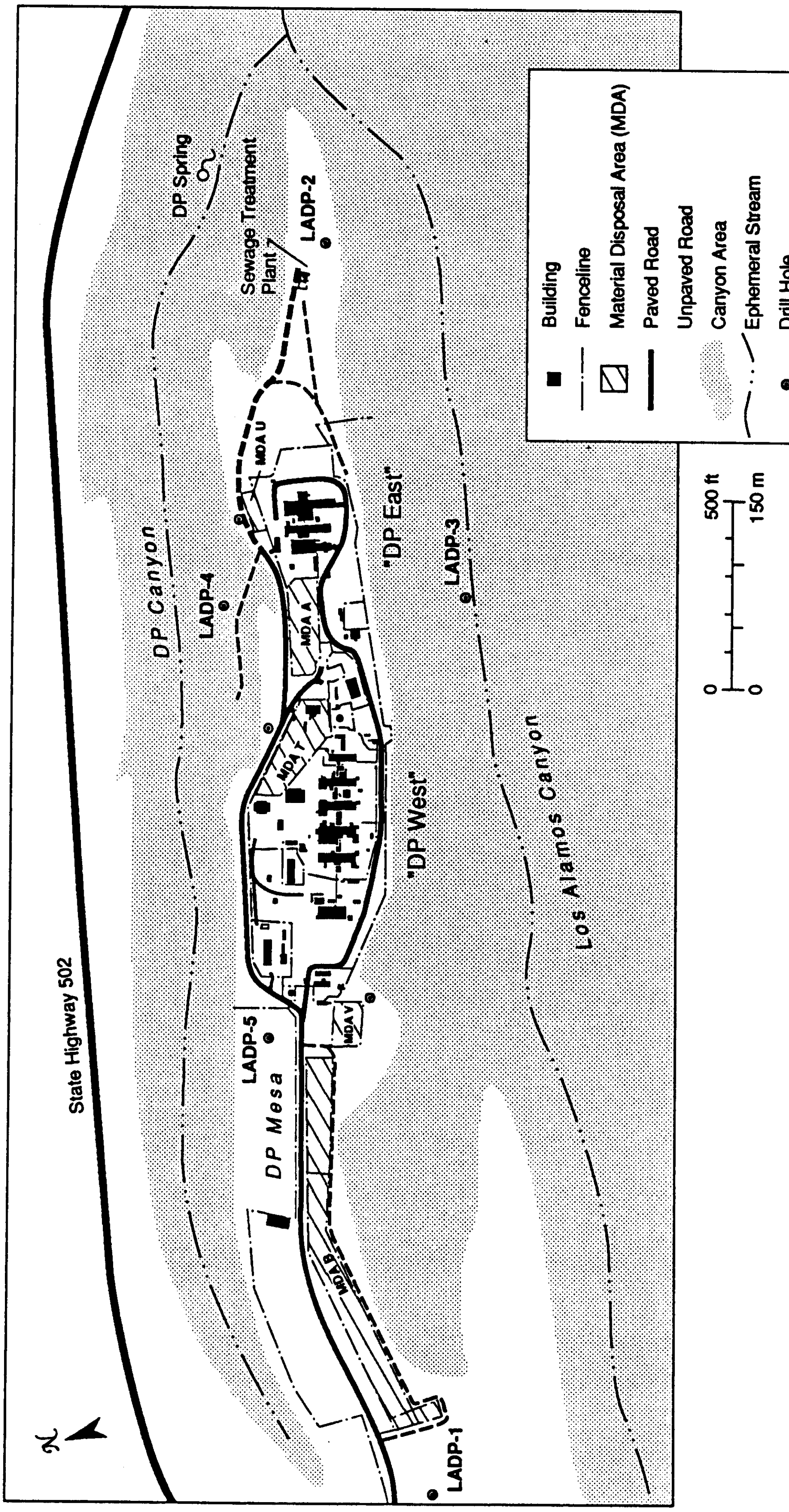


Fig. 11.9-1 Location of eight initial investigation geologic and hydrologic drill holes for TA-21.

TABLE 11.9-I
FIVE CATEGORIES OF GEOHYDROLOGIC CHARACTERIZATION

Measurement Category	Measurements performed	
	Background Characterization (5 holes)	MDA Characterization (3 holes)
Hydrogeological	all	selected[a]
Geochemical	all	all
Environmental Isotope	all	none
Straddle Packer Tests	all	all
Openhole Geophysics	all	all

[a]Hydrological tests performed at the MDAs include gravimetric water content, bulk density, dry density, and porosity.

Table 11.9-II

STANDARD GEOPHYSICAL PARAMETER

				Hydrogeological and Geochemical																	Environmental Isotopes									Open Hole Tests: Straddle Packer Tests								Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph		Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36		In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6		Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video

Saturated hydraulic conductivity. Quantitative measurement in intact, undisturbed core sample. ASTM method (ASTM D-2434-68)

Moisture characteristic curve. Quantitative measurement on intact, undisturbed core sample with the standard method to characterize wetting and drying cycles and verification at the dry end with the psychrometer method. American Society of Agronomy method (Chapter 24)

Air/water relative permeability. Calculated value determined by method of van Genuchten using data from saturated hydraulic conductivity test and moisture characteristic curves.

11.9.2 Geochemical Measurements

Clay mineralogy. X-ray diffraction test on powdered rock samples to determine type and relative abundance of clay minerals: kaolinite, illite, and montmorillonite.

Zeolite mineralogy. X-ray diffraction test on powdered rock samples to determine type and relative abundance of zeolite minerals.

Matrix mineralogy. X-ray diffraction test on powdered rock samples to characterize silica polymorphs, alkali feldspars, and volcanic glass.

Carbonate mineralogy. X-ray diffraction test on powdered rock samples to characterize carbonate minerals.

Iron and manganese mineralogy. X-ray diffraction tests on powdered rock samples to characterize iron and manganese minerals.

Total organic carbon. Measurement of total organic carbon in crushed rock samples by combustion in a muffle furnace. ASTM method (ASTM D-2974)

Cation exchange capacity. Measurement of cation ion exchange capacity on crushed samples of core by sodium absorption. EPA method 9080

Slurry pH. Measurement of Ph in a slurry of crushed core and deionized water. ASTM method (ASTM DG657)

11.9.3 Environmental Isotopes Measurements

Chloride-35/chloride-37. Isotope ratio measurement by accelerator mass spectrometer on soluble chloride leached with deionized water from crushed core samples.

Carbon-12/carbon-13. Isotope ratio measurement by mass spectrometer on pore water extracted under vacuum from crushed core samples.

Strontium-86/strontium-87. Isotope ratio measurement by mass spectrometer on pore water extracted under vacuum from crushed core samples.

Hydrogen/deuterium. Isotope ratio measurement by mass spectrometer on pore water extracted under vacuum from crushed core samples.

Oxygen-18/oxygen-16. Isotope ratio measurement by mass spectrometer on pore water extracted under vacuum from crushed core samples.

Tritium. Measurement of tritium activity in pore water extracted under vacuum from crushed core samples by direct counting with liquid scintillation method.

Carbon-14. Isotope age determination by accelerator mass spectrometer analysis on pore water under vacuum from crushed rock samples. Analytical results are corrected for carbon-13.

Chloride-36. Isotope age determination by accelerator mass spectrometer analysis on soluble chloride leached with deionized water from crushed core samples.

11.9.4 Straddle Packer Tests

***In situ* air permeability tests.** Tests performed over discrete depth intervals in open boreholes to measure *in situ* air permeability. Test is performed by vacuum extraction. Method for test is from Donahue and Erekian (1982).

Volatile organic compounds. Quantitative measurement on *in situ* gas samples extracted from discrete depth intervals in an open borehole. Analysis by US EPA Test Method (EPA TO14).

Carbon dioxide. Quantitative measurement on *in situ* gas samples extracted from discrete depth intervals in an open borehole. Analysis by ASTM Method (ASTM 1946).

Methane. Quantitative measurement on *in situ* gas samples extracted from discrete depth intervals in an open borehole. Analysis by ASTM Method (ASTM 1946).

Carbon-12/carbon-13. Isotope ratio analysis by mass spectrometer on *in situ* gas samples extracted from discrete depth intervals in an open borehole.

Relative humidity. Quantitative measurement on *in situ* gas samples extracted from discrete depth intervals in an open borehole. Analysis using thermocouple psychrometry method in Agronomy Monograph #9, Chapter 4.

Sulfur hexafluoride. Quantitative analysis performed on gas samples extracted from discrete depth intervals in an open borehole. Test is performed to evaluate contamination of the subsurface environment by air from air rotary drilling. Sulfur hexafluoride will be introduced as a tracer gas in the air supply used for drilling.

11.9.5 Open Hole Geophysical Measurements

Thermal neutron log. Continuous measurement in open borehole of the rock properties that capture thermal neutrons. Neutron capture is directly related to moisture content in unsaturated rocks and to porosity in saturated rocks.

Gamma gamma density log. Continuous measurement in an open borehole of rock properties that alternate and scatter gamma radiation. The measured values are directly related to bulk density of the rock. Instrument borehole sample uses a 100 mCi ^{137}Cs source.

Caliper log. Continuous mechanical measurement of the diameter of an open borehole. The measurements identify zones of fractured rock.

Axial borehole video log. A continuous television record of the walls of an open borehole. A wide angle lens provides a 360° view of the borehole wall. A compass mount provides directional orientation of discrete features such as fractures and joints.

Sidescan borehole video log. A continuous television record of a segment of the wall of a borehole. The sidescan lens is motor driven and will rotate 360° to provide complete viewing. A compass mount provides directional orientation of discrete features such as fractures and joints.

Electromagnetic induction log. A continuous measurement of the electrical properties of the bulk rock medium in an open borehole. The measurement may be taken in unsaturated or saturated environments.

Magnetic susceptibility log. A continuous measurement in open boreholes of the magnetic susceptibility of the rock matrix. The log is used for stratigraphic correlation.

Natural gamma radiation log. A continuous measurement in open or cased boreholes of the natural gamma radiation emitted by the rock matrix. The log is used for stratigraphic correlation.

Spectral gamma radiation log. A continuous measurement in open or cased boreholes of the natural gamma radiation emitted by the rock matrix. The gamma radiation spectrum is divided into three separate energy "windows" to differentiate abundances of uranium, thorium, and potassium. The log is used for stratigraphic correlation and to evaluate presence of radioactive contamination.

Prompt fission neutron log. A continuous measurement in the open hole of fissionable isotopes in the rock that may be related to radioactive contamination.

Geochemical (californium-252) log. Continuous measurement in the open borehole of the following suite of elements present in the rock matrix: aluminum, calcium, iron, silicon, sulfur, titanium, carbon, oxygen, hydrogen, chloride, potassium, thorium, and uranium. The method is measurement of gamma emissions that result from bombardment of the rock matrix by neutrons from a ^{252}Cf source.

11.10 Data Analysis

Several aspects of data analysis are integral to the use of the sequential sampling and decision analysis approaches described in Sec. 2.3 and the manner in which the field sampling plans have been structured. An overview of several important aspects of data analysis for the TA-21 OU is given below. Sequential sampling is briefly described first because this approach will cause data analysis to occur iteratively by sampling phase.

11.10.1 Sequential Sampling Approach

Sequential sampling involves the initial collection of one set of samples, with the results of measurements from this first set used to determine if additional sets of samples are required; the initial samples guiding the selection of the second set, and so on. Although unbiased estimates of population parameters can be based on a single set of samples, efficient and cost-effective data collection uses the first set of samples to determine the number of additional samples and their optimum locations for the required accuracy of the estimates. The second and further stages of the sequential sampling are used to give a more detailed characterization of the area, if required, and to confirm the predictions and parameter estimates of the earlier stages.

Sequential sampling will also be used to guide sample collection and chemical analysis when possible. Analytical results for the first set of the samples collected will be evaluated to determine if further analysis is necessary and to provide guidance for minimizing required analyses on subsequent samples. This is an efficient and cost-effective way to complete the analysis, particularly if adequate decisions can be made during the early stages.

11.10.2 Approaches to Data Analysis

Comparison to Local Levels. Due to the long history of operations at TA-21, with routine and accidental airborne releases and spills of liquid and solid materials, there is a concern for the presence of low-level contamination across the entire OU. In many of the SWMU-specific sampling plans, a major objective is the identification of suspected or unknown environmental releases of contaminants. In these situations, it is important not to confuse local contaminant levels because of historical OU-wide releases with evidence of a release from a particular SWMU. For this reason, all SWMU-specific data must be assessed against local contaminant levels in the area of the SWMU. Because there may be great variability across TA-21 of OU-wide contaminants, the suite of local data points against which a SWMU must be assessed will vary from SWMU to SWMU.

Use of Background Levels. The term background is used here in the context of Sec. 4.2.4 and means the ambient level of naturally occurring or nonsite-related elements, chemicals, or radionuclides. Comparison of sample analysis results or field instrument readings to background levels can be used to assess the presence of contaminants in certain media or at particular SWMUs. It is important to maintain the distinction between "local levels" discussed above and "background levels." The former is used to evaluate the presence of contaminants released from a particular SWMU versus the OU-wide contamination potentially present at TA-21. The latter provides one means for assessing the absolute presence of contamination versus ambient levels of a material in the environment.

Use of Action Levels. The use of action levels in assessing data obtained at TA-21 will be in accordance with the usage described in Sec. 3.5.2.2 of the IWP (LANL 1990). The action level concept is based on the EPA's proposed 40 CFR 264, Subpart S, and available action levels that have been proposed are listed in Appendix F of the IWP. Action levels will be used in conjunction with local levels and background levels to assess the presence, magnitude, and importance of environmental contamination from individual SWMUs. The comparison of sample analysis results to action levels will figure in the assessment of options for further characterization or the need for remediation.

Decisions to Conduct Additional Sampling. Within many of the individual sampling plans, options are presented to expand the scope of sampling based on immediate information from sample screening (Level I) and field laboratory measurements (Level II). These options allow the area covered by a sampling program to be adjusted as data become available and allow boreholes to be drilled deeper while contaminants are being detected.

In addition, many of the sampling plans provide plans or guidance for subsequent investigations. As part of the sequential sampling approach, subsequent investigations will be undertaken after review and evaluation of analytical data from initial sampling. In some cases, comparisons to action levels or a risk assessment may be part of the evaluation of the initial analytical data. A decision to conduct subsequent investigations will be based on a need to further characterize contaminant concentrations, vertical and lateral extent, or migration along particular pathways, dependent upon objectives of the given SWMU investigation.

Decisions Not to Conduct Additional Sampling. Characterization investigations may be terminated on the basis of one of several points as follows:

1. At many SWMUs, contamination is unknown or only suspected. In a number of these cases, initial results will be sufficient to determine that no significant contamination is present and that no further action is necessary.

2. In some cases, data from initial characterization may identify significant levels of contamination, but the nature and probable extent of contamination may indicate an easily remediated situation. A commonly encountered example is underground waste lines. In such cases, it may be judged more cost effective to remove the contaminated soil with careful monitoring to control excavation than it would be to do further characterization.

3. Initial characterization may identify waste types or contaminant situations for which the most appropriate approach is a pilot study to assess options for treatability or remedial alternatives.

4. In a few cases, further characterization may be curtailed so that effective planning of a corrective measures study can provide additional guidance.

Decision Analysis Approach. In all of these situations, the decision analysis approach, described in Sec. 2.1 above and in Appendix I of the IWP, will ensure that the decision-making process, with regard to additional characterization sampling, will be systematic. This will be documented by formal reports of data assessment. These will be prepared as technical addenda to the TA-21 OU work plan to document on-going activities.

References

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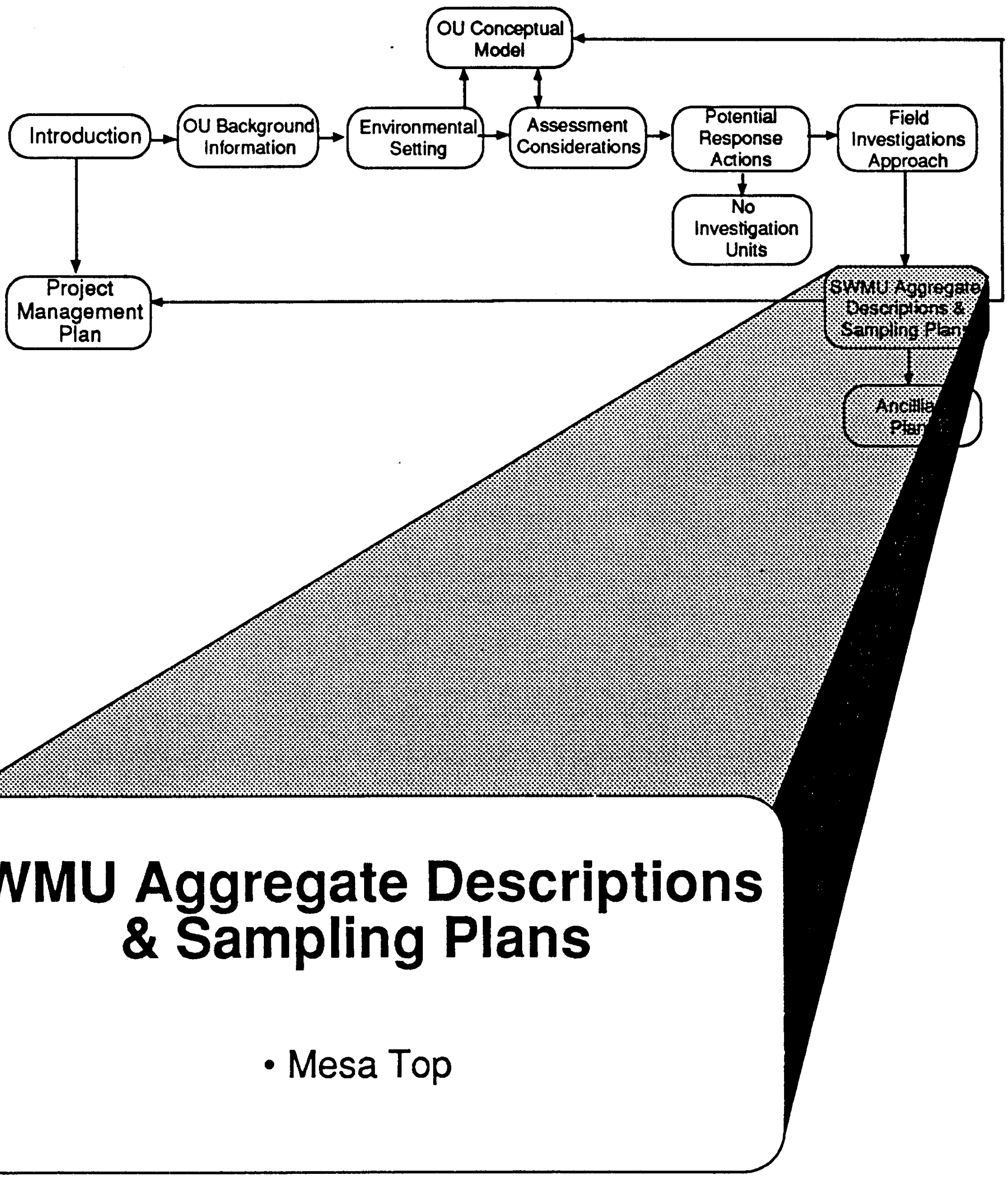
CHAPTER 12


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
Project Management Plan
SWMU Aggregate Descriptions & Sampling Plans
SWMU Aggregate Descriptions & Sampling Plans
• Mesa Top

12 MESA TOP SAMPLING PLAN

12.1 Introduction

The mesa top characterization effort is designed to characterize the surface and subsurface environmental setting of the entire OU.

The surface characterization is to document the local contaminant levels in surface soils across the OU. The field investigation is coordinated with the field investigation to investigate deposition of radionuclides across the surface of the TA-21 OU from stack emissions (see Chapter 13). The two field investigations will collect samples at the same locations defined by a surveyed grid established over the OU. The strategy for the field investigation to characterize surface soils is presented in Sec. 12.4 and is summarized in Fig. 12.1-1. (See all tables and figures at the end of this chapter). Tables 12.1-I through 12.1-IV summarize field measurements and laboratory analyses.

The subsurface characterization effort is designed to provide a fundamental understanding of the hydrogeologic framework within which TA-21 and its associated SWMUs lie. The strategy for the subsurface field investigation is presented in Sec. 12.5 and is summarized in Fig. 12.1-2. The measurement methods used in the characterization and the type and number of samples collected for analysis are summarized in Tables 12.1-I through 12.1-VI. The methods for field measurements and laboratory analyses are discussed in Chapter 11.

Because one of the primary potential remedial alternatives to be evaluated for SWMUs with subsurface contamination (e.g., MDAs; see Chapter 16) is capping-in-place with *in situ* stabilization, vadose zone characterization below the existing depth of contamination for the entire OU is important. Therefore, the subsurface characterization investigation includes six vertical drill holes to a depth of 300 ft that are located strategically around the top of the mesa. Three of these holes are in background areas and three are located between the three liquid MDAs and the mesa edge.

In addition, the initial investigation includes one drill hole in Los Alamos Canyon and one drill hole in DP Canyon to determine the potential presence of deep perched water. It also includes tracer tests to characterize the hydrogeologic setting of DP Spring. A required subsequent investigation includes two drill holes in DP Canyon to investigate the presence of an alluvial aquifer. If needed for hydrogeologic characterization, an additional vertical drill hole will be located at each of the liquid MDAs in the subsequent investigation.

The subsurface studies are designed to characterize the three-dimensional hydrogeology of the unsaturated zone at the OU. The field investigation includes tests to quantitatively characterize fracture flow, matrix flow, and vapor phase flow. Environmental isotope analyses of pore fluids through vertical profiles will characterize the history of groundwater in the subsurface. Geochemical and chemical characterization on core samples will provide required input for modeling contaminant transport and will also provide background concentration levels for contaminants of concern at TA-21 SWMUs.

The results of the hydrogeologic characterization to 300 ft from both OU-wide and MDAs' drill holes will be evaluated to determine the need for subsequent investigations to further characterize the physical setting related to subsurface contaminant migration.

12.2 Mesa Top Sampling/Investigation Rationale

A fundamental understanding of the hydrogeologic framework within which TA-21 and its associated SWMUs lie is necessary for characterization, assessment, and remediation of TA-21 SWMUs. The sampling plan presented in this chapter is intended to provide data to further define the OU conceptual model presented in Chapter 7 by addressing data needs stated in Chapter 8. This chapter presents the regulatory and technical rationale for this approach.

12.2.1 Regulatory

First, general hydrogeologic characterization is required in the Laboratory's RCRA Part B permit (EPA 1990), which details required RCRA facility investigation activities in Section P, Task III, Facility Investigation. A.1 of this section requires a program to evaluate hydrogeologic conditions, which will provide the following information:

a. A description of the regional and facility specific geologic and hydrogeologic characteristics affecting groundwater flow beneath the facility;

b. An analysis of any topographic features that might influence the groundwater flow system. (Note Stereographic analysis of aerial photographs may aid in this analysis);

c. An analysis of fractures within the tuff, addressing tectonic trend fractures versus cooling fractures;

d. Based on field data, tests, (gamma and neutron logging of existing and new wells, piezometers and borings) and cores, a representative and accurate classification and description of the hydrogeologic units which may be part of the migration pathways at the facility (i.e., the aquifers and any intervening saturated and unsaturated units);

e. Based on field studies and cores, structural geology and hydrogeologic cross sections showing the extent (depth, thickness, lateral extent) of hydrogeologic units which may be part of the migration pathways identifying;

i) Unconsolidated sand and gravel deposits,

ii) Zones of fracturing or channeling in consolidated or unconsolidated depos its, and

iii) Zones of high permeability or low permeability that might direct and restrict the flow of contaminants.

f. Based on data obtained from groundwater monitoring wells and piezometers installed upgradient and downgradient of the potential contaminant source a representative description of water level or fluid pressure monitoring;

g. A description of manmade influences that may affect the hydrogeology of the site; and

h. Analysis of available geophysical information and remote sensing information such as infrared photography and Landsat imagery.

The RCRA Part B permit also details a soils program to characterize soil and rock units above the water table in the vicinity of contaminant release(s). Section P, Task III, A.2 specifies that this characterization program will include, but is not limited to, the following information:

a. Surface soil distribution;

b. Soil profile, including ASTM classification of soils;

c. Transects of soil stratigraphy;

d. Saturated hydraulic conductivity;

e. Porosity;

f. Cation exchange capacity (CEC);

g. Soil pH;

i. Particle size distribution;

j. Depth of water table;

k. Moisture content;

l. Effect of stratification on unsaturated flow;

m. Infiltration;

n. Evapotranspiration;

o. Residual concentration of contaminants in soil;

p. Mineral and metal content;

q. Trace element geochemistry as a means of differentiating units within the tuff; and

r. Water balance scenarios.

In summary, the RCRA Part B Permit requires comprehensive hydrogeological and soils characterization of the vadose zone to the water table as stated in Section P, Task III, A.1.d.:

> ...a representative and accurate classification and description of the hydrogeologic units which may be part of the migration pathways at the facility (i.e., the aquifers and any intervening saturated and unsaturated units).

The following sections detail required technical data to meet these regulatory requirements.

12.2.2 Technical

A technical understanding is necessary to assess potential movement of contaminants within the hydrogeologic system. A systematic study of the general hydrogeology of the TA-21 OU using a sequential sampling approach will provide an understanding of the general framework, which is essential for defining the nature and extent of contamination from SWMUs. This investigation will define pathways and migration mechanisms critical for performing long-term risk assessments required as a part of the evaluation of remedial alternatives at individual TA-21 SWMUs.

TA-21 is one of the most complicated of the Laboratory's ER Program OUs. General hydrogeological data are crucial to determine remedial alternatives for SWMUs. The preferred remedial alternative in the majority of situations, detailed in Chapter 10, will likely be in-place stabilization. Supporting this passive remedial alternative will require demonstration that offsite contaminant migration will not occur. As discussed in Chapter 4, available geohydrologic characterization data for TA-21 pertain to only a 100-ft depth (Nyhan et al. 1984). Deeper geologic zones and their hydrologic properties will affect potential contaminant migration to greater depths.

Geologic and hydrologic studies of DP Mesa include surface and subsurface characterization. Surface studies are an important component of site characterization because surface water, stream sediments, and airborne particulates are likely media through which contaminants could be transported to potential receptors. These surface pathways need to be characterized because contaminated materials can be readily exposed by erosion of shallow waste disposal beds. Certain MDAs (see Chapter 16 for detail) are vulnerable to erosion because of their locations near canyon rims; these canyon rims are areas of headward and lateral erosion and may be susceptible to mass wasting. Subsurface studies are designed to determine the geologic framework of the site and to understand the hydrologic processes controlling water movement through the mesa. Possible perched water and groundwater movement and subsurface vadose zone movement, probably in the vapor phase, are important media for contaminant transport in the subsurface environment.

Site remediation recommendations will be based in large part on evaluating the ability of natural geologic barriers to contain contaminants. For example, there is the potential that contaminants, including long-lived radionuclides, may be isolated in the thick vadose zone for thousands of years because of the low permeability of unsaturated tuffs and because of the retardation of contaminant movement by rock-water and rock-contaminant interactions. Thus, the removal of buried waste from SWMUs may not be warranted if geologic and hydrologic conditions make it unlikely that contaminants will be transported to adjacent canyons or to the water table. On the other hand, if remedial work is necessary, the geologic and hydrologic studies detailed in this chapter will provide information about the physical and chemical properties of rocks; characterization of these properties will affect potential remediation technologies for the site and enhance long-term monitoring programs.

12.2.3 Sampling Objectives

Surface geologic and hydrologic studies at TA-21 will determine lateral and vertical variations in rock properties and delineate structural and geomorphic features that can affect contaminant transport in the uppermost part of the vadose zone. Data from surface studies will be integrated with drill hole data to produce geologic cross sections for a three-dimensional model of the site geologic framework. These data will be used to support models that require lithologic and structural information to constrain calculations of geochemical transport. Subsurface characterization of TA-21 combines field and laboratory studies to determine the geologic and hydrologic properties of rock units that presently contain waste or that lie between waste disposal facilities and the main aquifer beneath the site.

Specific sampling objectives of geologic and hydrologic studies at TA-21 are

- to develop a three-dimensional conceptual model of the geology and hydrology of DP Mesa by determining vertical and lateral changes in stratigraphy, lithology, and mineralogic and hydrologic characteristics;
- to characterize faults, fractures, partings, stratigraphic contacts, welding zones, and other features that may affect contaminant transport pathways;

- to provide measurements of physical properties of rock units for use in transport and groundwater travel time calculations;
- to identify potential natural barriers to contaminant transport;
- to document the nature of the surficial materials and the surface transport processes and pathways on the mesa tops and canyon sides that relate to possible contaminant transport; and
- to identify perched water in the vadose zone and characterize the chemical and isotopic composition of any water encountered.

12.3 Geomorphologic Sampling Plan

12.3.1 Geologic Base Map

Surface studies will initially entail the preparation of a detailed geologic map on a 1:3600 scale topographic base using the Geologic Mapping of Bedrock Units SOP to show the distribution of all rock units and surficial materials and to show the orientation and dip of contacts, bedding planes, foliations, faults, and other discontinuities. In addition, the location of springs and other major hydrologic features will be shown. The map will show the lateral extent and thickness of rock units and major subunits and the relative offsets, orientations, and fracture density. The map will be used to support subsequent surface and subsurface studies by summarizing baseline geologic information for the site.

12.3.2 Stratigraphic Sections

At least two stratigraphic sections will be measured in the upper Bandelier Tuff at outcrops on the south side of DP Mesa. Similar stratigraphic sections will be measured for the lower Bandelier Tuff in Pueblo Canyon. Characterization will include detailed descriptions and measured positions of lithologies, stratigraphic contacts, welding and devitrification features, and zones of vapor phase crystallization. Structures, such as cooling joints and tectonic fractures, will be mapped, and their orientations will be measured. These sections will identify the major hydrogeologic subunits whose matrix and fracture properties control the movement of moisture and contaminants. Secondary minerals in matrix and fracture materials will be determined to identify groundwater pathways and to identify potential mineralogic barriers that may retard contaminant migration.

Additional stratigraphic sections will be compiled for the epiclastic rocks in the Cerro Toledo rhyolite and on the fluvial sedimentary rocks that occur in the Puye Formation and the Santa Fe

Group. Tuffaceous sediments of the Cerro Toledo rhyolite were deposited between the upper and lower members of the Bandelier Tuff throughout the DP Mesa area and include intercalated lenses of coarse boulder conglomerates and undulating channel fills that may provide permeable horizontal pathways of fluid migration. Fluvial sedimentary rocks of the Puye Formation and Santa Fe Group form the major hydrogeologic units beneath the Bandelier Tuff. Porous and permeable horizons, such as the Totavi Lentil, are interbedded with these sedimentary units and are potential transport pathways. These rock units do not crop out at DP Mesa, but excellent exposures of these rocks occur in Los Alamos, Pueblo, Guaje, and White Rock canyons.

12.3.3 Geomorphic Characterization

Geomorphic characterization of DP Mesa (using the Geomorphic Characterization SOP) and vicinity will identify significant erosional processes that may compromise the integrity of SWMUs near the mesa edge, such as the MDAs, and affect the residence times of contaminants in sediment storage sites downslope of these SWMUs. The geomorphic characterization will involve preparation of a 1:3600 scale map of surficial deposits on DP Mesa and in the adjacent canyons and an additional 1:3600 scale map of landforms and drainage patterns, including sites of active erosion and sites of groundwater emergence and potential infiltration. Surficial deposits to be mapped include colluvium and artificial fill on the tops and sides of the mesa and colluvium and alluvium in the canyon bottoms. During the mapping of drainage channels, local sediment storage sites will be delineated. Sediment deposition areas will be sampled as part of associated SWMU investigations, as detailed in Chapters 15 and 16.

Sediments in DP Canyon and Los Alamos Canyon will be studied to determine the magnitude, location, and timing of erosional events. As appropriate, this information collection will be integrated with the ER Program Canyons' Task. Colluvial and alluvial deposits will be described from soil pits and trenches. The locations of these pits and trenches will be determined after the maps of surficial deposits have been prepared. Estimates of the ages of the different surficial deposits will be made using methods such as radiocarbon dating, the degree of soil profile development, and other techniques. During the mapping, evident erosional features including rills, gullies, and landslide scars will be located and used to describe the major erosional processes in the area and to identify areas susceptible to erosion.

12.4 Surface Grid Sampling Plan

Surface characterization will be conducted by sampling the entire OU on a 40-m by 40-m grid. The purpose of this sampling is twofold: first, to characterize any surface soil contamination resulting from airborne stack emission SWMUs by sampling the top 0 to 1 in. (see Chapter 13 for detail); and second, to sample 0 to 6 in. at the same grid points to establish the local contaminant levels across the TA-21 OU. The 0- to 6-in. sampling will establish a reference point to distinguish the "TA-21 OU local background" from elevated contaminant levels at SWMUs and uses the same sample depth increment as will be used at the SWMUs to ensure data comparability.

Only the 0- to 6-in. sampling is discussed here; the rationale and details for 0- to 1-in. sampling at grid points is discussed in Chapter 13. Surface characterization will consist of surface soil sampling (for method, see Sec. 11.5.2.1) at the nodes of the gridded area shown in Fig. 13.3. For the areas with buildings, samples will be taken from the center of overlapping circles, as described in Sec. 13.2.4.1 (see Fig. 13.4). The rationale for the grid and sampling density is detailed in Sec. 13.2.3.

There are approximately 210 sampling locations in the surface grids. An additional 20 samples will be taken at points 10 m from the grid points to provide a measure of spatial variation. All samples will be field-screened at the time of collection (for method see Sec. 11.6.1.1 and 11.6.1.2) and will be submitted to an analytical laboratory for radionuclides, semivolatiles, and metals analysis as detailed in Table 12.4-I. Twenty-five percent of the samples will be analyzed in the analytical laboratory for isotopic uranium and isotopic thorium.

To provide "TA-21 OU local background" data for field surveys at the SWMUs, measurements will be made at each sampling location with radiation survey instruments as indicated in Table 12.4-I.

12.5 Subsurface Sampling Plan

Hydrogeologic data are currently available only to a depth of 100 ft beneath TA-21. Certain SWMUs received liquid waste that has driven contaminants into the vadose zone (e.g., at MDA T where contamination has been found to 100 ft; see Sec. 16.3). However, because of the approximate 1150-ft thickness of the vadose zone, as stated in the OU conceptual model, the groundwater pathway is unimportant at the TA-21 OU. Nonetheless, because one of the primary potential remedial alternatives to be evaluated for SWMUs with subsurface contamination (e.g., MDAs, see Chapter 16) is capping-in-place with *in situ* stabilization, vadose zone characterization below the existing depth of contamination for the entire OU is important.

Subsurface OU-wide characterization is phased as follows:

1. Five deep vertical holes will be drilled at the perimeter of the TA-21 OU to identify potential transport pathways and migration mechanisms in the vadose zone and to characterize the lateral and vertical variations of geologic and hydrologic properties of

deeper stratigraphic units beneath existing vadose zone contamination. Three of the holes, located on top of the mesa, will be drilled to 300 ft. One drill hole located in DP Canyon will be 675-ft deep. One drill hole in Los Alamos Canyon will be 400-ft deep.

2. Three 300-ft holes will be drilled, one each at each liquid waste MDA (T, U, and V) to further define hydrogeological properties in proximity to these SWMUs.

3. If needed, based on evaluation of initial results, an additional 300-ft hole may be drilled at each of the three liquid waste MDAs to further define hydrogeological properties.

4. A tracer test will be performed to define the source for elevated concentrations of tritium present in DP Spring. A subsequent investigation will include two drill holes to 200 ft to characterize the hydrogeologic setting of DP Spring.

5. The results of hydrogeological property characterization from both OU-wide and MDA boreholes will be evaluated. The OU conceptual model will be updated (the current conceptual model states that deep vadose zone movement and the groundwater pathway are relatively unimportant), and the need for deeper subsurface characterization data will be evaluated. Drilling holes to groundwater is contingent upon what is learned from the above characterization.

12.5.1 Initial Investigation

The subsurface studies presented in this section are designed to characterize the three-dimensional hydrogeology of the unsaturated zone at the TA-21 OU. The importance of fracture flow, matrix flow, and vapor-phase flow is to be characterized. The needed data are acquired through a program of laboratory analyses performed on rock samples. The characterization includes the rock units within the Bandelier Formation because this formation extends from the top of DP Mesa to beneath the floors of DP Canyon and Los Alamos Canyon. The studies are based on stratigraphy developed for the Bandelier Formation discussed in Chapter 4.

The subsurface studies presented in this section will develop the data required for characterization of the physical system related to migration of contaminants through the unsaturated zone. Depending on the results of this investigation, additional characterization studies of the hydrogeologic and geochemical controls on the migration pathways and mechanisms may be conducted at MDAs or OU-wide.

The studies included in this section do not include K_d tests on rock samples. However, bulk rock samples for representative lithologies will be archived as part of the studies. The samples will be available for the performance of K_d tests that, if needed, will be designed using the results of investigations at the MDAs and SWMUs to identify contaminants of concern.

12.5.1.1 Drilling Program for Subsurface Characterization

Eight geologic and hydrologic characterization holes in the upper 750 ft of the vadose zone (measured from the mesa top elevation) will be drilled at TA-21. Five are located to bound OU-wide conditions (Fig. 12.5-I), and three are located adjacent to the liquid waste MDAs (T, U, and V). The holes are located away from TA-21 SWMUs to minimize the possibility of encountering subsurface contamination or opening potential transport pathways.

Table 12.5-I presents the approximate stratigraphy to groundwater for the five OU-wide drill holes. As shown, some holes may penetrate the Otowi Member of the Bandelier Formation. Continuous core will be collected for the entire depth of all five drill holes because this stratigraphic section is most important for characterization of contaminant transport within the unsaturated zone. The core will be sampled to perform laboratory tests to characterize representative hydrostratigraphic units of the Bandelier Formation (see Table 12.5.-II). Collection of continuous core for stratigraphic units within the Bandelier Formation is achievable based on previous drilling experience at the Laboratory.

Drilling Method Requirements for Subsurface Characterization. The characterization activities presented in this section place special requirements on the drilling methods used for the geologic and hydrologic characterization holes. These requirements include the following:

1. Continuous core sampling through the Bandelier Formation.
2. Discrete core sampling within the Puye Formation to characterize all lithologies.
3. Core must not be contaminated with drilling fluid or dried by contact with drilling air.
4. Isotopic characterization of water extracted from rock pores in the unsaturated zone would require a large volume of rock sample that has not been contaminated with drilling fluid or dried by air used for drilling. This characterization is most important for the stratigraphic units from ground surface to a depth of 200 ft. Cuttings from drilling with a hollow-stem auger method would be suitable for analysis.
5. An open drill hole is required through the Bandelier Formation for *in situ* packer tests to collect soil gas samples and to measure *in situ* permeability. The open drill hole is also required for a suite of borehole geophysical logs. The walls of the drill hole must be free of contamination by drilling fluids or by air used for drilling.
6. The diameter of the finished drill hole must be of suitable diameter for installation of monitor well casing. A 10-in. diameter is preferred for the drill hole.

12.5.1.2 Eight Bandelier Formation Characterization Holes

Eight deep drill holes will be drilled to identify potential transport pathways in the vadose zone and to characterize the lateral and vertical variation of geologic and hydrologic properties of the rock section.

Three Liquid Waste MDA Drill Holes. Three 300-ft holes are located adjacent to the liquid waste MDAs T, U, and V. Geohydrologic characterization will be conducted as detailed in Secs. 12.5.1.4 and 12.5.1.5 for these holes. Background contaminant levels will not be determined on core from these holes because of the proximity of these holes to the MDAs.

Five OU-wide Drill Holes. Five holes at varying depths are located at areas selected as representative of the entire OU. Their depths were selected to include zones of potential perched water in adjacent side canyons and to intersect the top of a potential basalt zone, based on general stratigraphic information obtained from the nearest boreholes to groundwater (Boreholes T-2 and 0-4; see Sec. 4.1.).

Drill holes LADP-3 and -4, located in Los Alamos and DP Canyons, respectively, will be drilled first to see whether a deep perched water zone is encountered and to determine whether it is at the same elevation in each drill hole. If a perched zone is encountered at the same elevation in each of these holes, drill holes on the mesa top (i.e., LADP-1, -2, and -5) may be deepened beyond the 300-ft depth in a subsequent investigation to determine whether perched water is continuous beneath the mesa. The general rationale for the location of each of the drill holes is given below.

Because subsurface variations are expected to be greatest in an east-west direction, holes LADP-1 and -2 will be drilled at the extreme western and eastern ends of the site, respectively (Fig. 12.5-1). The third deep drill hole on the Mesa (LADP-5) is located north of MDA V near the suspected location of a fault that strikes north-south in the vicinity of MDA V.

Drill hole LADP-3 is located in Los Alamos Canyon south of MDA A (Fig. 12.5-1). This drill hole will characterize potential perched water pathways beneath the canyon floor. In addition, information from LADP-2 and -3 will be compared to geologic and hydrologic data from water well Otowi 4 to determine the variability in the geology and hydrology of the stratigraphic section below the Bandelier Tuff. LADP-3 will be drilled to 400 ft because it is projected that a perched zone could be encountered at approximately 340 ft and that the top of the basalt layer should be at approximately 380 ft.

Drill hole LADP-4 is located in DP Canyon in a "swampy" area north of MDAs A and T (Fig. 12.5-1). The drill hole will investigate the presence of perched water in this part of DP Canyon and will characterize the geologic and hydrologic properties of stratigraphic units present beneath DP Canyon. This hole will be drilled to a 675-ft depth because it is estimated that perched water could be encountered at 625 ft and that the top of the basalt lies at 665 ft.

If perched groundwater is encountered during drilling of any of the five drill holes, then drilling will stop and the hole will be completed as a monitor well in the perched zone. This does not include shallow alluvial aquifers. The deep drill hole will be moved to a new location at least 100 ft away from the perched zone monitoring well. Any deep perched water encountered near the nominal borehole depth will cause drilling to cease and the hole to be completed as a monitoring well. Any perched water encountered will be sampled, analyzed for the full suite of contaminants, and analyzed for stable isotope variation in water, as detailed later in Sec. 12.6.1.2.

12.5.1.3 Characterization of Background Concentrations in Core Samples

Rock samples will be collected from each of the drill holes to characterize background concentrations. The analytical suite for chemical and radionuclide characterization is presented in Table 12.5-III. Background contaminant levels will not be determined on core from the three MDA drill holes because of the proximity of these holes to the MDAs.

Five background samples will be collected from each of the drill holes. The exact samples that are selected from a given drill hole will be determined by geologic description of the core as it is collected. If present, fracture zones will be sampled. Analytical tables assume three fracture samples per borehole. The field staff will collect samples to provide a real and vertical coverage of hydrostratigraphic units listed in Table 12.5-II for the Bandelier Formation.

12.5.1.4 Characterization of Hydrogeological Parameters on Core Samples

Intact, high quality core will be submitted to a geotechnical laboratory for the following suite of analyses:

- gravimetric moisture content;
- porosity (helium injection test);
- bulk density;
- saturated hydraulic conductivity;

- air-water relative permeability; and
- moisture characteristic curves (wetting and drying [analysis with laboratory thermocouple psychrometer method]).

Characterization of the vertical variation in moisture content is an important parameter to evaluate transport of contaminants. Other investigations at the Laboratory have determined that moisture content can vary greatly over a short vertical distance. Therefore, core samples for moisture content would be collected on an average interval of 5 ft from land surface to the total depth of the drill holes (see Table 12.5-III). Core samples will be distributed so that all hydrostratigraphic units are sampled as represented in Table 12.5-II; samples will be collected close to open joints, from clay-filled joints, and distant from joints in welded and nonwelded rocks.

Bulk density, dry density, and porosity values will be calculated for each core sample for which moisture content is determined (every 5-ft-core interval). The analytical results would be used along with information from geologic characterization and borehole geophysics to select core samples to determine porosity (helium gas injection), water characteristic curves, air-water relative permeability, and saturated hydraulic conductivity. Sample interval for these tests will be every 20 ft (Table 12.5-IV).

The hydrogeological parameter tests can be sequentially performed in a geotechnical laboratory on intact high-quality core that is collected for the gravimetric moisture test. The discrete core samples must be sealed in air tight containers at the time of collection in order to prevent changes in moisture content. Sample collection and laboratory tests will be performed using either the following LANL ER Program SOPs or conventional laboratory methods identified in parentheses below (e.g., ASTM):

- field methodology to collect and preserve rock core samples for hydrogeologic parameter tests;
- laboratory method to determine gravimetric moisture content on rock samples (ASTM Method D-4531-86);
- laboratory method (helium injection test) to determine porosity on intact, undisturbed rock core samples (American Petroleum Institute Method 40, Sec. 3.58);
- laboratory method to determine bulk density on intact, undisturbed rock core samples (ASTM Method D-4531-86);
- laboratory method to determine saturated hydraulic conductivity on intact, undisturbed rock core samples (ASTM Method ASTM D-2434-68);
- laboratory method to determine air-water relative permeability on intact, undisturbed rock core samples; and

- laboratory method (thermocouple psychrometer method) to determine moisture characteristic curves (wetting and drying cycles) on intact, undisturbed rock core samples (American Society of Agronomy Method, Chapter 24).

12.5.1.5 Characterization of Mineralogy and Geochemical Parameters on Core Samples

Geochemical characterization on rock samples is needed as input for geochemical models (using numerical codes such as PHREEQE) to predict migration of contaminants. The analytical suite includes the following parameters:

- clay mineralogy,
- zeolite mineralogy,
- rock matrix mineralogy,
- carbonate mineralogy,
- iron and manganese mineralogy,
- total organic carbon,
- cation exchange capacity, and
- slurry pH.

The analyses may be performed on crushed samples. The interval for sample collection in the drill holes will be every 20 ft (Table 12.5-IV). Additional samples of the core will be selected to characterize fracture-lining minerals, changes in lithology, or zones of sorptive minerals. An additional three samples per borehole are assumed. Where possible, mineralogic and hydrologic testing will be done on the same suite of samples. The number and distribution of samples for the characterization of fracture-lining minerals are dependent on the number and nature of fractures encountered by the drill holes; core samples appropriate for characterization will be identified after inspection of the drill core. Sampling will be guided by geologic descriptions to characterize all hydrostratigraphic units presented in Table 12.5-II.

Sample collection and laboratory tests will be performed using either the following LANL ER Program SOPs or conventional laboratory methods (e.g., ASTM):

- field methodology to collect and preserve rock core samples for geochemical parameters tests;
- pulverizing rock samples for chemical and mineralogic analyses;
- purification of zeolite samples for mineralogic identification;

- procedure for collecting mineralogic data by x-ray diffraction;
- laboratory method to determine total organic carbon content in rock samples;
- laboratory method to determine cation exchange capacity in rock samples (EPA Method 9080); and
- laboratory method to determine slurry pH in rock samples.

12.5.1.6 Logs In Open Boreholes

A suite of borehole logs will be collected in open boreholes. The logs will be performed to extend information gathered from geologic description and tests performed on core samples. The logs would enhance stratigraphic correlation, identify and map orientation of fractures and joints, define the relative variation in moisture within the unsaturated zone, and the variation in bulk density within the vertical hydrogeologic section. In addition, the logging suite includes logs to investigate the presence of radioactive and chemical contaminants. Running these logs in these uncontaminated background holes would establish a baseline for comparison to logs that may later be collected in areas of suspected contamination. Table 12.5-V lists the logs to be collected in open boreholes and describes the objective of each log.

All borehole geophysical logging activities will be performed in accordance with either LANL ER Program SOPs or conventional field procedures as follows:

- Borehole Gamma Logging
- Borehole Neutron Logging
- Borehole Caliper Logging
- Borehole Gamma Gamma Logging
- Borehole Video Logging (Axial and Sidescan)
- Borehole Induction (Geonics EM-39) Logging
- Borehole Magnetic Susceptibility Logging (Romulus Instrument)
- Borehole Spectral Gamma Logging
- Borehole Prompt Fission Neutron Logging
- Borehole Geochemical Logging with Neutron Activation and Elastic Scattering
- Borehole Temperature Gradient Logging

12.5.1.7 Characterization of Stable Isotope Variation in Water

Characterization of a suite of stable isotopes in the vertical stratigraphic section on water extracted from rock samples and on water samples collected from springs, seeps, and perched zones would provide the needed information to delineate the depth of migration of water that has infiltrated into the subsurface below DP Mesa and below the floor of Los Alamos Canyon and DP Canyon. The suite of stable isotopes includes ratios for the pairs listed in Table 12.5-VI. In addition, analysis will be performed on a suite of radioactive isotopes (listed in Table 12.5-VI) to determine absolute ages of groundwater in the vertical hydrostratigraphic section of each drill hole. The sample interval for analysis will be every 20 ft for the depth interval from land surface to 100 ft. At depths greater than 100 ft, sampling will be approximately every 40 ft or at zones of high moisture content as determined by the gravimetric moisture content tests on core samples. This is because the isotopic characterization requires extraction of pore water from a large volume of rock sample when the *in situ* moisture content is at low values. Moisture contents would be less than 10% in much of the vertical stratigraphic section. Therefore, this activity requires drilling with a hollow stem auger method and collection of the auger cuttings on a 10 ft depth interval. The cuttings must be immediately drummed in an air tight container. Argon gas is used to purge atmospheric air from the container before sealing. The purging and sealing are required to prevent contamination of the cuttings by atmospheric moisture.

Sample collection and laboratory tests will be performed using either the following LANL ER SOPs or conventional laboratory methods:

- field methodology to collect and preserve rock samples for stable isotope analyses on *in situ* moisture;
- laboratory method to extract *in situ* moisture from rock core for isotopic analyses; and
- laboratory methods to analyze water samples for environmental isotopes.

Water samples collected from seeps and any perched zones would also be analyzed for the stable isotope pairs and environmental radioactive isotopes presented in Table 12.5-VI. The samples will be collected with a method to prevent aeration and will be immediately sealed in an air tight glass bottle.

Sample collection and laboratory tests will be performed using either the following LANL ER SOPs or conventional laboratory methods:

- field methodology to collect and preserve groundwater samples from seeps, springs, and monitoring wells for environmental isotope analyses.

12.5.1.8 Straddle Packer Tests in Open Boreholes

An inflatable straddle packer assembly will be used to determine *in situ* permeabilities for discrete depth intervals in the open borehole of each drill hole. The testing method will be vacuum extraction. The testing interval will be every 20 ft for the first 100 ft and every 40 ft thereafter. The discrete intervals selected for testing will be based on the results of geologic description of core, the interpretation of the suite of borehole geophysical logs, and the results from the moisture content tests on core samples. The above information will be used to select discrete stratigraphic intervals for testing that would represent the hydrostratigraphic units presented in Table 12.5-II for the Bandelier Formation.

Pore gas samples would be collected during performance of the straddle packer tests to determine *in situ* permeabilities. The data are needed to characterize the vapor transport pathway. The collected gas samples will be analyzed for the following:

- volatile organic contaminants,
- carbon dioxide,
- methane,
- carbon-12/carbon-13,
- relative humidity, and
- SF_6 (a gas introduced during drilling to trace contamination of *in situ* pore gas by drilling air).

Sample collection and laboratory tests will be performed using either the following LANL ER Program SOPs or conventional field and laboratory procedures:

- field methodology to collect and preserve pore gas samples collected from discrete intervals in open boreholes using pneumatic straddle packers and
- laboratory method to analyze constituents in pore gas samples.

12.5.2 Subsequent Investigation

Hydrogeological property characterization data to 750 ft OU-wide and to 300 ft in liquid MDA boreholes will be assessed. If a perched zone is encountered at the same elevation in drill holes LADP-3 and -4, then drill holes on the mesa top (i.e., LADP-1, -2, and -5) may be deepened beyond the 300-ft depth to determine whether perched water is continuous beneath the mesa. As shown in Table 12.5-VII, it is assumed that these holes will be deepened to 750 ft. Analytical requirements are assumed to be the same as in the initial investigation as shown in Tables 12.5-VII and 12.5-VIII. Additionally, if needed, one 300-ft drill hole will be added at each liquid MDA.

Data from the eight characterization holes will also be used to update the OU conceptual model. In conjunction with initial characterization data from SWMUs with deep liquid releases (particularly MDA T, other liquid MDAs, and the acid waste sumps), the need for deeper subsurface characterization data will be evaluated.

12.6 Transient Groundwater Emergence Sampling Plan

Lateral groundwater flow, which is controlled by stratigraphic permeability barriers within the Bandelier Tuff, may daylight in canyon walls or emerge in canyon bottoms, providing a potentially important present or future transport path for contaminant migration. Transient groundwater emergence sites will be identified by repeated field inspection during spring and summer months when spring flow on the Pajarito Plateau is greatest. The bedrock and geomorphic characteristics will be determined at any such sites of groundwater emergence, and the water will be sampled and analyzed for volatile, organic, and inorganic contaminants (Table 12.5-VI). In addition, geomorphic features such as amphitheater-shaped alcoves will be examined to identify potential sites of significant groundwater emergence during periods of wet climatic conditions. One such known site, DP Spring, will be investigated as detailed below. Analytical tables provide for five samples of seasonal surface water encountered (Table 12.6-I). Water will be analyzed for water quality parameters detailed in Table 12.5-VI.

12.6.1 Initial Investigation

12.6.1.1 DP Spring

Tracer Experiment, DP Spring. DP Spring is a recently discovered spring in lower DP Canyon, located east of the main technical area at TA-21 (Fig. 12.5-1). The spring issues from the north side of the canyon wall at the contact between the Tshirege member of the Bandelier Tuff and the overlying colluvium which is composed primarily of tuff debris. The shape of the colluvium body suggests it is filling in a paleocanyon cut into the tuff before the present canyon was formed. DP Spring flows from 2 to 20 L/min depending on season, and the spring water cascades down a vertical drop of about 10 m from the spring orifice to the present canyon floor. Vegetation growing around the spring indicates it has existed for at least 10 years.

Three tritium measurements made on the spring in 1990 show that it contains 1295 to 2590 pCi/L. Because tritium in rain water in the Los Alamos area is 65 to 130 pCi/L, this spring contains anomalous tritium, presumably from a source upstream of the spring. One possible source is the sewage effluent from TA-21. The effluent, which was dumped into a small branch canyon of DP Canyon upstream of DP Spring, contained as much as 8740 pCi/L in 1991.

In order to find a direct hydraulic linkage between the sewage outfall effluent and the spring, a simple tracer test using fluorescein dye will be conducted. Fluorescein is an organic dye commonly used in tracer tests because it is nontoxic, biodegradable after several months, and easy to detect in diluted water using a spectrophotometer, or fluorometer (Dash et al. 1983). Detection limits with equipment presently available in the EES-1 chemistry laboratory are 50 ppb.

Our procedure will be to pour about 4 L of concentrated fluorescein distilled water solution into the small pond in the side canyon directly beneath the sewage outfall. This "pour" will be done in mid-June, near the end of the dry season. Samples of DP Spring water will then be collected on a twice daily basis (morning and night), on a 7-day-per-week schedule to get real-time data on the travel time and concentration maxima of fluorescein from the pond to DP Spring. If no fluorescein is observed within three months, samples will no longer be collected. Subsequent investigations will test other recharge sources for this spring.

Routine Monitoring. Any surface water seasonally present in DP Canyon will be sampled. Additionally, DP Spring will be sampled monthly for the first year. The water will be analyzed for radionuclides, VOAs, semivolatiles, and metals as detailed in Table 12.6-I.

12.6.1.2 Perched Water Zones Encountered In Borehole Drilling

Any perched water zones encountered while drilling will be sampled. In the initial investigation detailed in Sec. 12.5.1, perched water may be encountered in boreholes LADP-3 and -4, to be drilled in Los Alamos and DP Canyons, respectively. If so, this water will be sampled for the constituents given in Table 12.5-IV, including stable isotopes. This is indicated as water quality parameters in Table 12.6-II for two perched water samples. Subsequent quarterly samples for the duration of the RFI will be analyzed for a reduced analytical suite, depending on initial results. If no contaminants are found in the initial sample, quarterly samples will be analyzed for a water quality screening suite. However, for planning purposes, it is assumed a full analytical suite is analyzed for the first year.

Activities related to the installation and development of monitoring wells and piezometers and the routine measurement of water levels will be performed in accordance with either LANL ER Program SOPs or conventional field procedures as follows:

- Well Installation
- Well Development
- Piezometer Installation
- Piezometer Development
- Water Level Measurements

Activities related to the collection, preservation, transport, and analyses of water samples shall be performed in accordance with either LANL ER Program SOPs or conventional field procedures:

- Purging of Wells for Representative Sampling of Groundwater
- Field Analytical Measurements of Groundwater
- Sampling for Volatile Organics
- Field Methodology for Sampling Springs and Seep
- General Instructions SOP as guidance for Groundwater Sampling

12.6.2 Subsequent Investigations

12.6.2.1 Perched Zone Drill Holes in DP Canyon

Two geological and hydrologic characterization holes would be located in the eastern part of DP Canyon to characterize possible perched water (not a shallow alluvial aquifer that may be present) beneath DP Canyon and to investigate the source of tritium contamination found in DP Spring . Locations of the perched zone drill holes (designated as LAUZ-1 and LAUZ-2) are shown in Fig. 12.5-1. LAUZ-1 is downstream of MDAs T, A, and U in the main drainage of DP Canyon. LAUZ-2 is located in a tributary drainage to DP Canyon downstream of the outfall of the sewage treatment plant at the east end of the site. The estimated stratigraphy of these holes is given in Table 12.6-III.

The two holes would be drilled to the first perched zone encountered (again, not including any shallow alluvial aquifer that may be present) or to a total depth of approximately 200 ft (60 m). The exact depth for the drill holes would be determined from geologic and hydrologic information at drill holes LADP-3 and -4. The core from these holes will be sampled every 5 ft for constituents detailed in Table 12.6-

IV. If perched water is encountered, it will be sampled for the constituents given in Table 12.5-VI and indicated as water quality parameters in Table 12.6-V for two perched water samples. It is assumed this water will be sampled quarterly for three and a half years.

If perched water is not encountered at the LAUZ drill holes, then the decision to complete the drill holes with a screened monitor well will be determined by evaluation of the results from geologic description of core, geophysical logs that have been collected in the open boreholes, and from moisture content measurements on core. If the evaluation of the above data indicates that perched water may be present seasonally at a certain depth interval, then a monitor well will be constructed in the potential perched zone. If a zone for seasonal perched water is not identified, then the drill hole will be abandoned and sealed from total depth to land surface with cement grout.

12.6.2.2 DP Spring

After the initial year, DP Spring will be monitored quarterly for the duration of the RFI. Additional investigations will be closely coordinated with the Canyons' Task. For planning purposes, it is assumed that the spring will continue to be monitored quarterly for the duration of the RFI (Table 12.6-VI).

12.6.2.3 Perched Water Sampling

Any perched water zones encountered in the initial investigation will be sampled quarterly for the duration of the RFI (an additional four years) (Table 12.6-VI).

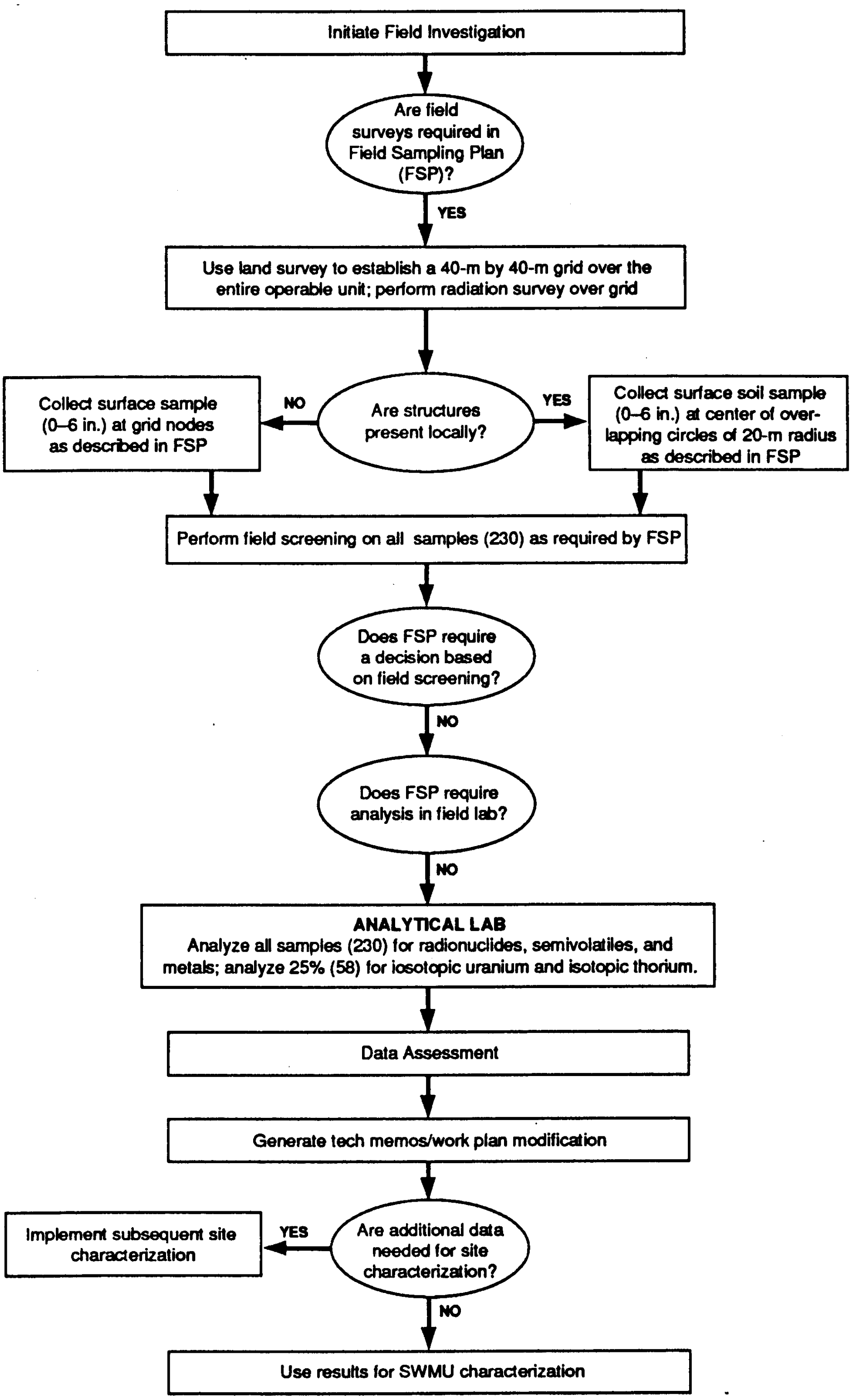


Fig. 12.1-1 Logic flow for field investigations for surface soil characterization of the entire operable unit.

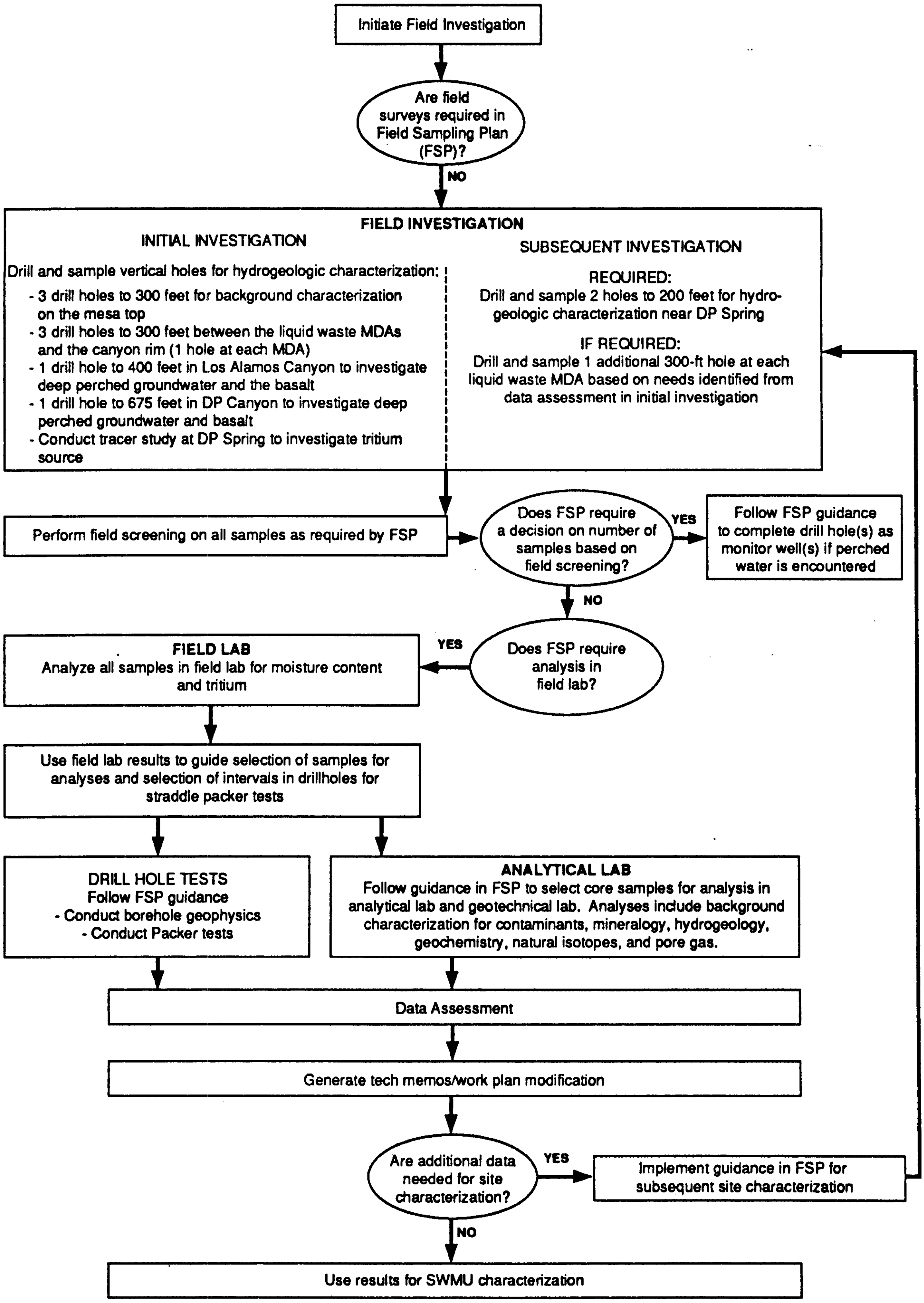


Fig. 12.1-2 Logic flow for hydrogeologic characterization investigations at TA-21.

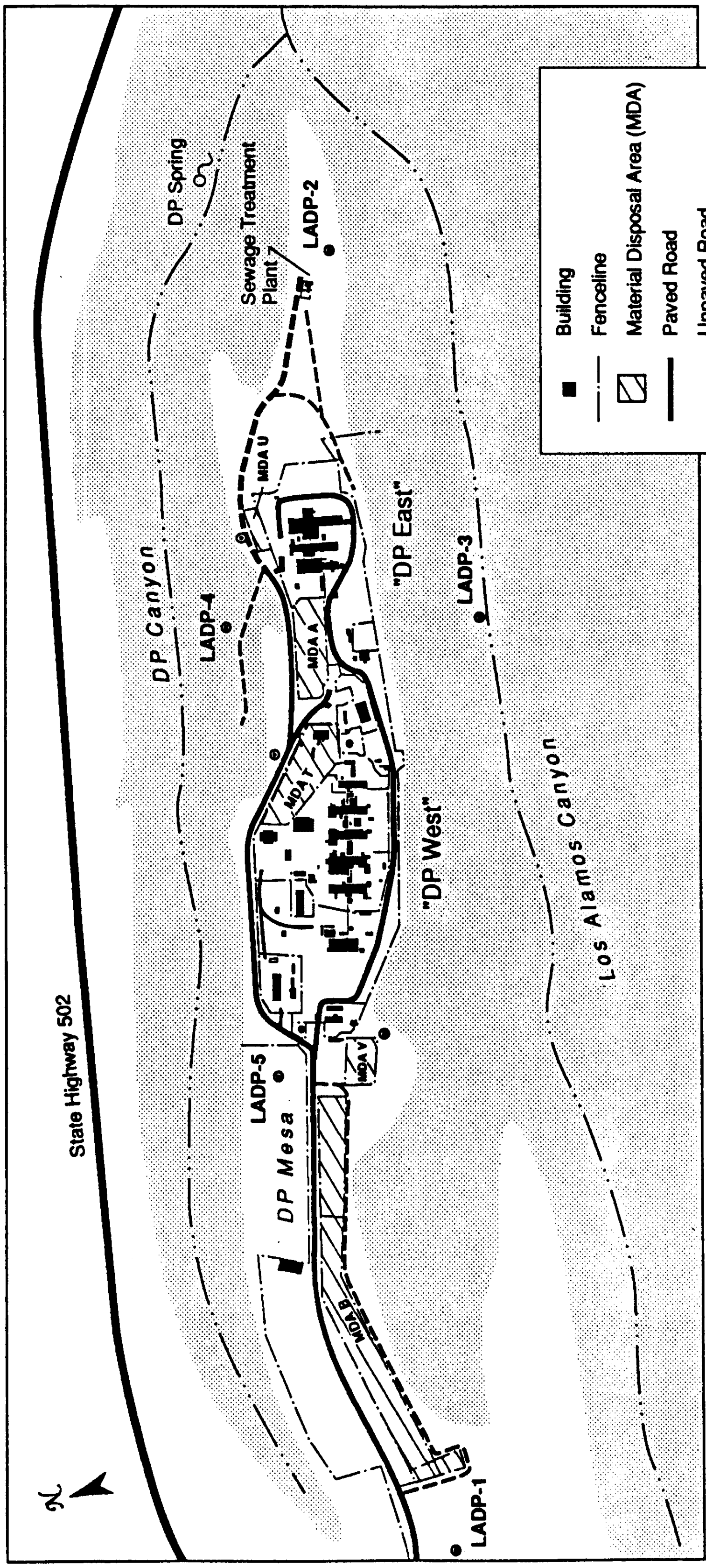


Fig. 12.5-1 Location of eight initial investigation geologic and hydrologic drill holes for TA-21.

TABLE 12.1-I SUMMARY OF INITIAL INVESTIGATIONS BY SECTION FOR CHAPTER 12.

		Survey Areas			Surface	Near Surface Soil Samples		Water Samples
Section	Description	Land	Radiological	Geophysical	Soil Samples	No. of Locations	No. of Samples	
12-4	Mesa Top Soil	1	2		230			
12-5	Mesa Top Boreholes							
12-6	Water Sampling							25
	Total	1	2		230			25

		Boreholes									
		Shallow			Vertical			Angled			Q A
Section	Description	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	
12-4	Mesa Top Soil										37
12-5	Mesa Top Boreholes				8	2875	593				40
12-6	Water Sampling										37
	Total				8	2875	593				114

TABLE 12-1-II SUMMARY OF SAMPLE AND ANALYSIS FOR INITIAL INVESTIGATIONS BY SECTION FOR CHAPTER 12

		12.4	12.5	12.6							Total
Field Sample Screening											
Gross Gamma		230	575								805
Gross Alpha		230	575								805
Tritium Vapor											
Organic Vapor			575								575
Combustable Gas/Oxygen			575								575
Lithological Logging			575								575
Field Laboratory Measurements											
Gross Alpha											
Gamma Spectrometry											
Tritium			575								575
Volatile Organics											
PCB											
Soil Moisture			575								575
Laboratory Analysis											
Gamma Spectrometry		255	53								308
Tritium		255	53	38							346
Total Uranium		255	53	26							334
Isotopic Plutonium		255	53	26							334
Isotopic Uranium		69									69
Strontium 90		255	53	26							334
VOA (SW 8240)			83	62							145
Semivolatiles (SW 8270)		267	58	50							375
Metals (SW 6010)		267	58	50							375
PCB (SW 8080)											
Isotopic Thorium		69	53								122
Water Quality Parameters				26							26
Gross Alpha/Beta				26							26

TABLE 12.1-III SUMMARY OF SUBSEQUENT INVESTIGATIONS BY SECTION FOR CHAPTER 12.

		Survey Areas			Surface	Near Surface Soil Samples		Water Samples
Section	Description	Land	Radiological	Geophysical	Soil Samples	No. of Locations	No. of Samples	
12-5	Mesa Top Boreholes							
12-6	Water Sampling							80
	Total							80

		Boreholes									
		Shallow			Vertical			Angled			Q A
Section	Description	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	
12-5	Mesa Top Boreholes				3	1350	270				
12-6	Water Sampling				2	400	80				74
	Total				5	1750	350				74

TABLE 12-1-IV SUMMARY OF SAMPLE AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS BY SECTION FOR CHAPTER 12

			12.5	12.6							Total
Field Sample Screening											
Gross Gamma			270	80							350
Gross Alpha			270	80							350
Tritium Vapor											
Organic Vapor			270	80							350
Combustable Gas/Oxygen			270	80							350
Lithological Logging			270	80							350
Field Laboratory Measurements											
Gross Alpha											
Gamma Spectrometry											
Tritium			270								270
Volatile Organics											
PCB											
Soil Moisture			270	80							350
Laboratory Analysis											
Gamma Spectrometry				92							92
Tritium				192							192
Total Uranium				176							176
Isotopic Plutonium				176							176
Isotopic Uranium											
Strontium 90				176							176
VOA (SW 8240)				234							234
Semivolatiles (SW 8270)				214							214
Metals (SW 6010)				214							214
PCB (SW 8080)											
Isotopic Thorium											
Water Quality Parameters				84							84
Gross Alpha/Beta				84							84

12-1-V SUMMARY OF INITIAL INVESTIGATIONS GEOHYDROLOGICAL ANALYSES FOR CHAPTER 12.

From Table:							12.5-IV				Total
Hydrogeological and Geochemical											
Gravimetric Water Content							615				615
Bulk Density							575				575
Dry Density							575				575
Porosity							575				575
Porosity (He injection)							144				144
Saturated Hydraulic Conductivity							144				144
Air Water Relative Permeability							144				144
Moisture Characteristic Curve							144				144
Clay Mineral Content							184				184
Zeolite Mineralogy							184				184
Sulfate Mineral Content							184				184
Carbonate Mineral Content							184				184
Fe and Mn Content							184				184
Total Organic Compound							184				184
Cation Exchange Capacity							184				184
Slurry Ph							184				184
Environmental Isotopes											
Chloride-35/Chloride-37							90				90
Carbon-12/Carbon-13							90				90
Strontium-86/Strontium -87							90				90
Hydrogen/Deuterium							90				90
Oxygen-16/Oxygen-18							90				90
Tritium							90				90
Carbon-14							90				90
Chloride-36							90				90
Straddle Packer Tests											
In Situ Permeability							90				90
VOA's - Pore Gas							90				90
CO2 - Pore Gas							90				90
CH4 - Pore Gas							90				90
C-12/C-13 - Pore Gas							90				90
Relative Humidity - Pore Gas							90				90
SF6							90				90

12-1-VI SUMMARY OF SUBSEQUENT INVESTIGATIONS GEOHYDROLOGICAL ANALYSES FOR CHAPTER 12.

From Table:							12.5-VIII				Total
Hydrogeological and Geochemical											
Gravimetric Water Content							285				285
Bulk Density							270				270
Dry Density							270				270
Porosity							270				270
Porosity (He injection)							69				69
Saturated Hydraulic Conductivity							69				69
Air Water Relative Permeability							69				69
Moisture Characteristic Curve							69				69
Clay Mineral Content							84				84
Zeolite Mineralogy							84				84
Sulfate Mineral Content							84				84
Carbonate Mineral Content							84				84
Fe and Mn Content							84				84
Total Organic Compound							84				84
Cation Exchange Capacity							84				84
Slurry Ph							84				84
Environmental Isotopes											
Chloride-35/Chloride-37							36				36
Carbon-12/Carbon-13							36				36
Strontium-86/Strontium -87							36				36
Hydrogen/Deuterium							36				36
Oxygen-16/Oxygen-18							36				36
Tritium							36				36
Carbon-14							36				36
Chloride-36							36				36
Straddle Packer Tests											
In Situ Permeability							36				36
VOA's - Pore Gas							36				36
CO2 - Pore Gas							36				36
CH4 - Pore Gas							36				36
C-12/C-13 - Pore Gas							36				36
Relative Humidity - Pore Gas							36				36
SF6							36				36

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Mesa Top Surface Sampling				X	X		X																											
Surface Soil Sample	1	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	2	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	3	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	4	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	5	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	6	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	7	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	8	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	9	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	10	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Rinsate Blank																						X	X	X	X		X		X	X				
Field Blank																													X	X				
	11	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	12	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	13	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	14	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	15	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	16	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	17	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	18	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	19	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	20	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	21	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	22	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	23	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	24	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	25	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	26	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	27	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	28	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	29	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	30	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Rinsate Blank																						X	X	X	X		X		X	X				
Field Blank																													X	X				
	31	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	32	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	33	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	34	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	35	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	36	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	37	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	38	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	39	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	40	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	41	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	42	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	43	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	44	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		

Table 12.4–I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Field Duplicate																						X	X	X	X	X	X		X	X		X		
	45	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	46	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	47	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	48	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	49	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	50	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	51	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	52	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	53	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	54	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	55	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	56	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	57	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	58	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	59	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	60	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	61	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	62	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	63	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	64	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Field Duplicate																						X	X	X	X	X	X		X	X		X		
	65	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	66	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
	67	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	68	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	69	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	70	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	71	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	72	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	73	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	74	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	75	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	76	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	77	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	78	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	79	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	80	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Field Duplicate																						X	X	X	X	X	X		X	X		X		
	81	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	82	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	83	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	84	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	85	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	86	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	87	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	88	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	89	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	90	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	91	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	92	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	93	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	94	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	95	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	96	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	97	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	98	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	99	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	100	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	101	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	102	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	103	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	104	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	105	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	106	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	107	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	108	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	109	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	110	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	111	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	112	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	113	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	114	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	115	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	116	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	117	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	118	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	119	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	120	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	121	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	122	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	123	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	124	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	125	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Rinsate Blank																						X	X	X	X		X		X	X				
Field Blank																													X	X				
	126	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	127	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	128	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	129	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	130	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	131	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	132	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	133	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Field Duplicate																						X	X	X	X		X		X	X				
	134	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	135	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	136	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	137	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	138	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	139	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	140	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	141	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	142	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	143	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	144	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	145	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	146	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	147	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	148	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	149	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	150	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	151	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	152	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	153	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	154	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	155	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	156	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	157	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	158	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	159	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	160	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	161	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	162	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	163	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	164	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	165	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	166	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	167	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	168	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	169	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	170	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	171	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	172	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	173	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	174	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				
	175	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	176	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	177	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	178	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:
	179	0.0 - 6.0 in						X	X												
	180	0.0 - 6.0 in						X	X												
	181	0.0 - 6.0 in						X	X												
	182	0.0 - 6.0 in						X	X												
	183	0.0 - 6.0 in						X	X												
	184	0.0 - 6.0 in						X	X												
Rinsate Blank																					
Field Blank																					
	185	0.0 - 6.0 in						X	X												
	186	0.0 - 6.0 in						X	X												
	187	0.0 - 6.0 in						X	X												
	188	0.0 - 6.0 in						X	X												
	189	0.0 - 6.0 in						X	X												
	190	0.0 - 6.0 in						X	X												
	191	0.0 - 6.0 in						X	X												
	192	0.0 - 6.0 in						X	X												
	193	0.0 - 6.0 in						X	X												
	194	0.0 - 6.0 in						X	X												
	195	0.0 - 6.0 in						X	X												
Field Duplicate																					
	196	0.0 - 6.0 in						X	X												
	197	0.0 - 6.0 in						X	X												
	198	0.0 - 6.0 in						X	X												
	199	0.0 - 6.0 in						X	X												
	200	0.0 - 6.0 in						X	X												
	201	0.0 - 6.0 in						X	X												

Sample Type	Sampling Location	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	179	X	X	X	X		X		X	X				
	180	X	X	X	X	X	X		X	X		X		
	181	X	X	X	X		X		X	X				
	182	X	X	X	X		X		X	X				
	183	X	X	X	X		X		X	X				
	184	X	X	X	X	X	X		X	X		X		
Rinsate Blank		X	X	X	X	X	X		X	X		X		
Field Blank									X	X				
	185	X	X	X	X		X		X	X				
	186	X	X	X	X		X		X	X				
	187	X	X	X	X		X		X	X				
	188	X	X	X	X	X	X		X	X		X		
	189	X	X	X	X		X		X	X				
	190	X	X	X	X		X		X	X				
	191	X	X	X	X		X		X	X				
	192	X	X	X	X	X	X		X	X		X		
	193	X	X	X	X		X		X	X				
	194	X	X	X	X		X		X	X				
	195	X	X	X	X		X		X	X				
Field Duplicate		X	X	X	X		X		X	X				
	196	X	X	X	X	X	X		X	X		X		
	197	X	X	X	X		X		X	X				
	198	X	X	X	X		X		X	X				
	199	X	X	X	X		X		X	X				
	200	X	X	X	X	X	X		X	X		X		
	201	X	X	X	X		X		X	X				

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture
	202	0.0 - 6.0 in						X	X									
	203	0.0 - 6.0 in						X	X									
	204	0.0 - 6.0 in						X	X									
Rinsate Blank																		
Field Blank																		
	205	0.0 - 6.0 in						X	X									
	206	0.0 - 6.0 in						X	X									
	207	0.0 - 6.0 in						X	X									
	208	0.0 - 6.0 in						X	X									
	209	0.0 - 6.0 in						X	X									
	210	0.0 - 6.0 in						X	X									
	211	0.0 - 6.0 in						X	X									
	212	0.0 - 6.0 in						X	X									
	213	0.0 - 6.0 in						X	X									
	214	0.0 - 6.0 in						X	X									
Field Duplicate																		
	215	0.0 - 6.0 in						X	X									
	216	0.0 - 6.0 in						X	X									
	217	0.0 - 6.0 in						X	X									
	218	0.0 - 6.0 in						X	X									
	219	0.0 - 6.0 in						X	X									
	220	0.0 - 6.0 in						X	X									
	221	0.0 - 6.0 in						X	X									
	222	0.0 - 6.0 in						X	X									
	223	0.0 - 6.0 in						X	X									
	224	0.0 - 6.0 in						X	X									

Sample Type	Sampling Location	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	202	X	X	X	X		X		X	X				
	203	X	X	X	X		X		X	X				
	204	X	X	X	X	X	X		X	X		X		
Rinsate Blank		X	X	X	X	X	X		X	X		X		
Field Blank									X	X				
	205	X	X	X	X		X		X	X				
	206	X	X	X	X		X		X	X				
	207	X	X	X	X		X		X	X				
	208	X	X	X	X	X	X		X	X		X		
	209	X	X	X	X		X		X	X				
	210	X	X	X	X		X		X	X				
	211	X	X	X	X		X		X	X				
	212	X	X	X	X	X	X		X	X		X		
	213	X	X	X	X		X		X	X				
	214	X	X	X	X		X		X	X				
Field Duplicate		X	X	X	X		X		X	X				
	215	X	X	X	X		X		X	X				
	216	X	X	X	X	X	X		X	X		X		
	217	X	X	X	X		X		X	X				
	218	X	X	X	X		X		X	X				
	219	X	X	X	X		X		X	X				
	220	X	X	X	X	X	X		X	X		X		
	221	X	X	X	X		X		X	X				
	222	X	X	X	X		X		X	X				
	223	X	X	X	X		X		X	X				
	224	X	X	X	X	X	X		X	X		X		

Table 12.4-I

MESA TOP SURFACE SOIL SAMPLES.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Rinsate Blank																						X	X	X	X	X	X		X	X		X		
Field Blank																													X	X				
	225	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	226	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	227	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	228	0.0 - 6.0 in						X	X													X	X	X	X	X	X		X	X		X		
	229	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
	230	0.0 - 6.0 in						X	X													X	X	X	X		X		X	X				
Field Duplicate																						X	X	X	X		X		X	X				

TABLE 12.5-I
ESTIMATED THICKNESS OF STRATIGRAPHIC UNITS PRESENT AT DRILL HOLE LOCATIONS

Drill Hole No.[a]	Estimated Surface Elevation (ft)	Total Depth (ft)	Estimated Thickness (ft) of Stratigraphic Units in the Bandelier Formation: Tshirege Member Bed	Cerro Tsankawi Pumice	Toledo Rhyolite	Otowi Member Bed	Guaje Pumice	Estimated Total Thickness of Bandelier Formation (ft)	Thickness of Puye Formation in the unsaturated zone (ft)
LADP-1	7240	1340	315-335	0-2	0-30	290-310	0-30	600	620
LADP-2	7090	1190	250-270	0-2	0-30	290-310	0-30	570	620
LADP-3	6730	830	0	0	0	260-280	0-30	270	620
LADP-4	7040	1140	115-135	0-2	0-30	290-310	0-30	425	620
LADP-5	7170	1270	260-290	0-2	0-30	290-310	0-30	575	620

[a]Drill hole locations are shown in Figure 12.5-1.

TABLE 12.5-II
HYDROSTRATIGRAPHIC UNITS WITHIN THE BANDELIER FORMATION

IGNIMBRITE FLOW UNITS (TUFF)

- Characterize the following lithologies within cooling units
  - Welded tuff/nonwelded tuff
    - zeolite zones
    - lithic-rich zones
    - dense, competent tuff
    - fractured, jointed tuff
      - open fractures, joints
      - nature of mineral coatings on open surfaces
      - clay-filled fractures, joints
- Characterize vertical stratigraphic contacts between discrete cooling units
  - Weathered tuff in contact zones
  - Thin surge deposits in contact zones
  - Thin pumice, ash-fall deposits in contact zones

BEDDED DEPOSITS

- Characterize the following lithologies
  - Fluvial sands, gravels, and cobbles
  - Lacustrine fine sand, silt, and clay
  - Inter-layered alluvial, ash flow, and ash-fall deposits
- Characterize vertical stratigraphic contacts between contrasting lithologies

PUMICE BEDS

- Characterize the following lithologies
  - zeolite zones
  - lithic-rich zones
  - inter-layered surge deposits
- Characterize vertical stratigraphic contacts between contrasting lithologies

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis													
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta	
Subsurface samples																																			
Vertical Borehole	LADP–3	0.0 – 5.0 ft						X	X		X	X	X			X			X																
		5.0 – 10.0 ft						X	X		X	X	X			X			X																
		10.0 – 15.0 ft						X	X		X	X	X			X			X																
		15.0 – 20.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E			
Trip Blank																												E							
		20.0 – 25.0 ft						X	X		X	X	X			X			X																
		25.0 – 30.0 ft						X	X		X	X	X			X			X																
		30.0 – 35.0 ft						X	X		X	X	X			X			X																
		35.0 – 40.0 ft						X	X		X	X	X			X			X																
		40.0 – 45.0 ft						X	X		X	X	X			X			X																
		45.0 – 50.0 ft						X	X		X	X	X			X			X																
		50.0 – 55.0 ft						X	X		X	X	X			X			X																
		55.0 – 60.0 ft						X	X		X	X	X			X			X																
		60.0 – 65.0 ft						X	X		X	X	X			X			X																
		65.0 – 70.0 ft						X	X		X	X	X			X			X																
		70.0 – 75.0 ft						X	X		X	X	X			X			X																
		75.0 – 80.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E			
Trip Blank																												E							
		80.0 – 85.0 ft						X	X		X	X	X			X			X																
		85.0 – 90.0 ft						X	X		X	X	X			X			X																
		90.0 – 95.0 ft						X	X		X	X	X			X			X																
		95.0 – 100.0 ft						X	X		X	X	X			X			X																
		100.0 – 105.0 ft						X	X		X	X	X			X			X																
		105.0 – 110.0 ft						X	X		X	X	X			X			X																

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		110.0 - 115.0 ft						X	X		X	X	X			X			X															
		115.0 - 120.0 ft						X	X		X	X	X			X			X															
		120.0 - 125.0 ft						X	X		X	X	X			X			X															
		125.0 - 130.0 ft						X	X		X	X	X			X			X															
		130.0 - 135.0 ft						X	X		X	X	X			X			X															
		135.0 - 140.0 ft						X	X		X	X	X			X			X															
		140.0 - 145.0 ft						X	X		X	X	X			X			X															
		145.0 - 150.0 ft						X	X		X	X	X			X			X															
		150.0 - 155.0 ft						X	X		X	X	X			X			X															
		155.0 - 160.0 ft						X	X		X	X	X			X			X															
		160.0 - 165.0 ft						X	X		X	X	X			X			X															
		165.0 - 170.0 ft						X	X		X	X	X			X			X															
		170.0 - 175.0 ft						X	X		X	X	X			X			X															
		175.0 - 180.0 ft						X	X		X	X	X			X			X															
		180.0 - 185.0 ft						X	X		X	X	X			X			X															
		185.0 - 190.0 ft						X	X		X	X	X			X			X															
		190.0 - 195.0 ft						X	X		X	X	X			X			X															
		195.0 - 200.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		200.0 - 205.0 ft						X	X		X	X	X			X			X															
		205.0 - 210.0 ft						X	X		X	X	X			X			X															
		210.0 - 215.0 ft						X	X		X	X	X			X			X															
		215.0 - 220.0 ft						X	X		X	X	X			X			X															
		220.0 - 225.0 ft						X	X		X	X	X			X			X															
		225.0 - 230.0 ft						X	X		X	X	X			X			X															
		230.0 - 235.0 ft						X	X		X	X	X			X			X															

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low–Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		235.0 – 240.0 ft						X	X		X	X	X			X			X															
		240.0 – 245.0 ft						X	X		X	X	X			X			X															
		245.0 – 250.0 ft						X	X		X	X	X			X			X															
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		260.0 – 265.0 ft						X	X		X	X	X			X			X															
		265.0 – 270.0 ft						X	X		X	X	X			X			X															
		270.0 – 275.0 ft						X	X		X	X	X			X			X															
		275.0 – 280.0 ft						X	X		X	X	X			X			X															
		280.0 – 285.0 ft						X	X		X	X	X			X			X															
		285.0 – 290.0 ft						X	X		X	X	X			X			X															
		290.0 – 295.0 ft						X	X		X	X	X			X			X															
		295.0 – 300.0 ft						X	X		X	X	X			X			X															
		300.0 – 305.0 ft						X	X		X	X	X			X			X															
		305.0 – 310.0 ft						X	X		X	X	X			X			X															
		310.0 – 315.0 ft						X	X		X	X	X			X			X															
		315.0 – 320.0 ft						X	X		X	X	X			X			X															
		320.0 – 325.0 ft						X	X		X	X	X			X			X															
		325.0 – 330.0 ft						X	X		X	X	X			X			X															
		330.0 – 335.0 ft						X	X		X	X	X			X			X															
		335.0 – 340.0 ft						X	X		X	X	X			X			X															
		340.0 – 345.0 ft						X	X		X	X	X			X			X															
		345.0 – 350.0 ft						X	X		X	X	X			X			X															
		350.0 – 355.0 ft						X	X		X	X	X			X			X															
		355.0 – 360.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Rinsate Blank																						E	E	E	E		E	E	E	E		E		
Field Duplicate																						E	E	E	E		E	E	E	E		E		
Field Blank																												E	E	E				
Trip Blank																												E						
		360.0 – 365.0 ft						X	X		X	X	X			X			X															
		365.0 – 370.0 ft						X	X		X	X	X			X			X															
		370.0 – 375.0 ft						X	X		X	X	X			X			X															
		375.0 – 380.0 ft						X	X		X	X	X			X			X															
		380.0 – 385.0 ft						X	X		X	X	X			X			X															
		385.0 – 390.0 ft						X	X		X	X	X			X			X															
		390.0 – 395.0 ft						X	X		X	X	X			X			X															
		395.0 – 400.0 ft						X	X		X	X	X			X			X															
Fracture Sampling Contingency																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: G. mma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
Subsurface samples																																		
Vertical Borehole	LADP-4	0.0 - 5.0 ft						X	X		X	X	X			X			X															
		5.0 - 10.0 ft						X	X		X	X	X			X			X															
		10.0 - 15.0 ft						X	X		X	X	X			X			X															
		15.0 - 20.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		20.0 - 25.0 ft						X	X		X	X	X			X			X															
		25.0 - 30.0 ft						X	X		X	X	X			X			X															
		30.0 - 35.0 ft						X	X		X	X	X			X			X															
		35.0 - 40.0 ft						X	X		X	X	X			X			X															
		40.0 - 45.0 ft						X	X		X	X	X			X			X															
		45.0 - 50.0 ft						X	X		X	X	X			X			X															
		50.0 - 55.0 ft						X	X		X	X	X			X			X															
		55.0 - 60.0 ft						X	X		X	X	X			X			X															
		60.0 - 65.0 ft						X	X		X	X	X			X			X															
		65.0 - 70.0 ft						X	X		X	X	X			X			X															
		70.0 - 75.0 ft						X	X		X	X	X			X			X															
		75.0 - 80.0 ft						X	X		X	X	X			X			X															
		80.0 - 85.0 ft						X	X		X	X	X			X			X															
		85.0 - 90.0 ft						X	X		X	X	X			X			X															
		90.0 - 95.0 ft						X	X		X	X	X			X			X															
		95.0 - 100.0 ft						X	X		X	X	X			X			X															
		100.0 - 105.0 ft						X	X		X	X	X			X			X															
		105.0 - 110.0 ft						X	X		X	X	X			X			X															
		110.0 - 115.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		115.0 - 120.0 ft						X	X		X	X	X			X			X															
		120.0 - 125.0 ft						X	X		X	X	X			X			X															
		125.0 - 130.0 ft						X	X		X	X	X			X			X															
		130.0 - 135.0 ft						X	X		X	X	X			X			X															
		135.0 - 140.0 ft						X	X		X	X	X			X			X															
		140.0 - 145.0 ft						X	X		X	X	X			X			X															
		145.0 - 150.0 ft						X	X		X	X	X			X			X															
		150.0 - 155.0 ft						X	X		X	X	X			X			X															
		155.0 - 160.0 ft						X	X		X	X	X			X			X															
		160.0 - 165.0 ft						X	X		X	X	X			X			X															
		165.0 - 170.0 ft						X	X		X	X	X			X			X															
		170.0 - 175.0 ft						X	X		X	X	X			X			X															
		175.0 - 180.0 ft						X	X		X	X	X			X			X															
		180.0 - 185.0 ft						X	X		X	X	X			X			X															
		185.0 - 190.0 ft						X	X		X	X	X			X			X															
		190.0 - 195.0 ft						X	X		X	X	X			X			X															
		195.0 - 200.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		200.0 - 205.0 ft						X	X		X	X	X			X			X															
		205.0 - 210.0 ft						X	X		X	X	X			X			X															
		210.0 - 215.0 ft						X	X		X	X	X			X			X															
		215.0 - 220.0 ft						X	X		X	X	X			X			X															
		220.0 - 225.0 ft						X	X		X	X	X			X			X															
		225.0 - 230.0 ft						X	X		X	X	X			X			X															
		230.0 - 235.0 ft						X	X		X	X	X			X			X															
		235.0 - 240.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		240.0 – 245.0 ft						X	X		X	X	X			X			X															
		245.0 – 250.0 ft						X	X		X	X	X			X			X															
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X															
		260.0 – 265.0 ft						X	X		X	X	X			X			X															
		265.0 – 270.0 ft						X	X		X	X	X			X			X															
		270.0 – 275.0 ft						X	X		X	X	X			X			X															
		275.0 – 280.0 ft						[illegible]	X		X	X	X			X			X															
		280.0 – 285.0 ft						X	X		X	X	X			[illegible]			[illegible]															
		285.0 – 290.0 ft						X	X		X	X	X			X			X															
		290.0 – 295.0 ft						X	X		X	X	X			X			X															
		295.0 – 300.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		300.0 – 305.0 ft						X	X		X	X	X			X			X															
		305.0 – 310.0 ft						X	X		X	X	X			X			X															
		310.0 – 315.0 ft						X	X		X	X	X			X			X															
		315.0 – 320.0 ft						X	X		X	X	X			X			X															
		320.0 – 325.0 ft						X	X		X	X	X			X			X															
		325.0 – 330.0 ft						X	X		X	X	X			X			X															
		330.0 – 335.0 ft						X	X		X	X	X			X			X															
		335.0 – 340.0 ft						X	X		X	X	X			X			X															
		340.0 – 345.0 ft						X	X		X	X	X			X			X															
		345.0 – 350.0 ft						[illegible]	X		X	X	X			X			X															
		350.0 – 355.0 ft						X	X		X	X	X			X			X															
		355.0 – 360.0 ft						X	X		X	X	X			X			X															
		360.0 – 365.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		365.0 – 370.0 ft						X	X		X	X	X			X			X															
		370.0 – 375.0 ft						X	X		X	X	X			X			X															
		375.0 – 380.0 ft						X	X		X	X	X			X			X															
		380.0 – 385.0 ft						X	X		X	X	X			X			X															
		385.0 – 390.0 ft						X	X		X	X	X			X			X															
		390.0 – 395.0 ft						X	X		X	X	X			X			X															
		395.0 – 400.0 ft						X	X		X	X	X			X			X															
		400.0 – 405.0 ft						X	X		X	X	X			X			X															
		405.0 – 410.0 ft						X	X		X	X	X			X			X															
		410.0 – 415.0 ft						X	X		X	X	X			X			X															
		415.0 – 420.0 ft						X	X		X	X	X			X			X															
		420.0 – 425.0 ft						X	X		X	X	X			X			X															
		425.0 – 430.0 ft						X	X		X	X	X			X			X															
		430.0 – 435.0 ft						X	X		X	X	X			X			X															
		435.0 – 440.0 ft						X	X		X	X	X			X			X															
		440.0 – 445.0 ft						X	X		X	X	X			X			X															
		445.0 – 450.0 ft						X	X		X	X	X			X			X															
		450.0 – 455.0 ft						X	X		X	X	X			X			X															
		455.0 – 460.0 ft						X	X		X	X	X			X			X															
		460.0 – 465.0 ft						X	X		X	X	X			X			X															
		465.0 – 470.0 ft						X	X		X	X	X			X			X															
		470.0 – 475.0 ft						X	X		X	X	X			X			X															
		475.0 – 480.0 ft						X	X		X	X	X			X			X															
		480.0 – 485.0 ft						X	X		X	X	X			X			X															
		485.0 – 490.0 ft						X	X		X	X	X			X			X															
		490.0 – 495.0 ft						X	X		X	X	X			X			X															

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		495.0 – 500.0 ft						X	X		X	X	X			X			X			m	m	m	m		m	m	m	m		m		
Trip Blank																												m						
		500.0 – 505.0 ft						X	X		X	X	X			X			X															
		505.0 – 510.0 ft						X	X		X	X	X			X			X															
		510.0 – 515.0 ft						X	X		X	X	X			X			X															
		515.0 – 520.0 ft						X	X		X	X	X			X			X															
		520.0 – 525.0 ft						X	X		X	X	X			X			X															
		525.0 – 530.0 ft						X	X		X	X	X			X			X															
		530.0 – 535.0 ft						X	X		X	X	X			X			X															
		535.0 – 540.0 ft						X	X		X	X	X			X			X															
		540.0 – 545.0 ft						X	X		X	X	X			X			X															
		545.0 – 550.0 ft						X	X		X	X	X			X			X															
		550.0 – 555.0 ft						X	X		X	X	X			X			X															
		555.0 – 560.0 ft						X	X		X	X	X			X			X															
		560.0 – 565.0 ft						X	X		X	X	X			X			X															
		565.0 – 570.0 ft						X	X		X	X	X			X			X															
		570.0 – 575.0 ft						X	X		X	X	X			X			X															
		575.0 – 580.0 ft						X	X		X	X	X			X			X															
		580.0 – 585.0 ft						X	X		X	X	X			X			X															
		585.0 – 590.0 ft						X	X		X	X	X			X			X															
		590.0 – 595.0 ft						X	X		X	X	X			X			X															
		595.0 – 600.0 ft						X	X		X	X	X			X			X															
		600.0 – 605.0 ft						X	X		X	X	X			X			X															
		605.0 – 610.0 ft						X	X		X	X	X			X			X															
		610.0 – 615.0 ft						X	X		X	X	X			X			X															
		615.0 – 620.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
		620.0 - 625.0 ft						X	X		X	X	X			X			X															
		625.0 - 630.0 ft						X	X		X	X	X			X			X															
		630.0 - 635.0 ft						X	X		X	X	X			X			X															
		635.0 - 640.0 ft						X	X		X	X	X			X			X															
		640.0 - 645.0 ft						X	X		X	X	X			X			X															
		645.0 - 650.0 ft						X	X		X	X	X			X			X															
		650.0 - 655.0 ft						X	X		X	X	X			X			X															
		655.0 - 660.0 ft						X	X		X	X	X			X			X															
		660.0 - 665.0 ft						X	X		X	X	X			X			X															
		665.0 - 670.0 ft						X	X		X	X	X			X			X															
		670.0 - 675.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Rinsate Blank																						E	E	E	E		E	E	E	E		E		
Field Blank																												E	E	E				
Field Duplicate																						E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
Fracture Sampling Contingency																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
Subsurface samples																																		
Vertical Borehole	LADP-1	0.0 - 5.0 ft						X	X		X	X	X			X			X															
		5.0 - 10.0 ft						X	X		X	X	X			X			X															
		10.0 - 15.0 ft						X	X		X	X	X			X			X															
		15.0 - 20.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
																												E						
Trip Blank																																		
		20.0 - 25.0 ft						X	X		X	X	X			X			X															
		25.0 - 30.0 ft						X	X		X	X	X			X			X															
		30.0 - 35.0 ft						X	X		X	X	X			X			X															
		35.0 - 40.0 ft						X	X		X	X	X			X			X															
		40.0 - 45.0 ft						X	X		X	X	X			X			X															
		45.0 - 50.0 ft						X	X		X	X	X			X			X															
		50.0 - 55.0 ft						X	X		X	X	X			X			X															
		55.0 - 60.0 ft						X	X		X	X	X			X			X															
		60.0 - 65.0 ft						X	X		X	X	X			X			X															
		65.0 - 70.0 ft						X	X		X	X	X			X			X															
		70.0 - 75.0 ft						X	X		X	X	X			X			X															
		75.0 - 80.0 ft						X	X		X	X	X			X			X															
		80.0 - 85.0 ft						X	X		X	X	X			X			X															
		85.0 - 90.0 ft						X	X		X	X	X			X			X															
		90.0 - 95.0 ft						X	X		X	X	X			X			X															
		95.0 - 100.0 ft						X	X		X	X	X			X			X															
		100.0 - 105.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
																												E						
Trip Blank																																		
		105.0 - 110.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
		110.0 - 115.0 ft						X	X		X	X	X			X			X															
		115.0 - 120.0 ft						X	X		X	X	X			X			X															
		120.0 - 125.0 ft						X	X		X	X	X			X			X															
		125.0 - 130.0 ft						X	X		X	X	X			X			X															
		130.0 - 135.0 ft						X	X		X	X	X			X			X															
		135.0 - 140.0 ft						X	X		X	X	X			X			X															
		140.0 - 145.0 ft						X	X		X	X	X			X			X															
		145.0 - 150.0 ft						X	X		X	X	X			X			X															
		150.0 - 155.0 ft						X	X		X	X	X			X			X															
		155.0 - 160.0 ft						X	X		X	X	X			X			X															
		160.0 - 165.0 ft						X	X		X	X	X			X			X															
		165.0 - 170.0 ft						X	X		X	X	X			X			X															
		170.0 - 175.0 ft						X	X		X	X	X			X			X															
		175.0 - 180.0 ft						X	X		X	X	X			X			X															
		180.0 - 185.0 ft						X	X		X	X	X			X			X															
		185.0 - 190.0 ft						X	X		X	X	X			X			X															
		190.0 - 195.0 ft						X	X		X	X	X			X			X															
		195.0 - 200.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		200.0 - 205.0 ft						X	X		X	X	X			X			X															
		205.0 - 210.0 ft						X	X		X	X	X			X			X															
		210.0 - 215.0 ft						X	X		X	X	X			X			X															
		215.0 - 220.0 ft						X	X		X	X	X			X			X															
		220.0 - 225.0 ft						X	X		X	X	X			X			X															
		225.0 - 230.0 ft						X	X		X	X	X			X			X															
		230.0 - 235.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Field Screening: Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Field Laboratory Measurements: Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		235.0 - 240.0 ft						X	X		X	X	X			X			X															
		240.0 - 245.0 ft						X	X		X	X	X			X			X															
		245.0 - 250.0 ft						X	X		X	X	X			X			X															
		250.0 - 255.0 ft						X	X		X	X	X			X			X															
		255.0 - 260.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		260.0 - 265.0 ft						X	X		X	X	X			X			X															
		265.0 - 270.0 ft						X	X		X	X	X			X			X															
		270.0 - 275.0 ft						X	X		X	X	X			X			X															
		275.0 - 280.0 ft						X	X		X	X	X			X			X															
		280.0 - 285.0 ft						X	X		X	X	X			X			X															
		285.0 - 290.0 ft						X	X		X	X	X			X			X															
		290.0 - 295.0 ft						X	X		X	X	X			X			X															
		295.0 - 300.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Rinsate Blank																						E	E	E	E		E	E	E	E		E		
Field Blank																												E	E	E				
Field Duplicate																						E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
Fracture Sampling Contingency																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
Vertical Borehole	LADP-2	0.0 - 5.0 ft						X	X		X	X	X			X			X															
		5.0 - 10.0 ft						X	X		X	X	X			X			X															
		10.0 - 15.0 ft						X	X		X	X	X			X			X															
		15.0 - 20.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
Trip Blank																												E						
		20.0 – 25.0 ft						X	X		X	X	X			X			X															
		25.0 – 30.0 ft						X	X		X	X	X			X			X															
		30.0 – 35.0 ft						X	X		X	X	X			X			X															
		35.0 – 40.0 ft						X	X		X	X	X			X			X															
		40.0 – 45.0 ft						X	X		X	X	X			X			X															
		45.0 – 50.0 ft						X	X		X	X	X			X			X															
		50.0 – 55.0 ft						X	X		X	X	X			X			X															
		55.0 – 60.0 ft						X	X		X	X	X			X			X															
		60.0 – 65.0 ft						X	X		X	X	X			X			X															
		65.0 – 70.0 ft						X	X		X	X	X			X			X															
		70.0 – 75.0 ft						X	X		X	X	X			X			X															
		75.0 – 80.0 ft						X	X		X	X	X			X			X															
		80.0 – 85.0 ft						X	X		X	X	X			X			X															
		85.0 – 90.0 ft						X	X		X	X	X			X			X															
		90.0 – 95.0 ft						X	X		X	X	X			X			X															
		95.0 – 100.0 ft						X	X		X	X	X			X			X															
		100.0 – 105.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
																												E						
Trip Blank																																		
		105.0 – 110.0 ft						X	X		X	X	X			X			X															
		110.0 – 115.0 ft						X	X		X	X	X			X			X															
		115.0 – 120.0 ft						X	X		X	X	X			X			X															
		120.0 – 125.0 ft						X	X		X	X	X			X			X															
		125.0 – 130.0 ft						X	X		X	X	X			X			X															
		130.0 – 135.0 ft						X	X		X	X	X			X			X															
		135.0 – 140.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		140.0 – 145.0 ft						X	X		X	X	X			X			X															
		145.0 – 150.0 ft						X	X		X	X	X			X			X															
		150.0 – 155.0 ft						X	X		X	X	X			X			X															
		155.0 – 160.0 ft						X	X		X	X	X			X			X															
		160.0 – 165.0 ft						X	X		X	X	X			X			X															
		165.0 – 170.0 ft						X	X		X	X	X			X			X															
		170.0 – 175.0 ft						X	X		X	X	X			X			X															
		175.0 – 180.0 ft						X	X		X	X	X			X			X															
		180.0 – 185.0 ft						X	X		X	X	X			X			X															
		185.0 – 190.0 ft						X	X		X	X	X			X			X															
		190.0 – 195.0 ft						X	X		X	X	X			X			X															
		195.0 – 200.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		200.0 – 205.0 ft						X	X		X	X	X			X			X															
		205.0 – 210.0 ft						X	X		X	X	X			X			X															
		210.0 – 215.0 ft						X	X		X	X	X			X			X															
		215.0 – 220.0 ft						X	X		X	X	X			X			X															
		220.0 – 225.0 ft						X	X		X	X	X			X			X															
		225.0 – 230.0 ft						X	X		X	X	X			X			X															
		230.0 – 235.0 ft						X	X		X	X	X			X			X															
		235.0 – 240.0 ft						X	X		X	X	X			X			X															
		240.0 – 245.0 ft						X	X		X	X	X			X			X															
		245.0 – 250.0 ft						X	X		X	X	X			X			X															
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Field Surveys, Field Screening, Field Laboratory Measurements

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture
		260.0 – 265.0 ft						X	X	X	X	X			X			X
		265.0 – 270.0 ft						X	X	X	X	X			X			X
		270.0 – 275.0 ft						X	X	X	X	X			X			X
		275.0 – 280.0 ft						X	X	X	X	X			X			X
		280.0 – 285.0 ft						X	X	X	X	X			X			X
		285.0 – 290.0 ft						X	X	X	X	X			X			X
		290.0 – 295.0 ft						X	X	X	X	X			X			X
		295.0 – 300.0 ft						X	X	X	X	X			X			X
Rinsate Blank																		
Field Blank																		
Field Duplicate																		
Trip Blank																		
Fracture Sampling Contingency																		
Vertical Borehole	LADP-5	0.0 – 5.0 ft						X	X	X	X	X			X			X
		5.0 – 10.0 ft						X	X	X	X	X			X			X
		10.0 – 15.0 ft						X	X	X	X	X			X			X
		15.0 – 20.0 ft						X	X	X	X	X			X			X
Trip Blank																		
		20.0 – 25.0 ft						X	X	X	X	X			X			X
		25.0 – 30.0 ft						X	X	X	X	X			X			X
		30.0 – 35.0 ft						X	X	X	X	X			X			X
		35.0 – 40.0 ft						X	X	X	X	X			X			X
		40.0 – 45.0 ft						X	X	X	X	X			X			X

Laboratory Analysis

Sample Type	Sampling Location	Interval	Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		260.0 – 265.0 ft													
		265.0 – 270.0 ft													
		270.0 – 275.0 ft													
		275.0 – 280.0 ft													
		280.0 – 285.0 ft													
		285.0 – 290.0 ft													
		290.0 – 295.0 ft													
		295.0 – 300.0 ft	E	E	E	E		E	E	E	E		E		
Rinsate Blank			E	E	E	E		E	E	E	E		E		
Field Blank									E	E	E				
Field Duplicate			E	E	E	E		E	E	E	E		E		
Trip Blank									E						
Fracture Sampling Contingency			C	C	C	C		C	C	C	C		C		
			C	C	C	C		C	C	C	C		C		
			C	C	C	C		C	C	C	C		C		
			C	C	C	C		C	C	C	C		C		
Vertical Borehole	LADP-5	0.0 – 5.0 ft													
		5.0 – 10.0 ft													
		10.0 – 15.0 ft													
		15.0 – 20.0 ft	E	E	E	E		E	E	E	E		E		
Trip Blank									E						
		20.0 – 25.0 ft													
		25.0 – 30.0 ft													
		30.0 – 35.0 ft													
		35.0 – 40.0 ft													
		40.0 – 45.0 ft													

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
		45.0 - 50.0 ft						X	X		X	X	X			X			X															
		50.0 - 55.0 ft						X	X		X	X	X			X			X															
		55.0 - 60.0 ft						X	X		X	X	X			X			X															
		60.0 - 65.0 ft						X	X		X	X	X			X			X															
		65.0 - 70.0 ft						X	X		X	X	X			X			X															
		70.0 - 75.0 ft						X	X		X	X	X			X			X															
		75.0 - 80.0 ft						X	X		X	X	X			X			X															
		80.0 - 85.0 ft						X	X		X	X	X			X			X															
		85.0 - 90.0 ft						X	X		X	X	X			X			X															
		90.0 - 95.0 ft						X	X		X	X	X			X			X															
		95.0 - 100.0 ft						X	X		X	X	X			X			X															
		100.0 - 105.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		105.0 - 110.0 ft						X	X		X	X	X			X			X															
		110.0 - 115.0 ft						X	X		X	X	X			X			X															
		115.0 - 120.0 ft						X	X		X	X	X			X			X															
		120.0 - 125.0 ft						X	X		X	X	X			X			X															
		125.0 - 130.0 ft						X	X		X	X	X			X			X															
		130.0 - 135.0 ft						X	X		X	X	X			X			X															
		135.0 - 140.0 ft						X	X		X	X	X			X			X															
		140.0 - 145.0 ft						X	X		X	X	X			X			X															
		145.0 - 150.0 ft						X	X		X	X	X			X			X															
		150.0 - 155.0 ft						X	X		X	X	X			X			X															
		155.0 - 160.0 ft						X	X		X	X	X			X			X															
		160.0 - 165.0 ft						X	X		X	X	X			X			X															
		165.0 - 170.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		170.0 – 175.0 ft						X	X		X	X	X			X			X															
		175.0 – 180.0 ft						X	X		X	X	X			X			X															
		180.0 – 185.0 ft						X	X		X	X	X			X			X															
		185.0 – 190.0 ft						X	X		X	X	X			X			X															
		190.0 – 195.0 ft						X	X		X	X	X			X			X															
		195.0 – 200.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		200.0 – 205.0 ft						X	X		X	X	X			X			X															
		205.0 – 210.0 ft						X	X		X	X	X			X			X															
		210.0 – 215.0 ft						X	X		X	X	X			X			X															
		215.0 – 220.0 ft						X	X		X	X	X			X			X															
		220.0 – 225.0 ft						X	X		X	X	X			X			X															
		225.0 – 230.0 ft						X	X		X	X	X			X			X															
		230.0 – 235.0 ft						X	X		X	X	X			X			X															
		235.0 – 240.0 ft						X	X		X	X	X			X			X															
		240.0 – 245.0 ft						X	X		X	X	X			X			X															
		245.0 – 250.0 ft						X	X		X	X	X			X			X															
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
		260.0 – 265.0 ft						X	X		X	X	X			X			X															
		265.0 – 270.0 ft						X	X		X	X	X			X			X															
		270.0 – 275.0 ft						X	X		X	X	X			X			X															
		275.0 – 280.0 ft						X	X		X	X	X			X			X															
		280.0 – 285.0 ft						X	X		X	X	X			X			X															
		285.0 – 290.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		290.0 – 295.0 ft						X	X		X	X	X			X			X															
		295.0 – 300.0 ft						X	X		X	X	X			X			X			E	E	E	E		E	E	E	E		E		
Rinsate Blank																						E	E	E	E		E	E	E	E		E		
Field Blank																												E	E	E				
Field Duplicate																						E	E	E	E		E	E	E	E		E		
Trip Blank																												E						
Fracture Sampling Contingency																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		
																						C	C	C	C		C	C	C	C		C		

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Subsurface samples																																		
Vertical Borehole	MDA T	0.0 - 5.0 ft						X	X		X	X	X			X			X															
		5.0 - 10.0 ft						X	X		X	X	X			X			X															
		10.0 - 15.0 ft						X	X		X	X	X			X			X															
		15.0 - 20.0 ft						X	X		X	X	X			X			X															
		20.0 - 25.0 ft						X	X		X	X	X			X			X															
		25.0 - 30.0 ft						X	X		X	X	X			X			X															
		30.0 - 35.0 ft						X	X		X	X	X			X			X															
		35.0 - 40.0 ft						X	X		X	X	X			X			X															
		40.0 - 45.0 ft						X	X		X	X	X			X			X															
		45.0 - 50.0 ft						X	X		X	X	X			X			X															
		50.0 - 55.0 ft						X	X		X	X	X			X			X															
		55.0 - 60.0 ft						X	X		X	X	X			X			X															
		60.0 - 65.0 ft						X	X		X	X	X			X			X															
		65.0 - 70.0 ft						X	X		X	X	X			X			X															
		70.0 - 75.0 ft						X	X		X	X	X			X			X															
		75.0 - 80.0 ft						X	X		X	X	X			X			X															
		80.0 - 85.0 ft						X	X		X	X	X			X			X															
		85.0 - 90.0 ft						X	X		X	X	X			X			X															
		90.0 - 95.0 ft						X	X		X	X	X			X			X															
		95.0 - 100.0 ft						X	X		X	X	X			X			X															
		100.0 - 105.0 ft						X	X		X	X	X			X			X															
		105.0 - 110.0 ft						X	X		X	X	X			X			X															
		110.0 - 115.0 ft						X	X		X	X	X			X			X															
		115.0 - 120.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Interval	Sample Type	Sampling Location	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey
120.0 - 125.0 ft							
125.0 - 130.0 ft							
130.0 - 135.0 ft							
135.0 - 140.0 ft							
140.0 - 145.0 ft							
145.0 - 150.0 ft							
150.0 - 155.0 ft							
155.0 - 160.0 ft							
160.0 - 165.0 ft							
165.0 - 170.0 ft							
170.0 - 175.0 ft							
175.0 - 180.0 ft							
180.0 - 185.0 ft							
185.0 - 190.0 ft							
190.0 - 195.0 ft							
195.0 - 200.0 ft							
200.0 - 205.0 ft							
205.0 - 210.0 ft							
210.0 - 215.0 ft							
215.0 - 220.0 ft							
220.0 - 225.0 ft							
225.0 - 230.0 ft							
230.0 - 235.0 ft							
235.0 - 240.0 ft							
240.0 - 245.0 ft							
245.0 - 250.0 ft							

Interval	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:
120.0 - 125.0 ft	X	X		X	X	X			X			X		
125.0 - 130.0 ft	X	X		X	X	X			X			X		
130.0 - 135.0 ft	X	X		X	X	X			X			X		
135.0 - 140.0 ft	X	X		X	X	X			X			X		
140.0 - 145.0 ft	X	X		X	X	X			X			X		
145.0 - 150.0 ft	X	X		X	X	X			X			X		
150.0 - 155.0 ft	X	X		X	X	X			X			X		
155.0 - 160.0 ft	X	X		X	X	X			X			X		
160.0 - 165.0 ft	X	X		X	X	X			X			X		
165.0 - 170.0 ft	X	X		X	X	X			X			X		
170.0 - 175.0 ft	X	X		X	X	X			X			X		
175.0 - 180.0 ft	X	X		X	X	X			X			X		
180.0 - 185.0 ft	X	X		X	X	X			X			X		
185.0 - 190.0 ft	X	X		X	X	X			X			X		
190.0 - 195.0 ft	X	X		X	X	X			X			X		
195.0 - 200.0 ft	X	X		X	X	X			X			X		
200.0 - 205.0 ft	X	X		X	X	X			X			X		
205.0 - 210.0 ft	X	X		X	X	X			X			X		
210.0 - 215.0 ft	X	X		X	X	X			X			X		
215.0 - 220.0 ft	X	X		X	X	X			X			X		
220.0 - 225.0 ft	X	X		X	X	X			X			X		
225.0 - 230.0 ft	X	X		X	X	X			X			X		
230.0 - 235.0 ft	X	X		X	X	X			X			X		
235.0 - 240.0 ft	X	X		X	X	X			X			X		
240.0 - 245.0 ft	X	X		X	X	X			X			X		
245.0 - 250.0 ft	X	X		X	X	X			X			X		

Interval	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
120.0 - 125.0 ft													
125.0 - 130.0 ft													
130.0 - 135.0 ft													
135.0 - 140.0 ft													
140.0 - 145.0 ft													
145.0 - 150.0 ft													
150.0 - 155.0 ft													
155.0 - 160.0 ft													
160.0 - 165.0 ft													
165.0 - 170.0 ft													
170.0 - 175.0 ft													
175.0 - 180.0 ft													
180.0 - 185.0 ft													
185.0 - 190.0 ft													
190.0 - 195.0 ft													
195.0 - 200.0 ft													
200.0 - 205.0 ft													
205.0 - 210.0 ft													
210.0 - 215.0 ft													
215.0 - 220.0 ft													
220.0 - 225.0 ft													
225.0 - 230.0 ft													
230.0 - 235.0 ft													
235.0 - 240.0 ft													
240.0 - 245.0 ft													
245.0 - 250.0 ft													

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X															
		260.0 – 265.0 ft						X	X		X	X	X			X			X															
		265.0 – 270.0 ft						X	X		X	X	X			X			X															
		270.0 – 275.0 ft						X	X		X	X	X			X			X															
		275.0 – 280.0 ft						X	X		X	X	X			X			X															
		280.0 – 285.0 ft						X	X		X	X	X			X			X															
		285.0 – 290.0 ft						X	X		X	X	X			X			X															
		290.0 – 295.0 ft						X	X		X	X	X			X			X															
		295.0 – 300.0 ft						X	X		X	X	X			X			X															
Vertical Borehole	MDA U	0.0 – 5.0 ft						X	X		X	X	X			X			X															
		5.0 – 10.0 ft						X	X		X	X	X			X			X															
		10.0 – 15.0 ft						X	X		X	X	X			X			X															
		15.0 – 20.0 ft						X	X		X	X	X			X			X															
		20.0 – 25.0 ft						X	X		X	X	X			X			X															
		25.0 – 30.0 ft						X	X		X	X	X			X			X															
		30.0 – 35.0 ft						X	X		X	X	X			X			X															
		35.0 – 40.0 ft						X	X		X	X	X			X			X															
		40.0 – 45.0 ft						X	X		X	X	X			X			X															
		45.0 – 50.0 ft						X	X		X	X	X			X			X															
		50.0 – 55.0 ft						X	X		X	X	X			X			X															
		55.0 – 60.0 ft						X	X		X	X	X			X			X															
		60.0 – 65.0 ft						X	X		X	X	X			X			X															
		65.0 – 70.0 ft						X	X		X	X	X			X			X															
		70.0 – 75.0 ft						X	X		X	X	X			X			X															
		75.0 – 80.0 ft						X	X		X	X	X			X			X															

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging
		80.0 - 85.0 ft						X	X		X	X	X
		85.0 - 90.0 ft						X	X		X	X	X
		90.0 - 95.0 ft						X	X		X	X	X
		95.0 - 100.0 ft						X	X		X	X	X
		100.0 - 105.0 ft						X	X		X	X	X
		105.0 - 110.0 ft						X	X		X	X	X
		110.0 - 115.0 ft						X	X		X	X	X
		115.0 - 120.0 ft						X	X		X	X	X
		120.0 - 125.0 ft						X	X		X	X	X
		125.0 - 130.0 ft						X	X		X	X	X
		130.0 - 135.0 ft						X	X		X	X	X
		135.0 - 140.0 ft						X	X		X	X	X
		140.0 - 145.0 ft						X	X		X	X	X
		145.0 - 150.0 ft						X	X		X	X	X
		150.0 - 155.0 ft						X	X		X	X	X
		155.0 - 160.0 ft						X	X		X	X	X
		160.0 - 165.0 ft						X	X		X	X	X
		165.0 - 170.0 ft						X	X		X	X	X
		170.0 - 175.0 ft						X	X		X	X	X
		175.0 - 180.0 ft						X	X		X	X	X
		180.0 - 185.0 ft						X	X		X	X	X
		185.0 - 190.0 ft						X	X		X	X	X
		190.0 - 195.0 ft						X	X		X	X	X
		195.0 - 200.0 ft						X	X		X	X	X
		200.0 - 205.0 ft						X	X		X	X	X
		205.0 - 210.0 ft						X	X		X	X	X

Interval	Field Laboratory Measurements: Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture		
80.0 - 85.0 ft			X			X		
85.0 - 90.0 ft			X			X		
90.0 - 95.0 ft			X			X		
95.0 - 100.0 ft			X			X		
100.0 - 105.0 ft			X			X		
105.0 - 110.0 ft			X			X		
110.0 - 115.0 ft			X			X		
115.0 - 120.0 ft			X			X		
120.0 - 125.0 ft			X			X		
125.0 - 130.0 ft			X			X		
130.0 - 135.0 ft			X			X		
135.0 - 140.0 ft			X			X		
140.0 - 145.0 ft			X			X		
145.0 - 150.0 ft			X			X		
150.0 - 155.0 ft			X			X		
155.0 - 160.0 ft			X			X		
160.0 - 165.0 ft			X			X		
165.0 - 170.0 ft			X			X		
170.0 - 175.0 ft			X			X		
175.0 - 180.0 ft			X			X		
180.0 - 185.0 ft			X			X		
185.0 - 190.0 ft			X			X		
190.0 - 195.0 ft			X			X		
195.0 - 200.0 ft			X			X		
200.0 - 205.0 ft			X			X		
205.0 - 210.0 ft			X			X		

Interval	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
80.0 - 85.0 ft													
85.0 - 90.0 ft													
90.0 - 95.0 ft													
95.0 - 100.0 ft													
100.0 - 105.0 ft													
105.0 - 110.0 ft													
110.0 - 115.0 ft													
115.0 - 120.0 ft													
120.0 - 125.0 ft													
125.0 - 130.0 ft													
130.0 - 135.0 ft													
135.0 - 140.0 ft													
140.0 - 145.0 ft													
145.0 - 150.0 ft													
150.0 - 155.0 ft													
155.0 - 160.0 ft													
160.0 - 165.0 ft													
165.0 - 170.0 ft													
170.0 - 175.0 ft													
175.0 - 180.0 ft													
180.0 - 185.0 ft													
185.0 - 190.0 ft													
190.0 - 195.0 ft													
195.0 - 200.0 ft													
200.0 - 205.0 ft													
205.0 - 210.0 ft													

Table 12.5-III

MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		210.0 – 215.0 ft						X	X		X	X	X			X			X															
		215.0 – 220.0 ft						X	X		X	X	X			X			X															
		220.0 – 225.0 ft						X	X		X	X	X			X			X															
		225.0 – 230.0 ft						X	X		X	X	X			X			X															
		230.0 – 235.0 ft						X	X		X	X	X			X			X															
		235.0 – 240.0 ft						X	X		X	X	X			X			X															
		240.0 – 245.0 ft						X	X		X	X	X			X			X															
		245.0 – 250.0 ft						X	X		X	X	X			X			X															
		250.0 – 255.0 ft						X	X		X	X	X			X			X															
		255.0 – 260.0 ft						X	X		X	X	X			X			X															
		260.0 – 265.0 ft						X	X		X	X	X			X			X															
		265.0 – 270.0 ft						X	X		X	X	X			X			X															
		270.0 – 275.0 ft						X	X		X	X	X			X			X															
		275.0 – 280.0 ft						X	X		X	X	X			X			X															
		280.0 – 285.0 ft						X	X		X	X	X			X			X															
		285.0 – 290.0 ft						X	X		X	X	X			X			X															
		290.0 – 295.0 ft						X	X		X	X	X			X			X															
		295.0 – 300.0 ft						X	X		X	X	X			X			X															
Vertical Borehole	MDA V	0.0 – 5.0 ft						X	X		X	X	X			X			X															
		5.0 – 10.0 ft						X	X		X	X	X			X			X															
		10.0 – 15.0 ft						X	X		X	X	X			X			X															
		15.0 – 20.0 ft						X	X		X	X	X			X			X															
		20.0 – 25.0 ft						X	X		X	X	X			X			X															
		25.0 – 30.0 ft						X	X		X	X	X			X			X															
		30.0 – 35.0 ft						X	X		X	X	X			X			X															
		35.0 – 40.0 ft						X	X		X	X	X			X			X															

Table 12.5–III

MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low–Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		40.0 – 45.0 ft						X	X		X	X	X			X			X															
		45.0 – 50.0 ft						X	X		X	X	X			X			X															
		50.0 – 55.0 ft						X	X		X	X	X			X			X															
		55.0 – 60.0 ft						X	X		X	X	X			X			X															
		60.0 – 65.0 ft						X	X		X	X	X			X			X															
		65.0 – 70.0 ft						X	X		X	X	X			X			X															
		70.0 – 75.0 ft						X	X		X	X	X			X			X															
		75.0 – 80.0 ft						X	X		X	X	X			X			X															
		80.0 – 85.0 ft						X	X		X	X	X			X			X															
		85.0 – 90.0 ft						X	X		X	X	X			X			X															
		90.0 – 95.0 ft						X	X		X	X	X			X			X															
		95.0 – 100.0 ft						X	X		X	X	X			X			X															
		100.0 – 105.0 ft						X	X		X	X	X			X			X															
		105.0 – 110.0 ft						X	X		X	X	X			X			X															
		110.0 – 115.0 ft						X	X		X	X	X			X			X															
		115.0 – 120.0 ft						X	X		X	X	X			X			X															
		120.0 – 125.0 ft						X	X		X	X	X			X			X															
		125.0 – 130.0 ft						X	X		X	X	X			X			X															
		130.0 – 135.0 ft						X	X		X	X	X			X			X															
		135.0 – 140.0 ft						X	X		X	X	X			X			X															
		140.0 – 145.0 ft						X	X		X	X	X			X			X															
		145.0 – 150.0 ft						X	X		X	X	X			X			X															
		150.0 – 155.0 ft						X	X		X	X	X			X			X															
		155.0 – 160.0 ft						X	X		X	X	X			X			X															
		160.0 – 165.0 ft						X	X		X	X	X			X			X															
		165.0 – 170.0 ft						X	X		X	X	X			X			X															

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He Injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		190.0 - [illegible]		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
		300.0 - 305.0 ft		X	X	X	X												
		305.0 - 310.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		310.0 - 315.0 ft		X	X	X	X												
		315.0 - 320.0 ft		X	X	X	X												
		320.0 - 325.0 ft		X	X	X	X												
		325.0 - 330.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		330.0 - 335.0 ft		X	X	X	X												
		335.0 - 340.0 ft		X	X	X	X												
		340.0 - 345.0 ft		X	X	X	X												
		345.0 - 350.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		350.0 - 355.0 ft		X	X	X	X												
		355.0 - 360.0 ft		X	X	X	X												
		360.0 - 365.0 ft		X	X	X	X												
		365.0 - 370.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Environmental Isotopes; Open Hole Tests: Straddle Packer Tests

Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
190.0 - [illegible]															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															
225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
230.0 - 235.0 ft															
235.0 - 240.0 ft															
240.0 - 245.0 ft															
245.0 - 250.0 ft															
250.0 - 255.0 ft															
255.0 - 260.0 ft															
260.0 - 265.0 ft															
265.0 - 270.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
270.0 - 275.0 ft															
275.0 - 280.0 ft															
280.0 - 285.0 ft															
285.0 - 290.0 ft															
290.0 - 295.0 ft															
295.0 - 300.0 ft															
300.0 - 305.0 ft															
305.0 - 310.0 ft															
310.0 - 315.0 ft															
315.0 - 320.0 ft															
320.0 - 325.0 ft															
325.0 - 330.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
330.0 - 335.0 ft															
335.0 - 340.0 ft															
340.0 - 345.0 ft															
345.0 - 350.0 ft															
350.0 - 355.0 ft															
355.0 - 360.0 ft															
360.0 - 365.0 ft															
365.0 - 370.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Open Hole Tests: Geophysics

Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
190.0 - [illegible]											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											
210.0 - 215.0 ft											
215.0 - 220.0 ft											
220.0 - 225.0 ft											
225.0 - 230.0 ft											
230.0 - 235.0 ft											
235.0 - 240.0 ft											
240.0 - 245.0 ft											
245.0 - 250.0 ft											
250.0 - 255.0 ft											
255.0 - 260.0 ft											
260.0 - 265.0 ft											
265.0 - 270.0 ft											
270.0 - 275.0 ft											
275.0 - 280.0 ft											
280.0 - 285.0 ft											
285.0 - 290.0 ft											
290.0 - 295.0 ft											
295.0 - 300.0 ft											
300.0 - 305.0 ft											
305.0 - 310.0 ft											
310.0 - 315.0 ft											
315.0 - 320.0 ft											
320.0 - 325.0 ft											
325.0 - 330.0 ft											
330.0 - 335.0 ft											
335.0 - 340.0 ft											
340.0 - 345.0 ft											
345.0 - 350.0 ft											
350.0 - 355.0 ft											
355.0 - 360.0 ft											
360.0 - 365.0 ft											
365.0 - 370.0 ft											

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
				Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		370.0 - 375.0 ft		X	X	X	X																																						
		375.0 - 380.0 ft		X	X	X	X																																						
		380.0 - 385.0 ft		X	X	X	X																																						
		385.0 - 390.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		390.0 - 395.0 ft		X	X	X	X																																						
		395.0 - 400.0 ft		X	X	X	X																																						
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
Vertical Borehole	LADP-4																																												
Continuous Downhole																																			X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft		X	X	X	X																																						
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		10.0 - 15.0 ft		X	X	X	X																																						
		15.0 - 20.0 ft		X	X	X	X																																						
		20.0 - 25.0 ft		X	X	X	X																																						
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		30.0 - 35.0 ft		X	X	X	X																																						
		35.0 - 40.0 ft		X	X	X	X																																						
		40.0 - 45.0 ft		X	X	X	X																																						
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		50.0 - 55.0 ft		X	X	X	X																																						
		55.0 - 60.0 ft		X	X	X	X																																						
		60.0 - 65.0 ft		X	X	X	X																																						
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		70.0 - 75.0 ft		X	X	X	X																																						
		75.0 - 80.0 ft		X	X	X	X																																						
		80.0 - 85.0 ft		X	X	X	X																																						
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		90.0 - 95.0 ft		X	X	X	X																																						
		95.0 - 100.0 ft		X	X	X	X																																						
		100.0 - 105.0 ft		X	X	X	X																																						
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical															
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		180.0 - 185.0 ft		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												

	Environmental Isotopes								Open Hole Tests: Straddle Packer Tests						
Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
180.0 - 185.0 ft															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															
225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
230.0 - 235.0 ft															
235.0 - 240.0 ft															
240.0 - 245.0 ft															
245.0 - 250.0 ft															
250.0 - 255.0 ft															
255.0 - 260.0 ft															
260.0 - 265.0 ft															
265.0 - 270.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
270.0 - 275.0 ft															
275.0 - 280.0 ft															
280.0 - 285.0 ft															

	Open Hole Tests: Geophysics										
Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
110.0 - 115.0 ft											
115.0 - 120.0 ft											
120.0 - 125.0 ft											
125.0 - 130.0 ft											
130.0 - 135.0 ft											
135.0 - 140.0 ft											
140.0 - 145.0 ft											
145.0 - 150.0 ft											
150.0 - 155.0 ft											
155.0 - 160.0 ft											
160.0 - 165.0 ft											
165.0 - 170.0 ft											
170.0 - 175.0 ft											
175.0 - 180.0 ft											
180.0 - 185.0 ft											
185.0 - 190.0 ft											
190.0 - 195.0 ft											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											
210.0 - 215.0 ft											
215.0 - 220.0 ft											
220.0 - 225.0 ft											
225.0 - 230.0 ft											
230.0 - 235.0 ft											
235.0 - 240.0 ft											
240.0 - 245.0 ft											
245.0 - 250.0 ft											
250.0 - 255.0 ft											
255.0 - 260.0 ft											
260.0 - 265.0 ft											
265.0 - 270.0 ft											
270.0 - 275.0 ft											
275.0 - 280.0 ft											
280.0 - 285.0 ft											

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
				Hydrogeological and Geochemical															
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
		300.0 - 305.0 ft		X	X	X	X												
		305.0 - 310.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		310.0 - 315.0 ft		X	X	X	X												
		315.0 - 320.0 ft		X	X	X	X												
		320.0 - 325.0 ft		X	X	X	X												
		325.0 - 330.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		330.0 - 335.0 ft		X	X	X	X												
		335.0 - 340.0 ft		X	X	X	X												
		340.0 - 345.0 ft		X	X	X	X												
		345.0 - 350.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		350.0 - 355.0 ft		X	X	X	X												
		355.0 - 360.0 ft		X	X	X	X												
		360.0 - 365.0 ft		X	X	X	X												
		365.0 - 370.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		370.0 - 375.0 ft		X	X	X	X												
		375.0 - 380.0 ft		X	X	X	X												
		380.0 - 385.0 ft		X	X	X	X												
		385.0 - 390.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		390.0 - 395.0 ft		X	X	X	X												
		395.0 - 400.0 ft		X	X	X	X												
		400.0 - 405.0 ft		X	X	X	X												
		405.0 - 410.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		410.0 - 415.0 ft		X	X	X	X												
		415.0 - 420.0 ft		X	X	X	X												
		420.0 - 425.0 ft		X	X	X	X												
		425.0 - 430.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		430.0 - 435.0 ft		X	X	X	X												
		435.0 - 440.0 ft		X	X	X	X												
		440.0 - 445.0 ft		X	X	X	X												
		445.0 - 450.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		450.0 - 455.0 ft		X	X	X	X												
		455.0 - 460.0 ft		X	X	X	X												

Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium -87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
	Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
285.0 - 290.0 ft																										
290.0 - 295.0 ft																										
295.0 - 300.0 ft																										
300.0 - 305.0 ft																										
305.0 - 310.0 ft																										
310.0 - 315.0 ft																										
315.0 - 320.0 ft																										
320.0 - 325.0 ft																										
325.0 - 330.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
330.0 - 335.0 ft																										
335.0 - 340.0 ft																										
340.0 - 345.0 ft																										
345.0 - 350.0 ft																										
350.0 - 355.0 ft																										
355.0 - 360.0 ft																										
360.0 - 365.0 ft																										
365.0 - 370.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
370.0 - 375.0 ft																										
375.0 - 380.0 ft																										
380.0 - 385.0 ft																										
385.0 - 390.0 ft																										
390.0 - 395.0 ft																										
395.0 - 400.0 ft																										
400.0 - 405.0 ft																										
405.0 - 410.0 ft																										
410.0 - 415.0 ft																										
415.0 - 420.0 ft																										
420.0 - 425.0 ft																										
425.0 - 430.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
430.0 - 435.0 ft																										
435.0 - 440.0 ft																										
440.0 - 445.0 ft																										
445.0 - 450.0 ft																										
450.0 - 455.0 ft																										
455.0 - 460.0 ft																										

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		460.0 - 465.0 ft		X	X	X	X																																						
		465.0 - 470.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		470.0 - 475.0 ft		X	X	X	X																																						
		475.0 - 480.0 ft		X	X	X	X																																						
		480.0 - 485.0 ft		X	X	X	X																																						
		485.0 - 490.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		490.0 - 495.0 ft		X	X	X	X																																						
		495.0 - 500.0 ft		X	X	X	X																																						
		500.0 - 505.0 ft		X	X	X	X																																						
		505.0 - 510.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		510.0 - 515.0 ft		X	X	X	X																																						
		515.0 - 520.0 ft		X	X	X	X																																						
		520.0 - 525.0 ft		X	X	X	X																																						
		525.0 - 530.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		530.0 - 535.0 ft		X	X	X	X																																						
		535.0 - 540.0 ft		X	X	X	X																																						
		540.0 - 545.0 ft		X	X	X	X																																						
		545.0 - 550.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		550.0 - 555.0 ft		X	X	X	X																																						
		555.0 - 560.0 ft		X	X	X	X																																						
		560.0 - 565.0 ft		X	X	X	X																																						
		565.0 - 570.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		570.0 - 575.0 ft		X	X	X	X																																						
		575.0 - 580.0 ft		X	X	X	X																																						
		580.0 - 585.0 ft		X	X	X	X																																						
		585.0 - 590.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		590.0 - 595.0 ft		X	X	X	X																																						
		595.0 - 600.0 ft		X	X	X	X																																						
		600.0 - 605.0 ft		X	X	X	X																																						
		605.0 - 610.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		610.0 - 615.0 ft		X	X	X	X																																						
		615.0 - 620.0 ft		X	X	X	X																																						
		620.0 - 625.0 ft		X	X	X	X																																						
		625.0 - 630.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		630.0 - 635.0 ft		X	X	X	X																																						

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride–35/Chloride–37	Carbon–12/Carbon–13	Strontium–86/Strontium–87	Hydrogen/Deuterium	Oxygen–16/Oxygen–18	Tritium	Carbon–14	Chloride–36	In Situ Permeability	VOA's – Pore Gas	CO2 – Pore Gas	CH4 – Pore Gas	C–12/C–13 – Pore Gas	Relative Humidity – Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM–39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium–252)	Side Scan Video
		635.0 – 640.0 ft		X	X	X	X																																						
		640.0 – 645.0 ft		X	X	X	X																																						
		645.0 – 650.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		650.0 – 655.0 ft		X	X	X	X																																						
		655.0 – 660.0 ft		X	X	X	X																																						
		660.0 – 665.0 ft		X	X	X	X																																						
		665.0 – 670.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		670.0 – 675.0 ft		X	X	X	X																																						
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO_2 - Pore Gas	CH_4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF_6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
Vertical Borehole	LADP-1																																												
Continuous Downhole																																			X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft		X	X	X	X																																						
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		10.0 - 15.0 ft		X	X	X	X																																						
		15.0 - 20.0 ft		X	X	X	X																																						
		20.0 - 25.0 ft		X	X	X	X																																						
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		30.0 - 35.0 ft		X	X	X	X																																						
		35.0 - 40.0 ft		X	X	X	X																																						
		40.0 - 45.0 ft		X	X	X	X																																						
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		50.0 - 55.0 ft		X	X	X	X																																						
		55.0 - 60.0 ft		X	X	X	X																																						
		60.0 - 65.0 ft		X	X	X	X																																						
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		70.0 - 75.0 ft		X	X	X	X																																						
		75.0 - 80.0 ft		X	X	X	X																																						
		80.0 - 85.0 ft		X	X	X	X																																						
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		90.0 - 95.0 ft		X	X	X	X																																						
		95.0 - 100.0 ft		X	X	X	X																																						
		100.0 - 105.0 ft		X	X	X	X																																						
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		110.0 - 115.0 ft		X	X	X	X																																						
		115.0 - 120.0 ft		X	X	X	X																																						
		120.0 - 125.0 ft		X	X	X	X																																						
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		130.0 - 135.0 ft		X	X	X	X																																						
		135.0 - 140.0 ft		X	X	X	X																																						
		140.0 - 145.0 ft		X	X	X	X																																						
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		150.0 - 155.0 ft		X	X	X	X																																						
		155.0 - 160.0 ft		X	X	X	X																																						
		160.0 - 165.0 ft		X	X	X	X																																						
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		170.0 - 175.0 ft		X	X	X	X																																						
		175.0 - 180.0 ft		X	X	X	X																																						
		180.0 - 185.0 ft		X	X	X	X																																						
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		190.0 - 195.0 ft		X	X	X	X																																						
		195.0 - 200.0 ft		X	X	X	X																																						
		200.0 - 205.0 ft		X	X	X	X																																						
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		210.0 - 215.0 ft		X	X	X	X																																						
		215.0 - 220.0 ft		X	X	X	X																																						
		220.0 - 225.0 ft		X	X	X	X																																						
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		230.0 - 235.0 ft		X	X	X	X																																						
		235.0 - 240.0 ft		X	X	X	X																																						
		240.0 - 245.0 ft		X	X	X	X																																						
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		250.0 - 255.0 ft		X	X	X	X																																						
		255.0 - 260.0 ft		X	X	X	X																																						
		260.0 - 265.0 ft		X	X	X	X																																						
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		270.0 - 275.0 ft		X	X	X	X																																						
		275.0 - 280.0 ft		X	X	X	X																																						
		280.0 - 285.0 ft		X	X	X	X																																						
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		290.0 - 295.0 ft		X	X	X	X																																						
		295.0 - 300.0 ft		X	X	X	X																																						
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
Vertical Borehole	LADP-2																																												
Continuous Downhole																																			X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft		X	X	X	X																																						
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		10.0 - 15.0 ft		X	X	X	X																																						
		15.0 - 20.0 ft		X	X	X	X																																						
		20.0 - 25.0 ft		X	X	X	X																																						
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		30.0 - 35.0 ft		X	X	X	X																																						

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical: Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He Injection)	Satur. Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		35.0 - 40.0 ft		X	X	X	X												
		40.0 - 45.0 ft		X	X	X	X												
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		50.0 - 55.0 ft		X	X	X	X												
		55.0 - 60.0 ft		X	X	X	X												
		60.0 - 65.0 ft		X	X	X	X												
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		70.0 - 75.0 ft		X	X	X	X												
		75.0 - 80.0 ft		X	X	X	X												
		80.0 - 85.0 ft		X	X	X	X												
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		90.0 - 95.0 ft		X	X	X	X												
		95.0 - 100.0 ft		X	X	X	X												
		[illegible]		X	X	X	X												
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		180.0 - 185.0 ft		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Interval	Environmental Isotopes: Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	Open Hole Tests: Straddle Packer Tests: In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
35.0 - 40.0 ft															
40.0 - 45.0 ft															
45.0 - 50.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
50.0 - 55.0 ft															
55.0 - 60.0 ft															
60.0 - 65.0 ft															
65.0 - 70.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
70.0 - 75.0 ft															
75.0 - 80.0 ft															
80.0 - 85.0 ft															
85.0 - 90.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.0 - 95.0 ft															
95.0 - 100.0 ft															
[illegible]															
105.0 - 110.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
180.0 - 185.0 ft															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															

Interval	Open Hole Tests: Geophysics: Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
35.0 - 40.0 ft											
40.0 - 45.0 ft											
45.0 - 50.0 ft											
50.0 - 55.0 ft											
55.0 - 60.0 ft											
60.0 - 65.0 ft											
65.0 - 70.0 ft											
70.0 - 75.0 ft											
75.0 - 80.0 ft											
80.0 - 85.0 ft											
85.0 - 90.0 ft											
90.0 - 95.0 ft											
95.0 - 100.0 ft											
[illegible]											
105.0 - 110.0 ft											
110.0 - 115.0 ft											
115.0 - 120.0 ft											
120.0 - 125.0 ft											
125.0 - 130.0 ft											
130.0 - 135.0 ft											
135.0 - 140.0 ft											
140.0 - 145.0 ft											
145.0 - 150.0 ft											
150.0 - 155.0 ft											
155.0 - 160.0 ft											
160.0 - 165.0 ft											
165.0 - 170.0 ft											
170.0 - 175.0 ft											
175.0 - 180.0 ft											
180.0 - 185.0 ft											
185.0 - 190.0 ft											
190.0 - 195.0 ft											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											

Table 12.5-IV

'INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
Vertical Borehole	LADP-5																		
Continuous Downhole																			
		0.0 - 5.0 ft		X	X	X	X												
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		10.0 - 15.0 ft		X	X	X	X												
		15.0 - 20.0 ft		X	X	X	X												
		20.0 - 25.0 ft		X	X	X	X												
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		30.0 - 35.0 ft		X	X	X	X												
		35.0 - 40.0 ft		X	X	X	X												
		40.0 - 45.0 ft		X	X	X	X												
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Environmental Isotopes; Open Hole Tests: Straddle Packer Tests

Sample Type	Sampling Location	Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
		210.0 - 215.0 ft															
		215.0 - 220.0 ft															
		220.0 - 225.0 ft															
		225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft															
		235.0 - 240.0 ft															
		240.0 - 245.0 ft															
		245.0 - 250.0 ft															
		250.0 - 255.0 ft															
		255.0 - 260.0 ft															
		260.0 - 265.0 ft															
		265.0 - 270.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft															
		275.0 - 280.0 ft															
		280.0 - 285.0 ft															
		285.0 - 290.0 ft															
		290.0 - 295.0 ft															
		295.0 - 300.0 ft															
Fracture Contingency Sample																	
Vertical Borehole	LADP-5																
Continuous Downhole																	
		0.0 - 5.0 ft															
		5.0 - 10.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		10.0 - 15.0 ft															
		15.0 - 20.0 ft															
		20.0 - 25.0 ft															
		25.0 - 30.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		30.0 - 35.0 ft															
		35.0 - 40.0 ft															
		40.0 - 45.0 ft															
		45.0 - 50.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Open Hole Tests: Geophysics

Sample Type	Sampling Location	Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		210.0 - 215.0 ft											
		215.0 - 220.0 ft											
		220.0 - 225.0 ft											
		225.0 - 230.0 ft											
		230.0 - 235.0 ft											
		235.0 - 240.0 ft											
		240.0 - 245.0 ft											
		245.0 - 250.0 ft											
		250.0 - 255.0 ft											
		255.0 - 260.0 ft											
		260.0 - 265.0 ft											
		265.0 - 270.0 ft											
		270.0 - 275.0 ft											
		275.0 - 280.0 ft											
		280.0 - 285.0 ft											
		285.0 - 290.0 ft											
		290.0 - 295.0 ft											
		295.0 - 300.0 ft											
Fracture Contingency Sample													
Vertical Borehole	LADP-5												
Continuous Downhole			X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft											
		5.0 - 10.0 ft											
		10.0 - 15.0 ft											
		15.0 - 20.0 ft											
		20.0 - 25.0 ft											
		25.0 - 30.0 ft											
		30.0 - 35.0 ft											
		35.0 - 40.0 ft											
		40.0 - 45.0 ft											
		45.0 - 50.0 ft											

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		50.0 - 55.0 ft		X	X	X	X												
		55.0 - 60.0 ft		X	X	X	X												
		60.0 - 65.0 ft		X	X	X	X												
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		70.0 - 75.0 ft		X	X	X	X												
		75.0 - 80.0 ft		X	X	X	X												
		80.0 - 85.0 ft		X	X	X	X												
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		90.0 - 95.0 ft		X	X	X	X												
		95.0 - 100.0 ft		X	X	X	X												
		100.0 - 105.0 ft		X	X	X	X												
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		180.0 - 185.0 ft		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												

Environmental Isotopes; Open Hole Tests: Straddle Packer Tests

Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
50.0 - 55.0 ft															
55.0 - 60.0 ft															
60.0 - 65.0 ft															
65.0 - 70.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
70.0 - 75.0 ft															
75.0 - 80.0 ft															
80.0 - 85.0 ft															
85.0 - 90.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.0 - 95.0 ft															
95.0 - 100.0 ft															
100.0 - 105.0 ft															
105.0 - 110.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
180.0 - 185.0 ft															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															

Open Hole Tests: Geophysics

Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
50.0 - 55.0 ft											
55.0 - 60.0 ft											
60.0 - 65.0 ft											
65.0 - 70.0 ft											
70.0 - 75.0 ft											
75.0 - 80.0 ft											
80.0 - 85.0 ft											
85.0 - 90.0 ft											
90.0 - 95.0 ft											
95.0 - 100.0 ft											
100.0 - 105.0 ft											
105.0 - 110.0 ft											
110.0 - 115.0 ft											
115.0 - 120.0 ft											
120.0 - 125.0 ft											
125.0 - 130.0 ft											
130.0 - 135.0 ft											
135.0 - 140.0 ft											
140.0 - 145.0 ft											
145.0 - 150.0 ft											
150.0 - 155.0 ft											
155.0 - 160.0 ft											
160.0 - 165.0 ft											
165.0 - 170.0 ft											
170.0 - 175.0 ft											
175.0 - 180.0 ft											
180.0 - 185.0 ft											
185.0 - 190.0 ft											
190.0 - 195.0 ft											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											
210.0 - 215.0 ft											
215.0 - 220.0 ft											
220.0 - 225.0 ft											

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
Vertical Borehole	MDA T																		
Continuous Downhole																			
		0.0 - 5.0 ft		X	X	X	X												
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		10.0 - 15.0 ft		X	X	X	X												
		15.0 - 20.0 ft		X	X	X	X												
		20.0 - 25.0 ft		X	X	X	X												
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		30.0 - 35.0 ft		X	X	X	X												
		35.0 - 40.0 ft		X	X	X	X												
		40.0 - 45.0 ft		X	X	X	X												
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		50.0 - 55.0 ft		X	X	X	X												
		55.0 - 60.0 ft		X	X	X	X												
		60.0 - 65.0 ft		X	X	X	X												

Environmental Isotopes; Open Hole Tests: Straddle Packer Tests

Sample Type	Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
	225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	230.0 - 235.0 ft															
	235.0 - 240.0 ft															
	240.0 - 245.0 ft															
	245.0 - 250.0 ft															
	250.0 - 255.0 ft															
	255.0 - 260.0 ft															
	260.0 - 265.0 ft															
	265.0 - 270.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	270.0 - 275.0 ft															
	275.0 - 280.0 ft															
	280.0 - 285.0 ft															
	285.0 - 290.0 ft															
	290.0 - 295.0 ft															
	295.0 - 300.0 ft															
Fracture Contingency Sample																
Vertical Borehole (MDA T)																
Continuous Downhole																
	0.0 - 5.0 ft															
	5.0 - 10.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	10.0 - 15.0 ft															
	15.0 - 20.0 ft															
	20.0 - 25.0 ft															
	25.0 - 30.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	30.0 - 35.0 ft															
	35.0 - 40.0 ft															
	40.0 - 45.0 ft															
	45.0 - 50.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	50.0 - 55.0 ft															
	55.0 - 60.0 ft															
	60.0 - 65.0 ft															

Open Hole Tests: Geophysics

Sample Type	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
Vertical Borehole (MDA T) Continuous Downhole	X	X	X	X	X	X	X	X	X	X	X

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical: Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		70.0 - 75.0 ft		X	X	X	X												
		75.0 - 80.0 ft		X	X	X	X												
		80.0 - 85.0 ft		X	X	X	X												
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		90.0 - 95.0 ft		X	X	X	X												
		95.0 - 100.0 ft		X	X	X	X												
		100.0 - 105.0 ft		X	X	X	X												
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		180.0 - 185.0 ft		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												

Interval	Environmental Isotopes: Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	Open Hole Tests: Straddle Packer Tests: In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF-6
65.0 - 70.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
70.0 - 75.0 ft															
75.0 - 80.0 ft															
80.0 - 85.0 ft															
85.0 - 90.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.0 - 95.0 ft															
95.0 - 100.0 ft															
100.0 - 105.0 ft															
105.0 - 110.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
180.0 - 185.0 ft															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															
225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
230.0 - 235.0 ft															
235.0 - 240.0 ft															

Interval	Open Hole Tests: Geophysics: Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
65.0 - 70.0 ft											
70.0 - 75.0 ft											
75.0 - 80.0 ft											
80.0 - 85.0 ft											
85.0 - 90.0 ft											
90.0 - 95.0 ft											
95.0 - 100.0 ft											
100.0 - 105.0 ft											
105.0 - 110.0 ft											
110.0 - 115.0 ft											
115.0 - 120.0 ft											
120.0 - 125.0 ft											
125.0 - 130.0 ft											
130.0 - 135.0 ft											
135.0 - 140.0 ft											
140.0 - 145.0 ft											
145.0 - 150.0 ft											
150.0 - 155.0 ft											
155.0 - 160.0 ft											
160.0 - 165.0 ft											
165.0 - 170.0 ft											
170.0 - 175.0 ft											
175.0 - 180.0 ft											
180.0 - 185.0 ft											
185.0 - 190.0 ft											
190.0 - 195.0 ft											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											
210.0 - 215.0 ft											
215.0 - 220.0 ft											
220.0 - 225.0 ft											
225.0 - 230.0 ft											
230.0 - 235.0 ft											
235.0 - 240.0 ft											

Table 12.5-IV

INITIAL GEOPHYSICAL INVESTIGATIONS

FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
Vertical Borehole	MDA U																		
Continuous Downhole																			
		0.0 - 5.0 ft		X	X	X	X												
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		10.0 - 15.0 ft		X	X	X	X												
		15.0 - 20.0 ft		X	X	X	X												
		20.0 - 25.0 ft		X	X	X	X												
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		30.0 - 35.0 ft		X	X	X	X												
		35.0 - 40.0 ft		X	X	X	X												
		40.0 - 45.0 ft		X	X	X	X												
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		50.0 - 55.0 ft		X	X	X	X												
		55.0 - 60.0 ft		X	X	X	X												
		60.0 - 65.0 ft		X	X	X	X												
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		70.0 - 75.0 ft		X	X	X	X												
		75.0 - 80.0 ft		X	X	X	X												

Environmental Isotopes

Sample Type	Sampling Location	Interval	Sample Identification	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36
		240.0 - 245.0 ft									
		245.0 - 250.0 ft									
		250.0 - 255.0 ft									
		255.0 - 260.0 ft									
		260.0 - 265.0 ft									
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X
		270.0 - 275.0 ft									
		275.0 - 280.0 ft									
		280.0 - 285.0 ft									
		285.0 - 290.0 ft									
		290.0 - 295.0 ft									
		295.0 - 300.0 ft									
Fracture Contingency Sample											
Vertical Borehole	MDA U										
Continuous Downhole											
		0.0 - 5.0 ft									
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X
		10.0 - 15.0 ft									
		15.0 - 20.0 ft									
		20.0 - 25.0 ft									
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X
		30.0 - 35.0 ft									
		35.0 - 40.0 ft									
		40.0 - 45.0 ft									
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X
		50.0 - 55.0 ft									
		55.0 - 60.0 ft									
		60.0 - 65.0 ft									
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X
		70.0 - 75.0 ft									
		75.0 - 80.0 ft									

Open Hole Tests: Straddle Packer Tests

Sample Type	Sampling Location	Interval	Sample Identification	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
		240.0 - 245.0 ft								
		245.0 - 250.0 ft								
		250.0 - 255.0 ft								
		255.0 - 260.0 ft								
		260.0 - 265.0 ft								
		265.0 - 270.0 ft		X	X	X	X	X	X	X
		270.0 - 275.0 ft								
		275.0 - 280.0 ft								
		280.0 - 285.0 ft								
		285.0 - 290.0 ft								
		290.0 - 295.0 ft								
		295.0 - 300.0 ft								
Fracture Contingency Sample										
Vertical Borehole	MDA U									
Continuous Downhole										
		0.0 - 5.0 ft								
		5.0 - 10.0 ft		X	X	X	X	X	X	X
		10.0 - 15.0 ft								
		15.0 - 20.0 ft								
		20.0 - 25.0 ft								
		25.0 - 30.0 ft		X	X	X	X	X	X	X
		30.0 - 35.0 ft								
		35.0 - 40.0 ft								
		40.0 - 45.0 ft								
		45.0 - 50.0 ft		X	X	X	X	X	X	X
		50.0 - 55.0 ft								
		55.0 - 60.0 ft								
		60.0 - 65.0 ft								
		65.0 - 70.0 ft		X	X	X	X	X	X	X
		70.0 - 75.0 ft								
		75.0 - 80.0 ft								

Open Hole Tests: Geophysics

Sample Type	Sampling Location	Interval	Sample Identification	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		240.0 - 245.0 ft												
		245.0 - 250.0 ft												
		250.0 - 255.0 ft												
		255.0 - 260.0 ft												
		260.0 - 265.0 ft												
		265.0 - 270.0 ft												
		270.0 - 275.0 ft												
		275.0 - 280.0 ft												
		280.0 - 285.0 ft												
		285.0 - 290.0 ft												
		290.0 - 295.0 ft												
		295.0 - 300.0 ft												
Fracture Contingency Sample														
Vertical Borehole	MDA U													
Continuous Downhole				X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft												
		5.0 - 10.0 ft												
		10.0 - 15.0 ft												
		15.0 - 20.0 ft												
		20.0 - 25.0 ft												
		25.0 - 30.0 ft												
		30.0 - 35.0 ft												
		35.0 - 40.0 ft												
		40.0 - 45.0 ft												
		45.0 - 50.0 ft												
		50.0 - 55.0 ft												
		55.0 - 60.0 ft												
		60.0 - 65.0 ft												
		65.0 - 70.0 ft												
		70.0 - 75.0 ft												
		75.0 - 80.0 ft												

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical: Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		80.0 - 85.0 ft		X	X	X	X												
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		90.0 - 95.0 ft		X	X	X	X												
		95.0 - 100.0 ft		X	X	X	X												
		100.0 - 105.0 ft		X	X	X	X												
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		[illegible]		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												

Interval	Environmental Isotopes: Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	Open Hole Tests: Straddle Packer Tests: In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
80.0 - 85.0 ft															
85.0 - 90.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.0 - 95.0 ft															
95.0 - 100.0 ft															
100.0 - 105.0 ft															
105.0 - 110.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
[illegible]															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															
225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
230.0 - 235.0 ft															
235.0 - 240.0 ft															
240.0 - 245.0 ft															
245.0 - 250.0 ft															
250.0 - 255.0 ft															

Interval	Open Hole Tests: Geophysics: Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
80.0 - 85.0 ft											
85.0 - 90.0 ft											
90.0 - 95.0 ft											
95.0 - 100.0 ft											
100.0 - 105.0 ft											
105.0 - 110.0 ft											
110.0 - 115.0 ft											
115.0 - 120.0 ft											
120.0 - 125.0 ft											
125.0 - 130.0 ft											
130.0 - 135.0 ft											
135.0 - 140.0 ft											
140.0 - 145.0 ft											
145.0 - 150.0 ft											
150.0 - 155.0 ft											
155.0 - 160.0 ft											
160.0 - 165.0 ft											
165.0 - 170.0 ft											
170.0 - 175.0 ft											
175.0 - 180.0 ft											
[illegible]											
185.0 - 190.0 ft											
190.0 - 195.0 ft											
195.0 - 200.0 ft											
200.0 - 205.0 ft											
205.0 - 210.0 ft											
210.0 - 215.0 ft											
215.0 - 220.0 ft											
220.0 - 225.0 ft											
225.0 - 230.0 ft											
230.0 - 235.0 ft											
235.0 - 240.0 ft											
240.0 - 245.0 ft											
245.0 - 250.0 ft											
250.0 - 255.0 ft											

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
				Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		255.0 - 260.0 ft		X	X	X	X																																						
		260.0 - 265.0 ft		X	X	X	X																																						
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		270.0 - 275.0 ft		X	X	X	X																																						
		275.0 - 280.0 ft		X	X	X	X																																						
		280.0 - 285.0 ft		X	X	X	X																																						
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		290.0 - 295.0 ft		X	X	X	X																																						
		295.0 - 300.0 ft		X	X	X	X																																						
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
Vertical Borehole	MDA V																																												
Continuous Downhole																																			X	X	X	X	X	X	X	X	X	X	X
		0.0 - 5.0 ft		X	X	X	X																																						
		5.0 - 10.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		10.0 - 15.0 ft		X	X	X	X																																						
		15.0 - 20.0 ft		X	X	X	X																																						
		20.0 - 25.0 ft		X	X	X	X																																						
		25.0 - 30.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		30.0 - 35.0 ft		X	X	X	X																																						
		35.0 - 40.0 ft		X	X	X	X																																						
		40.0 - 45.0 ft		X	X	X	X																																						
		45.0 - 50.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		50.0 - 55.0 ft		X	X	X	X																																						
		55.0 - 60.0 ft		X	X	X	X																																						
		60.0 - 65.0 ft		X	X	X	X																																						
		65.0 - 70.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		70.0 - 75.0 ft		X	X	X	X																																						
		75.0 - 80.0 ft		X	X	X	X																																						
		80.0 - 85.0 ft		X	X	X	X																																						
		85.0 - 90.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		90.0 - 95.0 ft		X	X	X	X																																						

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical															
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		95.0 - 100.0 ft		X	X	X	X												
		100.0 - 105.0 ft		X	X	X	X												
		105.0 - 110.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		110.0 - 115.0 ft		X	X	X	X												
		115.0 - 120.0 ft		X	X	X	X												
		120.0 - 125.0 ft		X	X	X	X												
		125.0 - 130.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		130.0 - 135.0 ft		X	X	X	X												
		135.0 - 140.0 ft		X	X	X	X												
		140.0 - 145.0 ft		X	X	X	X												
		145.0 - 150.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		150.0 - 155.0 ft		X	X	X	X												
		155.0 - 160.0 ft		X	X	X	X												
		160.0 - 165.0 ft		X	X	X	X												
		165.0 - 170.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		170.0 - 175.0 ft		X	X	X	X												
		175.0 - 180.0 ft		X	X	X	X												
		180.0 - 185.0 ft		X	X	X	X												
		185.0 - 190.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		190.0 - 195.0 ft		X	X	X	X												
		195.0 - 200.0 ft		X	X	X	X												
		200.0 - 205.0 ft		X	X	X	X												
		205.0 - 210.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		210.0 - 215.0 ft		X	X	X	X												
		215.0 - 220.0 ft		X	X	X	X												
		220.0 - 225.0 ft		X	X	X	X												
		225.0 - 230.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		230.0 - 235.0 ft		X	X	X	X												
		235.0 - 240.0 ft		X	X	X	X												
		240.0 - 245.0 ft		X	X	X	X												
		245.0 - 250.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		250.0 - 255.0 ft		X	X	X	X												
		255.0 - 260.0 ft		X	X	X	X												
		260.0 - 265.0 ft		X	X	X	X												
		265.0 - 270.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	Environmental Isotopes								Open Hole Tests: Straddle Packer Tests						
Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
95.0 - 100.0 ft															
100.0 - 105.0 ft															
105.0 - 110.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
110.0 - 115.0 ft															
115.0 - 120.0 ft															
120.0 - 125.0 ft															
125.0 - 130.0 ft															
130.0 - 135.0 ft															
135.0 - 140.0 ft															
140.0 - 145.0 ft															
145.0 - 150.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
150.0 - 155.0 ft															
155.0 - 160.0 ft															
160.0 - 165.0 ft															
165.0 - 170.0 ft															
170.0 - 175.0 ft															
175.0 - 180.0 ft															
180.0 - 185.0 ft															
185.0 - 190.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
190.0 - 195.0 ft															
195.0 - 200.0 ft															
200.0 - 205.0 ft															
205.0 - 210.0 ft															
210.0 - 215.0 ft															
215.0 - 220.0 ft															
220.0 - 225.0 ft															
225.0 - 230.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
230.0 - 235.0 ft															
235.0 - 240.0 ft															
240.0 - 245.0 ft															
245.0 - 250.0 ft															
250.0 - 255.0 ft															
255.0 - 260.0 ft															
260.0 - 265.0 ft															
265.0 - 270.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	Open Hole Tests: Geophysics											
Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video	
95.0 - 100.0 ft												
100.0 - 105.0 ft												
105.0 - 110.0 ft												
110.0 - 115.0 ft												
115.0 - 120.0 ft												
120.0 - 125.0 ft												
125.0 - 130.0 ft												
130.0 - 135.0 ft												
135.0 - 140.0 ft												
140.0 - 145.0 ft												
145.0 - 150.0 ft												
150.0 - 155.0 ft												
155.0 - 160.0 ft												
160.0 - 165.0 ft												
165.0 - 170.0 ft												
170.0 - 175.0 ft												
175.0 - 180.0 ft												
180.0 - 185.0 ft												
185.0 - 190.0 ft												
190.0 - 195.0 ft												
195.0 - 200.0 ft												
200.0 - 205.0 ft												
205.0 - 210.0 ft												
210.0 - 215.0 ft												
215.0 - 220.0 ft												
220.0 - 225.0 ft												
225.0 - 230.0 ft												
230.0 - 235.0 ft												
235.0 - 240.0 ft												
240.0 - 245.0 ft												
245.0 - 250.0 ft												
250.0 - 255.0 ft												
255.0 - 260.0 ft												
260.0 - 265.0 ft												
265.0 - 270.0 ft												

Table 12.5–IV

INITIAL GEOPHYSICAL INVESTIGATIONS

FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		270.0 - 275.0 ft		X	X	X	X												
		275.0 - 280.0 ft		X	X	X	X												
		280.0 - 285.0 ft		X	X	X	X												
		285.0 - 290.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		290.0 - 295.0 ft		X	X	X	X												
		295.0 - 300.0 ft		X	X	X	X												
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C
				C								C	C	C	C	C	C	C	C

Environmental Isotopes

Sample Type	Sampling Location	Interval	Sample Identification	Chloride–35/Chloride–37	Carbon–12/Carbon–13	Strontium–86/Strontium–87	Hydrogen/Deuterium	Oxygen–16/Oxygen–18	Tritium	Carbon–14	Chloride–36
		270.0 - 275.0 ft									
		275.0 - 280.0 ft									
		280.0 - 285.0 ft									
		285.0 - 290.0 ft									
		290.0 - 295.0 ft									
		295.0 - 300.0 ft									
Fracture Contingency Sample											

Open Hole Tests: Straddle Packer Tests

Sample Type	Sampling Location	Interval	Sample Identification	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
		270.0 - 275.0 ft								
		275.0 - 280.0 ft								
		280.0 - 285.0 ft								
		285.0 - 290.0 ft								
		290.0 - 295.0 ft								
		295.0 - 300.0 ft								
Fracture Contingency Sample										

Open Hole Tests: Geophysics

Sample Type	Sampling Location	Interval	Sample Identification	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM–39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium–252)	Side Scan Video
		270.0 - 275.0 ft												
		275.0 - 280.0 ft												
		280.0 - 285.0 ft												
		285.0 - 290.0 ft												
		290.0 - 295.0 ft												
		295.0 - 300.0 ft												
Fracture Contingency Sample														

TABLE 12.5-V
SUITE OF GEOPHYSICAL LOGS

Open Hole	Characterization: Hydrogeological	Characterization: Contamination
Thermal Neutron (Moisture)	% moisture, perched zones	
Gamma Gamma (Density)	bulk density of rocks	
Caliper	fracture	
Axial Borehole Video	fracture orientation	
Sidescan Borehole Video	fracture orientation	
EM Induction (Geonics EM-39)	stratigraphic correlation, perched zones	
Magnetic Susceptibility (Romulus)	stratigraphic correlation	
Natural gamma	stratigraphic correlation	radioactive contamination
Spectral Gamma (U, TH, K)	stratigraphic correlation	radioactive contamination
Prompt Fission Neutron	-Fissionable Isotopes	radioactive contamination
Geochemical (Californium-252)	- 8 to 10 elements that undergo neutron activation and elastic scattering	chemical contamination
<u>Cased Hole</u>		
Thermal Neutron (Moisture)	% moisture, perched zones	
Gamma Gamma (Density)	% moisture, perched zones	
EM Induction (PVC Casing)	perched zones	
Temperature Gradient (Requires fluid-stemming casing)	vapor phase transport	

TABLE 12.5-VI
ANALYTICAL SUITE FOR GROUNDWATER SAMPLES COLLECTED FROM SEEPS, PERCHED ZONES, AND ROCK PORES IN UNSATURATED ZONE

Major Anions
Carbonate
Chloride
Sulfate
Fluoride
Nitrate
Nitrite
Nitrate and Nitrite
Phosphate

Major Cations
Ammonium
Calcium
Magnesium
Potassium
Sodium
Silica

Radionuclides
Gross alpha
Gross beta
Radium-226
Thorium-230

Other Parameters
Total Organic Carbon
Total suspended solids (<10 micron)

Field Measured Parameters
Temperature
pH
Eh
Specific Conductance
Alkalinity
Dissolved Oxygen

Minor and Trace Constituents
Aluminum
Antimony
Arsenic
Barium
Beryllium
Boron
Bromide
Cadmium
Chromium
Cobalt
Copper
Cyanide
Iron
Lead
Manganese
Mercury
Molybdenum
Nickel
Selenium
Silver
Sulfide (as H_2S)
Strontium
Thallium
Uranium
Vanadium
Zinc

Environmental Isotopes
Chloride-35/Chloride-37
Carbon-12/Carbon-13
Strontium-86/Strontium-87
Hydrogen/Deuterium
Oxygen-16/Oxygen-18
Tritium
Carbon-14
Chloride-36

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Subsurface samples																																		
Vertical Borehole	LADP-1	300.0 – 305.0 ft						X	X		X	X	X			X			X															
		305.0 – 310.0 ft						X	X		X	X	X			X			X															
		310.0 – 315.0 ft						X	X		X	X	X			X			X															
		315.0 – 320.0 ft						X	X		X	X	X			X			X															
		320.0 – 325.0 ft						X	X		X	X	X			X			X															
		325.0 – 330.0 ft						X	X		X	X	X			X			X															
		330.0 – 335.0 ft						X	X		X	X	X			X			X															
		335.0 – 340.0 ft						X	X		X	X	X			X			X															
		340.0 – 345.0 ft						X	X		X	X	X			X			X															
		345.0 – 350.0 ft						X	X		X	X	X			X			X															
		350.0 – 355.0 ft						X	X		X	X	X			X			X															
		355.0 – 360.0 ft						X	X		X	X	X			X			X															
		360.0 – 365.0 ft						X	X		X	X	X			X			X															
		365.0 – 370.0 ft						X	X		X	X	X			X			X															
		370.0 – 375.0 ft						X	X		X	X	X			X			X															
		375.0 – 380.0 ft						X	X		X	X	X			X			X															
		380.0 – 385.0 ft						X	X		X	X	X			X			X															
		385.0 – 390.0 ft						X	X		X	X	X			X			X															
		390.0 – 395.0 ft						X	X		X	X	X			X			X															
		395.0 – 400.0 ft						X	X		X	X	X			X			X															
		400.0 – 405.0 ft						X	X		X	X	X			X			X															
		405.0 – 410.0 ft						X	X		X	X	X			X			X															
		410.0 – 415.0 ft						X	X		X	X	X			X			X															
		415.0 – 420.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		420.0 - 425.0 ft						X	X		X	X	X			X			X															
		425.0 - 430.0 ft						X	X		X	X	X			X			X															
		430.0 - 435.0 ft						X	X		X	X	X			X			X															
		435.0 - 440.0 ft						X	X		X	X	X			X			X															
		440.0 - 445.0 ft						X	X		X	X	X			X			X															
		445.0 - 450.0 ft						X	X		X	X	X			X			X															
		450.0 - 455.0 ft						X	X		X	X	X			X			X															
		455.0 - 460.0 ft						X	X		X	X	X			X			X															
		460.0 - 465.0 ft						X	X		X	X	X			X			X															
		465.0 - 470.0 ft						X	X		X	X	X			X			X															
		470.0 - 475.0 ft						X	X		X	X	X			X			X															
		475.0 - 480.0 ft						X	X		X	X	X			X			X															
		480.0 - 485.0 ft						X	X		X	X	X			X			X															
		485.0 - 490.0 ft						X	X		X	X	X			X			X															
		490.0 - 495.0 ft						X	X		X	X	X			X			X															
		495.0 - 500.0 ft						X	X		X	X	X			X			X															
		500.0 - 505.0 ft						X	X		X	X	X			X			X															
		505.0 - 510.0 ft						X	X		X	X	X			X			X															
		510.0 - 515.0 ft						X	X		X	X	X			X			X															
		515.0 - 520.0 ft						X	X		X	X	X			X			X															
		520.0 - 525.0 ft						X	X		X	X	X			X			X															
		525.0 - 530.0 ft						X	X		X	X	X			X			X															
		530.0 - 535.0 ft						X	X		X	X	X			X			X															
		535.0 - 540.0 ft						X	X		X	X	X			X			X															
		540.0 - 545.0 ft						X	X		X	X	X			X			X															
		545.0 - 550.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging
		550.0 - 555.0 ft						X	X		X	X	X
		555.0 - 560.0 ft						X	X		X	X	X
		560.0 - 565.0 ft						X	X		X	X	X
		565.0 - 570.0 ft						X	X		X	X	X
		570.0 - 575.0 ft						X	X		X	X	X
		575.0 - 580.0 ft						X	X		X	X	X
		580.0 - 585.0 ft						X	X		X	X	X
		585.0 - 590.0 ft						X	X		X	X	X
		590.0 - 595.0 ft						X	X		X	X	X
		595.0 - 600.0 ft						X	X		X	X	X
		600.0 - 605.0 ft						X	X		X	X	X
		605.0 - 610.0 ft						X	X		X	X	X
		610.0 - 615.0 ft						X	X		X	X	X
		615.0 - 620.0 ft						X	X		X	X	X
		620.0 - 625.0 ft						X	X		X	X	X
		625.0 - 630.0 ft						X	X		X	X	X
		630.0 - 635.0 ft						X	X		X	X	X
		635.0 - 640.0 ft						X	X		X	X	X
		640.0 - 645.0 ft						X	X		X	X	X
		645.0 - 650.0 ft						X	X		X	X	X
		650.0 - 655.0 ft						X	X		X	X	X
		655.0 - 660.0 ft						X	X		X	X	X
		660.0 - 665.0 ft						X	X		X	X	X
		665.0 - 670.0 ft						X	X		X	X	X
		670.0 - 675.0 ft						X	X		X	X	X
		675.0 - 680.0 ft						X	X		X	X	X

Interval	Field Laboratory Measurements: Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture		
550.0 - 555.0 ft			X			X		
555.0 - 560.0 ft			X			X		
560.0 - 565.0 ft			X			X		
565.0 - 570.0 ft			X			X		
570.0 - 575.0 ft			X			X		
575.0 - 580.0 ft			X			X		
580.0 - 585.0 ft			X			X		
585.0 - 590.0 ft			X			X		
590.0 - 595.0 ft			X			X		
595.0 - 600.0 ft			X			X		
600.0 - 605.0 ft			X			X		
605.0 - 610.0 ft			X			X		
610.0 - 615.0 ft			X			X		
615.0 - 620.0 ft			X			X		
620.0 - 625.0 ft			X			X		
625.0 - 630.0 ft			X			X		
630.0 - 635.0 ft			X			X		
635.0 - 640.0 ft			X			X		
640.0 - 645.0 ft			X			X		
645.0 - 650.0 ft			X			X		
650.0 - 655.0 ft			X			X		
655.0 - 660.0 ft			X			X		
660.0 - 665.0 ft			X			X		
665.0 - 670.0 ft			X			X		
670.0 - 675.0 ft			X			X		
675.0 - 680.0 ft			X			X		

Interval	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
550.0 - 555.0 ft													
555.0 - 560.0 ft													
560.0 - 565.0 ft													
565.0 - 570.0 ft													
570.0 - 575.0 ft													
575.0 - 580.0 ft													
580.0 - 585.0 ft													
585.0 - 590.0 ft													
590.0 - 595.0 ft													
595.0 - 600.0 ft													
600.0 - 605.0 ft													
605.0 - 610.0 ft													
610.0 - 615.0 ft													
615.0 - 620.0 ft													
620.0 - 625.0 ft													
625.0 - 630.0 ft													
630.0 - 635.0 ft													
635.0 - 640.0 ft													
640.0 - 645.0 ft													
645.0 - 650.0 ft													
650.0 - 655.0 ft													
655.0 - 660.0 ft													
660.0 - 665.0 ft													
665.0 - 670.0 ft													
670.0 - 675.0 ft													
675.0 - 680.0 ft													

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		680.0 - 685.0 ft						X	X		X	X	X			X			X															
		685.0 - 690.0 ft						X	X		X	X	X			X			X															
		690.0 - 695.0 ft						X	X		X	X	X			X			X															
		695.0 - 700.0 ft						X	X		X	X	X			X			X															
		700.0 - 705.0 ft						X	X		X	X	X			X			X															
		705.0 - 710.0 ft						X	X		X	X	X			X			X															
		710.0 - 715.0 ft						X	X		X	X	X			X			X															
		715.0 - 720.0 ft						X	X		X	X	X			X			X															
		720.0 - 725.0 ft						X	X		X	X	X			X			X															
		725.0 - 730.0 ft						X	X		X	X	X			X			X															
		730.0 - 735.0 ft						X	X		X	X	X			X			X															
		735.0 - 740.0 ft						X	X		X	X	X			X			X															
		740.0 - 745.0 ft						X	X		X	X	X			X			X															
		745.0 - 750.0 ft						X	X		X	X	X			X			X															
Vertical Borehole	LADP-2	300.0 - 305.0 ft						X	X		X	X	X			X			X															
		305.0 - 310.0 ft						X	X		X	X	X			X			X															
		310.0 - 315.0 ft						X	X		X	X	X			X			X															
		315.0 - 320.0 ft						X	X		X	X	X			X			X															
		320.0 - 325.0 ft						X	X		X	X	X			X			X															
		325.0 - 330.0 ft						X	X		X	X	X			X			X															
		330.0 - 335.0 ft						X	X		X	X	X			X			X															
		335.0 - 340.0 ft						X	X		X	X	X			X			X															
		340.0 - 345.0 ft						X	X		X	X	X			X			X															
		345.0 - 350.0 ft						X	X		X	X	X			X			X															
		350.0 - 355.0 ft						X	X		X	X	X			X			X															
		355.0 - 360.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		360.0 – 365.0 ft						X	X		X	X	X			X			X															
		365.0 – 370.0 ft						X	X		X	X	X			X			X															
		370.0 – 375.0 ft						X	X		X	X	X			X			X															
		375.0 – 380.0 ft						X	X		X	X	X			X			X															
		380.0 – 385.0 ft						X	X		X	X	X			X			X															
		385.0 – 390.0 ft						X	X		X	X	X			X			X															
		390.0 – 395.0 ft						X	X		X	X	X			X			X															
		395.0 – 400.0 ft						X	X		X	X	X			X			X															
		400.0 – 405.0 ft						X	X		X	X	X			X			X															
		405.0 – 410.0 ft						X	X		X	X	X			X			X															
		410.0 – 415.0 ft						X	X		X	X	X			X			X															
		415.0 – 420.0 ft						X	X		X	X	X			X			X															
		420.0 – 425.0 ft						X	X		X	X	X			X			X															
		425.0 – 430.0 ft						X	X		X	X	X			X			X															
		430.0 – 435.0 ft						X	X		X	X	X			X			X															
		435.0 – 440.0 ft						X	X		X	X	X			X			X															
		440.0 – 445.0 ft						X	X		X	X	X			X			X															
		445.0 – 450.0 ft						X	X		X	X	X			X			X															
		450.0 – 455.0 ft						X	X		X	X	X			X			X															
		455.0 – 460.0 ft						X	X		X	X	X			X			X															
		460.0 – 465.0 ft						X	X		X	X	X			X			X															
		465.0 – 470.0 ft						X	X		X	X	X			X			X															
		470.0 – 475.0 ft						X	X		X	X	X			X			X															
		475.0 – 480.0 ft						X	X		X	X	X			X			X															
		480.0 – 485.0 ft						X	X		X	X	X			X			X															
		485.0 – 490.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		490.0 – 495.0 ft						X	X		X	X	X			X			X															
		495.0 – 500.0 ft						X	X		X	X	X			X			X															
		500.0 – 505.0 ft						X	X		X	X	X			X			X															
		505.0 – 510.0 ft						X	X		X	X	X			X			X															
		510.0 – 515.0 ft						X	X		X	X	X			X			X															
		515.0 – 520.0 ft						X	X		X	X	X			X			X															
		520.0 – 525.0 ft						X	X		X	X	X			X			X															
		525.0 – 530.0 ft						X	X		X	X	X			X			X															
		530.0 – 535.0 ft						X	X		X	X	X			X			X															
		535.0 – 540.0 ft						X	X		X	X	X			X			X															
		540.0 – 545.0 ft						X	X		X	X	X			X			X															
		545.0 – 550.0 ft						X	X		X	X	X			X			X															
		550.0 – 555.0 ft						X	X		X	X	X			X			X															
		555.0 – 560.0 ft						X	X		X	X	X			X			X															
		560.0 – 565.0 ft						X	X		X	X	X			X			X															
		565.0 – 570.0 ft						X	X		X	X	X			X			X															
		570.0 – 575.0 ft						X	X		X	X	X			X			X															
		575.0 – 580.0 ft						X	X		X	X	X			X			X															
		580.0 – 585.0 ft						X	X		X	X	X			X			X															
		585.0 – 590.0 ft						X	X		X	X	X			X			X															
		590.0 – 595.0 ft						X	X		X	X	X			X			X															
		595.0 – 600.0 ft						X	X		X	X	X			X			X															
		600.0 – 605.0 ft						X	X		X	X	X			X			X															
		605.0 – 610.0 ft						X	X		X	X	X			X			X															
		610.0 – 615.0 ft						X	X		X	X	X			X			X															
		615.0 – 620.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		620.0 – 625.0 ft						v	v		v	v	v			X			X															
		625.0 – 630.0 ft						X	X		X	X	X			X			X															
		630.0 – 635.0 ft						X	X		X	X	X			X			X															
		635.0 – 640.0 ft						X	X		X	X	X			X			X															
		640.0 – 645.0 ft						X	X		X	X	X			X			X															
		645.0 – 650.0 ft						X	X		X	X	X			X			X															
		650.0 – 655.0 ft						X	X		X	X	X			X			X															
		655.0 – 660.0 ft						X	X		X	X	X			X			X															
		660.0 – 665.0 ft						X	X		X	X	X			X			X															
		665.0 – 670.0 ft						X	X		X	X	X			X			X															
		670.0 – 675.0 ft						X	X		X	X	X			X			X															
		675.0 – 680.0 ft						X	X		X	X	X			X			X															
		680.0 – 685.0 ft						X	X		X	X	X			X			X															
		685.0 – 690.0 ft						X	X		X	X	X			X			X															
		690.0 – 695.0 ft						X	X		X	X	X			X			X															
		695.0 – 700.0 ft						X	X		X	X	X			X			X															
		700.0 – 705.0 ft						X	X		X	X	X			X			X															
		705.0 – 710.0 ft						X	X		X	X	X			X			X															
		710.0 – 715.0 ft						X	X		X	X	X			X			X															
		715.0 – 720.0 ft						X	X		X	X	X			X			X															
		720.0 – 725.0 ft						X	X		X	X	X			X			X															
		725.0 – 730.0 ft						X	X		X	X	X			X			X															
		730.0 – 735.0 ft						X	X		X	X	X			X			X															
		735.0 – 740.0 ft						X	X		X	X	X			X			X															
		740.0 – 745.0 ft						X	X		X	X	X			X			X															
		745.0 – 750.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Vertical Borehole	LADP-5	300.0 - 305.0 ft						X	X		X	X	X			X			X															
		305.0 - 310.0 ft						X	X		X	X	X			X			X															
		310.0 - 315.0 ft						X	X		X	X	X			X			X															
		315.0 - 320.0 ft						X	X		X	X	X			X			X															
		320.0 - 325.0 ft						X	X		X	X	X			X			X															
		325.0 - 330.0 ft						X	X		X	X	X			X			X															
		330.0 - 335.0 ft						X	X		X	X	X			X			X															
		335.0 - 340.0 ft						X	X		X	X	X			X			X															
		340.0 - 345.0 ft						X	X		X	X	X			X			X															
		345.0 - 350.0 ft						X	X		X	X	X			X			X															
		350.0 - 355.0 ft						X	X		X	X	X			X			X															
		355.0 - 360.0 ft						X	X		X	X	X			X			X															
		360.0 - 365.0 ft						X	X		X	X	X			X			X															
		365.0 - 370.0 ft						X	X		X	X	X			X			X															
		370.0 - 375.0 ft						X	X		X	X	X			X			X															
		375.0 - 380.0 ft						X	X		X	X	X			X			X															
		380.0 - 385.0 ft						X	X		X	X	X			X			X															
		385.0 - 390.0 ft						X	X		X	X	X			X			X															
		390.0 - 395.0 ft						X	X		X	X	X			X			X															
		395.0 - 400.0 ft						X	X		X	X	X			X			X															
		400.0 - 405.0 ft						X	X		X	X	X			X			X															
		405.0 - 410.0 ft						X	X		X	X	X			X			X															
		410.0 - 415.0 ft						X	X		X	X	X			X			X															
		415.0 - 420.0 ft						X	X		X	X	X			X			X															
		420.0 - 425.0 ft						X	X		X	X	X			X			X															
		425.0 - 430.0 ft						X	X		X	X	X			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		430.0 - 435.0 ft						X	X		X	X	X			X			X															
		435.0 - 440.0 ft						X	X		X	X	X			X			X															
		440.0 - 445.0 ft						X	X		X	X	X			X			X															
		445.0 - 450.0 ft						X	X		X	X	X			X			X															
		450.0 - 455.0 ft						X	X		X	X	X			X			X															
		455.0 - 460.0 ft						X	X		X	X	X			X			X															
		460.0 - 465.0 ft						X	X		X	X	X			X			X															
		465.0 - 470.0 ft						X	X		X	X	X			X			X															
		470.0 - 475.0 ft						X	X		X	X	X			X			X															
		475.0 - 480.0 ft						X	X		X	X	X			X			X															
		480.0 - 485.0 ft						X	X		X	X	X			X			X															
		485.0 - 490.0 ft						X	X		X	X	X			X			X															
		490.0 - 495.0 ft						X	X		X	X	X			X			X															
		495.0 - 500.0 ft						X	X		X	X	X			X			X															
		500.0 - 505.0 ft						X	X		X	X	X			X			X															
		505.0 - 510.0 ft						X	X		X	X	X			X			X															
		510.0 - 515.0 ft						X	X		X	X	X			X			X															
		515.0 - 520.0 ft						X	X		X	X	X			X			X															
		520.0 - 525.0 ft						X	X		X	X	X			X			X															
		525.0 - 530.0 ft						X	X		X	X	X			X			X															
		530.0 - 535.0 ft						X	X		X	X	X			X			X															
		535.0 - 540.0 ft						X	X		X	X	X			X			X															
		540.0 - 545.0 ft						X	X		X	X	X			X			X															
		545.0 - 550.0 ft						X	X		X	X	X			X			X															
		550.0 - 555.0 ft						X	X		X	X	X			X			X															
		555.0 - 560.0 ft						X	X		X	X	X			X			X															

Table 12.5–VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low–Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging
		560.0 – 565.0 ft						X	X		X	X	X
		565.0 – 570.0 ft						X	X		X	X	X
		570.0 – 575.0 ft						X	X		X	X	X
		575.0 – 580.0 ft						X	X		X	X	X
		580.0 – 585.0 ft						X	X		X	X	X
		585.0 – 590.0 ft						X	X		X	X	X
		590.0 – 595.0 ft						X	X		X	X	X
		595.0 – 600.0 ft						X	X		X	X	X
		600.0 – 605.0 ft						X	X		X	X	X
		605.0 – 610.0 ft						X	X		X	X	X
		610.0 – 615.0 ft						X	X		X	X	X
		615.0 – 620.0 ft						X	X		X	X	X
		620.0 – 625.0 ft						X	X		X	X	X
		625.0 – 630.0 ft						X	X		X	X	X
		630.0 – 635.0 ft						X	X		X	X	X
		635.0 – 640.0 ft						X	X		X	X	X
		[illegible]						X	X		X	X	X
		645.0 – 650.0 ft						X	X		X	X	X
		650.0 – 655.0 ft						X	X		X	X	X
		655.0 – 660.0 ft						X	X		X	X	X
		660.0 – 665.0 ft						X	X		X	X	X
		665.0 – 670.0 ft						X	X		X	X	X
		670.0 – 675.0 ft						X	X		X	X	X
		675.0 – 680.0 ft						X	X		X	X	X
		680.0 – 685.0 ft						X	X		X	X	X
		685.0 – 690.0 ft						X	X		X	X	X

Interval	Field Laboratory Measurements: Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
560.0 – 565.0 ft			X			X															
565.0 – 570.0 ft			X			X															
570.0 – 575.0 ft			X			X															
575.0 – 580.0 ft			X			X															
580.0 – 585.0 ft			X			X															
585.0 – 590.0 ft			X			X															
590.0 – 595.0 ft			X			X															
595.0 – 600.0 ft			X			X															
600.0 – 605.0 ft			X			X															
605.0 – 610.0 ft			X			X															
610.0 – 615.0 ft			X			X															
615.0 – 620.0 ft			X			X															
620.0 – 625.0 ft			X			X															
625.0 – 630.0 ft			X			X															
630.0 – 635.0 ft			X			X															
635.0 – 640.0 ft			X			X															
[illegible]			X			X															
645.0 – 650.0 ft			X			X															
650.0 – 655.0 ft			X			X															
655.0 – 660.0 ft			X			X															
660.0 – 665.0 ft			X			X															
665.0 – 670.0 ft			X			X															
670.0 – 675.0 ft			X			X															
675.0 – 680.0 ft			X			X															
680.0 – 685.0 ft			X			X															
685.0 – 690.0 ft			X			X															

Table 12.5-VII

SUBSEQUENT INVESTIGATIONS, EXTENTION OF MESA TOP CHARACTERIZATION BOREHOLES

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		690.0 - 695.0 ft						X	X		X	X	X			X			X															
		695.0 - 700.0 ft						X	X		X	X	X			X			X															
		700.0 - 705.0 ft						X	X		X	X	X			X			X															
		705.0 - 710.0 ft						X	X		X	X	X			X			X															
		710.0 - 715.0 ft						X	X		X	X	X			X			X															
		715.0 - 720.0 ft						X	X		X	X	X			X			X															
		720.0 - 725.0 ft						X	X		X	X	X			X			X															
		725.0 - 730.0 ft						X	X		X	X	X			X			X															
		730.0 - 735.0 ft						X	X		X	X	X			X			X															
		735.0 - 740.0 ft						X	X		X	X	X			X			X															
		740.0 - 745.0 ft						X	X		X	X	X			X			X															
		745.0 - 750.0 ft						X	X		X	X	X			X			X															

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
Vertical Borehole	LADP-1																		
Continuous Downhole																			
		300.0 - 305.0 ft		X	X	X	X												
		305.0 - 310.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		310.0 - 315.0 ft		X	X	X	X												
		315.0 - 320.0 ft		X	X	X	X												
		320.0 - 325.0 ft		X	X	X	X												
		325.0 - 330.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		330.0 - 335.0 ft		X	X	X	X												
		335.0 - 340.0 ft		X	X	X	X												
		340.0 - 345.0 ft		X	X	X	X												
		345.0 - 350.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		350.0 - 355.0 ft		X	X	X	X												
		355.0 - 360.0 ft		X	X	X	X												
		360.0 - 365.0 ft		X	X	X	X												
		365.0 - 370.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		370.0 - 375.0 ft		X	X	X	X												
		375.0 - 380.0 ft		X	X	X	X												
		380.0 - 385.0 ft		X	X	X	X												
		385.0 - 390.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		390.0 - 395.0 ft		X	X	X	X												
		395.0 - 400.0 ft		X	X	X	X												
		400.0 - 405.0 ft		X	X	X	X												
		405.0 - 410.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		410.0 - 415.0 ft		X	X	X	X												
		415.0 - 420.0 ft		X	X	X	X												
		420.0 - 425.0 ft		X	X	X	X												
		425.0 - 430.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		430.0 - 435.0 ft		X	X	X	X												
		435.0 - 440.0 ft		X	X	X	X												
		440.0 - 445.0 ft		X	X	X	X												
		445.0 - 450.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		450.0 - 455.0 ft		X	X	X	X												
		455.0 - 460.0 ft		X	X	X	X												
		460.0 - 465.0 ft		X	X	X	X												
		465.0 - 470.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		470.0 - 475.0 ft		X	X	X	X												
		475.0 - 480.0 ft		X	X	X	X												
		480.0 - 485.0 ft		X	X	X	X												
		485.0 - 490.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Environmental Isotopes; Open Hole Tests: Straddle Packer Tests

Sample Type	Interval	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
Vertical Borehole																
Continuous Downhole																
	300.0 - 305.0 ft															
	305.0 - 310.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	310.0 - 315.0 ft															
	315.0 - 320.0 ft															
	320.0 - 325.0 ft															
	325.0 - 330.0 ft															
	330.0 - 335.0 ft															
	335.0 - 340.0 ft															
	340.0 - 345.0 ft															
	345.0 - 350.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	350.0 - 355.0 ft															
	355.0 - 360.0 ft															
	360.0 - 365.0 ft															
	365.0 - 370.0 ft															
	370.0 - 375.0 ft															
	375.0 - 380.0 ft															
	380.0 - 385.0 ft															
	385.0 - 390.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	390.0 - 395.0 ft															
	395.0 - 400.0 ft															
	400.0 - 405.0 ft															
	405.0 - 410.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	410.0 - 415.0 ft															
	415.0 - 420.0 ft															
	420.0 - 425.0 ft															
	425.0 - 430.0 ft															
	430.0 - 435.0 ft															
	435.0 - 440.0 ft															
	440.0 - 445.0 ft															
	445.0 - 450.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	450.0 - 455.0 ft															
	455.0 - 460.0 ft															
	460.0 - 465.0 ft															
	465.0 - 470.0 ft															
	470.0 - 475.0 ft															
	475.0 - 480.0 ft															
	480.0 - 485.0 ft															
	485.0 - 490.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Open Hole Tests: Geophysics

Sample Type	Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
Vertical Borehole												
Continuous Downhole		X	X	X	X	X	X	X	X	X	X	X
	300.0 - 305.0 ft											
	305.0 - 310.0 ft											
	310.0 - 315.0 ft											
	315.0 - 320.0 ft											
	320.0 - 325.0 ft											
	325.0 - 330.0 ft											
	330.0 - 335.0 ft											
	335.0 - 340.0 ft											
	340.0 - 345.0 ft											
	345.0 - 350.0 ft											
	350.0 - 355.0 ft											
	355.0 - 360.0 ft											
	360.0 - 365.0 ft											
	365.0 - 370.0 ft											
	370.0 - 375.0 ft											
	375.0 - 380.0 ft											
	380.0 - 385.0 ft											
	385.0 - 390.0 ft											
	390.0 - 395.0 ft											
	395.0 - 400.0 ft											
	400.0 - 405.0 ft											
	405.0 - 410.0 ft											
	410.0 - 415.0 ft											
	415.0 - 420.0 ft											
	420.0 - 425.0 ft											
	425.0 - 430.0 ft											
	430.0 - 435.0 ft											
	435.0 - 440.0 ft											
	440.0 - 445.0 ft											
	445.0 - 450.0 ft											
	450.0 - 455.0 ft											
	455.0 - 460.0 ft											
	460.0 - 465.0 ft											
	465.0 - 470.0 ft											
	470.0 - 475.0 ft											
	475.0 - 480.0 ft											
	480.0 - 485.0 ft											
	485.0 - 490.0 ft											

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

Hydrogeological and Geochemical

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		490.0 - 495.0 ft		X	X	X	X												
		495.0 - 500.0 ft		X	X	X	X												
		500.0 - 505.0 ft		X	X	X	X												
		505.0 - 510.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		510.0 - 515.0 ft		X	X	X	X												
		515.0 - 520.0 ft		X	X	X	X												
		520.0 - 525.0 ft		X	X	X	X												
		525.0 - 530.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		530.0 - 535.0 ft		X	X	X	X												
		535.0 - 540.0 ft		X	X	X	X												
		540.0 - 545.0 ft		X	X	X	X												
		545.0 - 550.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		550.0 - 555.0 ft		X	X	X	X												
		555.0 - 560.0 ft		X	X	X	X												
		560.0 - 565.0 ft		X	X	X	X												
		565.0 - 570.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		570.0 - 575.0 ft		X	X	X	X												
		575.0 - 580.0 ft		X	X	X	X												
		580.0 - 585.0 ft		X	X	X	X												
		585.0 - 590.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		590.0 - 595.0 ft		X	X	X	X												
		595.0 - 600.0 ft		X	X	X	X												
		600.0 - 605.0 ft		X	X	X	X												
		605.0 - 610.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		610.0 - 615.0 ft		X	X	X	X												
		615.0 - 620.0 ft		X	X	X	X												
		620.0 - 625.0 ft		X	X	X	X												
		625.0 - 630.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		630.0 - 635.0 ft		X	X	X	X												
		635.0 - 640.0 ft		X	X	X	X												
		[illegible]0.0 - 64[illegible]		X	X	X	X												
		[illegible]45.0 - [illegible]		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		[illegible]		X	X	X	X												
		655.0 - 660.0 ft		X	X	X	X												
		660.0 - 665.0 ft		X	X	X	X												
		665.0 - 670.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Environmental Isotopes

Interval	Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36
490.0 - 495.0 ft								
495.0 - 500.0 ft								
500.0 - 505.0 ft								
505.0 - 510.0 ft								
510.0 - 515.0 ft								
515.0 - 520.0 ft								
520.0 - 525.0 ft								
525.0 - 530.0 ft	X	X	X	X	X	X	X	X
530.0 - 535.0 ft								
535.0 - 540.0 ft								
540.0 - 545.0 ft								
545.0 - 550.0 ft								
550.0 - 555.0 ft								
555.0 - 560.0 ft								
560.0 - 565.0 ft								
565.0 - 570.0 ft	X	X	X	X	X	X	X	X
570.0 - 575.0 ft								
575.0 - 580.0 ft								
580.0 - 585.0 ft								
585.0 - 590.0 ft								
590.0 - 595.0 ft								
595.0 - 600.0 ft								
600.0 - 605.0 ft								
605.0 - 610.0 ft	X	X	X	X	X	X	X	X
610.0 - 615.0 ft								
615.0 - 620.0 ft								
620.0 - 625.0 ft								
625.0 - 630.0 ft								
630.0 - 635.0 ft								
635.0 - 640.0 ft								
[illegible]0.0 - 64[illegible]								
[illegible]45.0 - [illegible]	X	X	X	X	X	X	X	X
[illegible]								
655.0 - 660.0 ft								
660.0 - 665.0 ft								
665.0 - 670.0 ft								

Open Hole Tests: Straddle Packer Tests

Interval	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
490.0 - 495.0 ft							
495.0 - 500.0 ft							
500.0 - 505.0 ft							
505.0 - 510.0 ft							
510.0 - 515.0 ft							
515.0 - 520.0 ft							
520.0 - 525.0 ft							
525.0 - 530.0 ft	X	X	X	X	X	X	X
530.0 - 535.0 ft							
535.0 - 540.0 ft							
540.0 - 545.0 ft							
545.0 - 550.0 ft							
550.0 - 555.0 ft							
555.0 - 560.0 ft							
560.0 - 565.0 ft							
565.0 - 570.0 ft	X	X	X	X	X	X	X
570.0 - 575.0 ft							
575.0 - 580.0 ft							
580.0 - 585.0 ft							
585.0 - 590.0 ft							
590.0 - 595.0 ft							
595.0 - 600.0 ft							
600.0 - 605.0 ft							
605.0 - 610.0 ft	X	X	X	X	X	X	X
610.0 - 615.0 ft							
615.0 - 620.0 ft							
620.0 - 625.0 ft							
625.0 - 630.0 ft							
630.0 - 635.0 ft							
635.0 - 640.0 ft							
[illegible]0.0 - 64[illegible]							
[illegible]45.0 - [illegible]	X	X	X	X	X	X	X
[illegible]							
655.0 - 660.0 ft							
660.0 - 665.0 ft							
665.0 - 670.0 ft							

Open Hole Tests: Geophysics

Interval	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
490.0 - 495.0 ft											
495.0 - 500.0 ft											
500.0 - 505.0 ft											
505.0 - 510.0 ft											
510.0 - 515.0 ft											
515.0 - 520.0 ft											
520.0 - 525.0 ft											
525.0 - 530.0 ft											
530.0 - 535.0 ft											
535.0 - 540.0 ft											
540.0 - 545.0 ft											
545.0 - 550.0 ft											
550.0 - 555.0 ft											
555.0 - 560.0 ft											
560.0 - 565.0 ft											
565.0 - 570.0 ft											
570.0 - 575.0 ft											
575.0 - 580.0 ft											
580.0 - 585.0 ft											
585.0 - 590.0 ft											
590.0 - 595.0 ft											
595.0 - 600.0 ft											
600.0 - 605.0 ft											
605.0 - 610.0 ft											
610.0 - 615.0 ft											
615.0 - 620.0 ft											
620.0 - 625.0 ft											
625.0 - 630.0 ft											
630.0 - 635.0 ft											
635.0 - 640.0 ft											
[illegible]0.0 - 64[illegible]											
[illegible]45.0 - [illegible]											
[illegible]											
655.0 - 660.0 ft											
660.0 - 665.0 ft											
665.0 - 670.0 ft											

Table 12.5–VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS
FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical: Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Environmental Isotopes: Chloride–35/Chloride–37	Carbon–12/Carbon–13	Strontium–86/Strontium–87	Hydrogen/Deuterium	Oxygen–16/Oxygen–18	Tritium	Carbon–14	Chloride–36	Open Hole Tests: Straddle Packer Tests: In Situ Permeability	VOA's – Pore Gas	CO2 – Pore Gas	CH4 – Pore Gas	C–12/C–13 – Pore Gas	Relative Humidity – Pore Gas	SF6	Open Hole Tests: Geophysics: Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM–39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium–252)	Side Scan Video
		670.0 – 675.0 ft		X	X	X	X																																						
		675.0 – 680.0 ft		X	X	X	X																																						
		680.0 – 685.0 ft		X	X	X	X																																						
		685.0 – 690.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		690.0 – 695.0 ft		X	X	X	X																																						
		695.0 – 700.0 ft		X	X	X	X																																						
		700.0 – 705.0 ft		X	X	X	X																																						
		705.0 – 710.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		710.0 – 715.0 ft		X	X	X	X																																						
		715.0 – 720.0 ft		X	X	X	X																																						
		720.0 – 725.0 ft		X	X	X	X																																						
		725.0 – 730.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		730.0 – 735.0 ft		X	X	X	X																																						
		735.0 – 740.0 ft		X	X	X	X																																						
		740.0 – 745.0 ft		X	X	X	X																																						
		745.0 – 750.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
Vertical Borehole	LADP–2																																												
Continuous Downhole																																			X	X	X	X	X	X	X	X	X	X	X
		300.0 – 305.0 ft		X	X	X	X																																						
		305.0 – 310.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		310.0 – 315.0 ft		X	X	X	X																																						
		315.0 – 320.0 ft		X	X	X	X																																						
		320.0 – 325.0 ft		X	X	X	X																																						
		325.0 – 330.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		330.0 – 335.0 ft		X	X	X	X																																						
		335.0 – 340.0 ft		X	X	X	X																																						
		340.0 – 345.0 ft		X	X	X	X																																						
		345.0 – 350.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		350.0 – 355.0 ft		X	X	X	X																																						
		355.0 – 360.0 ft		X	X	X	X																																						

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS

FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Hydrogeological and Geochemical: Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		360.0 - 365.0 ft		X	X	X	X												
		365.0 - 370.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		370.0 - 375.0 ft		X	X	X	X												
		375.0 - 380.0 ft		X	X	X	X												
		380.0 - 385.0 ft		X	X	X	X												
		385.0 - 390.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		390.0 - 395.0 ft		X	X	X	X												
		395.0 - 400.0 ft		X	X	X	X												
		400.0 - 405.0 ft		X	X	X	X												
		405.0 - 410.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		410.0 - 415.0 ft		X	X	X	X												
		415.0 - 420.0 ft		X	X	X	X												
		420.0 - 425.0 ft		X	X	X	X												
		425.0 - 430.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		430.0 - 435.0 ft		X	X	X	X												
		435.0 - 440.0 ft		X	X	X	X												
		440.0 - 445.0 ft		X	X	X	X												
		445.0 - 450.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		450.0 - 455.0 ft		X	X	X	X												
		455.0 - 460.0 ft		X	X	X	X												
		460.0 - 465.0 ft		X	X	X	X												
		465.0 - 470.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		470.0 - 475.0 ft		X	X	X	X												
		475.0 - 480.0 ft		X	X	X	X												
		480.0 - 485.0 ft		X	X	X	X												
		485.0 - 490.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		490.0 - 495.0 ft		X	X	X	X												
		495.0 - 500.0 ft		X	X	X	X												
		500.0 - 505.0 ft		X	X	X	X												
		505.0 - 510.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		510.0 - 515.0 ft		X	X	X	X												
		515.0 - 520.0 ft		X	X	X	X												
		520.0 - 525.0 ft		X	X	X	X												
		525.0 - 530.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		530.0 - 535.0 ft		X	X	X	X												

Interval	Environmental Isotopes: Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	Open Hole Tests: Straddle Packer Tests: In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
360.0 - 365.0 ft															
365.0 - 370.0 ft															
370.0 - 375.0 ft															
375.0 - 380.0 ft															
380.0 - 385.0 ft															
385.0 - 390.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
390.0 - 395.0 ft															
395.0 - 400.0 ft															
400.0 - 405.0 ft															
405.0 - 410.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
410.0 - 415.0 ft															
415.0 - 420.0 ft															
420.0 - 425.0 ft															
425.0 - 430.0 ft															
430.0 - 435.0 ft															
435.0 - 440.0 ft															
440.0 - 445.0 ft															
445.0 - 450.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
450.0 - 455.0 ft															
455.0 - 460.0 ft															
460.0 - 465.0 ft															
465.0 - 470.0 ft															
470.0 - 475.0 ft															
475.0 - 480.0 ft															
480.0 - 485.0 ft															
485.0 - 490.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
490.0 - 495.0 ft															
495.0 - 500.0 ft															
500.0 - 505.0 ft															
505.0 - 510.0 ft															
510.0 - 515.0 ft															
515.0 - 520.0 ft															
520.0 - 525.0 ft															
525.0 - 530.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
530.0 - 535.0 ft															

Interval	Open Hole Tests: Geophysics: Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
360.0 - 365.0 ft											
365.0 - 370.0 ft											
370.0 - 375.0 ft											
375.0 - 380.0 ft											
380.0 - 385.0 ft											
385.0 - 390.0 ft											
390.0 - 395.0 ft											
395.0 - 400.0 ft											
400.0 - 405.0 ft											
405.0 - 410.0 ft											
410.0 - 415.0 ft											
415.0 - 420.0 ft											
420.0 - 425.0 ft											
425.0 - 430.0 ft											
430.0 - 435.0 ft											
435.0 - 440.0 ft											
440.0 - 445.0 ft											
445.0 - 450.0 ft											
450.0 - 455.0 ft											
455.0 - 460.0 ft											
460.0 - 465.0 ft											
465.0 - 470.0 ft											
470.0 - 475.0 ft											
475.0 - 480.0 ft											
480.0 - 485.0 ft											
485.0 - 490.0 ft											
490.0 - 495.0 ft											
495.0 - 500.0 ft											
500.0 - 505.0 ft											
505.0 - 510.0 ft											
510.0 - 515.0 ft											
515.0 - 520.0 ft											
520.0 - 525.0 ft											
525.0 - 530.0 ft											
530.0 - 535.0 ft											

Table 12.5–VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical															
				Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Sorption Rd
		535.0 – 540.0 ft		X	X	X	X												
		540.0 – 545.0 ft		X	X	X	X												
		545.0 – 550.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		550.0 – 555.0 ft		X	X	X	X												
		555.0 – 560.0 ft		X	X	X	X												
		560.0 – 565.0 ft		X	X	X	X												
		565.0 – 570.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		570.0 – 575.0 ft		X	X	X	X												
		575.0 – 580.0 ft		X	X	X	X												
		580.0 – 585.0 ft		X	X	X	X												
		585.0 – 590.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		590.0 – 595.0 ft		X	X	X	X												
		595.0 – 600.0 ft		X	X	X	X												
		600.0 – 605.0 ft		X	X	X	X												
		605.0 – 610.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		610.0 – 615.0 ft		X	X	X	X												
		615.0 – 620.0 ft		X	X	X	X												
		620.0 – 625.0 ft		X	X	X	X												
		625.0 – 630.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		630.0 – 635.0 ft		X	X	X	X												
		635.0 – 640.0 ft		X	X	X	X												
		640.0 – 645.0 ft		X	X	X	X												
		645.0 – 650.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		650.0 – 655.0 ft		X	X	X	X												
		655.0 – 660.0 ft		X	X	X	X												
		660.0 – 665.0 ft		X	X	X	X												
		665.0 – 670.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		670.0 – 675.0 ft		X	X	X	X												
		675.0 – 680.0 ft		X	X	X	X												
		680.0 – 685.0 ft		X	X	X	X												
		685.0 – 690.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		690.0 – 695.0 ft		X	X	X	X												
		695.0 – 700.0 ft		X	X	X	X												
		700.0 – 705.0 ft		X	X	X	X												
		705.0 – 710.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Interval	Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's – Pore Gas	CO2 – Pore Gas	CH4 – Pore Gas	C-12/C-13 – Pore Gas	Relative Humidity – Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
535.0 – 540.0 ft																										
540.0 – 545.0 ft																										
545.0 – 550.0 ft																										
550.0 – 555.0 ft																										
555.0 – 560.0 ft																										
560.0 – 565.0 ft																										
565.0 – 570.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
570.0 – 575.0 ft																										
575.0 – 580.0 ft																										
580.0 – 585.0 ft																										
585.0 – 590.0 ft																										
590.0 – 595.0 ft																										
595.0 – 600.0 ft																										
600.0 – 605.0 ft																										
605.0 – 610.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
610.0 – 615.0 ft																										
615.0 – 620.0 ft																										
620.0 – 625.0 ft																										
625.0 – 630.0 ft																										
630.0 – 635.0 ft																										
635.0 – 640.0 ft																										
640.0 – 645.0 ft																										
645.0 – 650.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
650.0 – 655.0 ft																										
655.0 – 660.0 ft																										
660.0 – 665.0 ft																										
665.0 – 670.0 ft																										
670.0 – 675.0 ft																										
675.0 – 680.0 ft																										
680.0 – 685.0 ft																										
685.0 – 690.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
690.0 – 695.0 ft																										
695.0 – 700.0 ft																										
700.0 – 705.0 ft																										
705.0 – 710.0 ft																										

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		710.0 - 715.0 ft		X	X	X	X																																						
		715.0 - 720.0 ft		X	X	X	X																																						
		720.0 - 725.0 ft		X	X	X	X																																						
		725.0 - 730.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		730.0 - 735.0 ft		X	X	X	X																																						
		735.0 - 740.0 ft		X	X	X	X																																						
		740.0 - 745.0 ft		X	X	X	X																																						
		745.0 - 750.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
Fracture Contingency	Sample			C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
				C								C	C	C	C	C	C	C	C																										
Vertical Borehole	LADP-5																																		X	X	X	X	X	X	X	X	X	X	X
Continuous Downhole																																													
		300.0 - 305.0 ft		X	X	X	X																																						
		305.0 - 310.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		310.0 - 315.0 ft		X	X	X	X																																						
		315.0 - 320.0 ft		X	X	X	X																																						
		320.0 - 325.0 ft		X	X	X	X																																						
		325.0 - 330.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		330.0 - 335.0 ft		X	X	X	X																																						
		335.0 - 340.0 ft		X	X	X	X																																						
		340.0 - 345.0 ft		X	X	X	X																																						
		345.0 - 350.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		350.0 - 355.0 ft		X	X	X	X																																						
		355.0 - 360.0 ft		X	X	X	X																																						
		360.0 - 365.0 ft		X	X	X	X																																						
		365.0 - 370.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		370.0 - 375.0 ft		X	X	X	X																																						
		375.0 - 380.0 ft		X	X	X	X																																						
		380.0 - 385.0 ft		X	X	X	X																																						
		385.0 - 390.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		390.0 - 395.0 ft		X	X	X	X																																						
		395.0 - 400.0 ft		X	X	X	X																																						

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS

FOR MESA TOP CHARACTERIZATION BOREHOLES

Sample Type	Sampling Location	Interval	Sample Identification	Hydrogeological and Geochemical															
				Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph
		400.0 - 405.0 ft		X	X	X	X												
		405.0 - 410.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		410.0 - 415.0 ft		X	X	X	X												
		415.0 - 420.0 ft		X	X	X	X												
		420.0 - 425.0 ft		X	X	X	X												
		425.0 - 430.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		430.0 - 435.0 ft		X	X	X	X												
		435.0 - 440.0 ft		X	X	X	X												
		440.0 - 445.0 ft		X	X	X	X												
		445.0 - 450.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		450.0 - 455.0 ft		X	X	X	X												
		455.0 - 460.0 ft		X	X	X	X												
		460.0 - 465.0 ft		X	X	X	X												
		465.0 - 470.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		470.0 - 475.0 ft		X	X	X	X												
		475.0 - 480.0 ft		X	X	X	X												
		480.0 - 485.0 ft		X	X	X	X												
		485.0 - 490.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		490.0 - 495.0 ft		X	X	X	X												
		495.0 - 500.0 ft		X	X	X	X												
		500.0 - 505.0 ft		X	X	X	X												
		505.0 - 510.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		510.0 - 515.0 ft		X	X	X	X												
		515.0 - 520.0 ft		X	X	X	X												
		520.0 - 525.0 ft		X	X	X	X												
		525.0 - 530.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		530.0 - 535.0 ft		X	X	X	X												
		535.0 - 540.0 ft		X	X	X	X												
		540.0 - 545.0 ft		X	X	X	X												
		545.0 - 550.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		550.0 - 555.0 ft		X	X	X	X												
		555.0 - 560.0 ft		X	X	X	X												
		560.0 - 565.0 ft		X	X	X	X												
		565.0 - 570.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		570.0 - 575.0 ft		X	X	X	X												

Interval	Environmental Isotopes								Open Hole Tests: Straddle Packer Tests						
	Chloride-36/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-18/Oxygen-18	Tritium	Carbon-14	Chloride-38	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6
400.0 - 405.0 ft															
405.0 - 410.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
410.0 - 415.0 ft															
415.0 - 420.0 ft															
420.0 - 425.0 ft															
425.0 - 430.0 ft															
430.0 - 435.0 ft															
435.0 - 440.0 ft															
440.0 - 445.0 ft															
445.0 - 450.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
450.0 - 455.0 ft															
455.0 - 460.0 ft															
460.0 - 465.0 ft															
465.0 - 470.0 ft															
470.0 - 475.0 ft															
475.0 - 480.0 ft															
480.0 - 485.0 ft															
485.0 - 490.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
490.0 - 495.0 ft															
495.0 - 500.0 ft															
500.0 - 505.0 ft															
505.0 - 510.0 ft															
510.0 - 515.0 ft															
515.0 - 520.0 ft															
520.0 - 525.0 ft															
525.0 - 530.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
530.0 - 535.0 ft															
535.0 - 540.0 ft															
540.0 - 545.0 ft															
545.0 - 550.0 ft															
550.0 - 555.0 ft															
555.0 - 560.0 ft															
560.0 - 565.0 ft															
565.0 - 570.0 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
570.0 - 575.0 ft															

Interval	Open Hole Tests: Geophysics										
	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
400.0 - 405.0 ft											
405.0 - 410.0 ft											
410.0 - 415.0 ft											
415.0 - 420.0 ft											
420.0 - 425.0 ft											
425.0 - 430.0 ft											
430.0 - 435.0 ft											
435.0 - 440.0 ft											
440.0 - 445.0 ft											
445.0 - 450.0 ft											
450.0 - 455.0 ft											
455.0 - 460.0 ft											
460.0 - 465.0 ft											
465.0 - 470.0 ft											
470.0 - 475.0 ft											
475.0 - 480.0 ft											
480.0 - 485.0 ft											
485.0 - 490.0 ft											
490.0 - 495.0 ft											
495.0 - 500.0 ft											
500.0 - 505.0 ft											
505.0 - 510.0 ft											
510.0 - 515.0 ft											
515.0 - 520.0 ft											
520.0 - 525.0 ft											
525.0 - 530.0 ft											
530.0 - 535.0 ft											
535.0 - 540.0 ft											
540.0 - 545.0 ft											
545.0 - 550.0 ft											
550.0 - 555.0 ft											
555.0 - 560.0 ft											
560.0 - 565.0 ft											
565.0 - 570.0 ft											
570.0 - 575.0 ft											

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																Environmental Isotopes								Open Hole Tests: Straddle Packer Tests							Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph	Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36	In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6	Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
		675.0 - 580.0 ft		X	X	X	X																																						
		580.0 - 585.0 ft		X	X	X	X																																						
		585.0 - 590.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		590.0 - 595.0 ft		X	X	X	X																																						
		595.0 - 600.0 ft		X	X	X	X																																						
		600.0 - 605.0 ft		X	X	X	X																																						
		605.0 - 610.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		610.0 - 615.0 ft		X	X	X	X																																						
		615.0 - 620.0 ft		X	X	X	X																																						
		620.0 - 625.0 ft		X	X	X	X																																						
		625.0 - 630.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		630.0 - 635.0 ft		X	X	X	X																																						
		635.0 - 640.0 ft		X	X	X	X																																						
		640.0 - 645.0 ft		X	X	X	X																																						
		645.0 - 650.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		650.0 - 655.0 ft		X	X	X	X																																						
		655.0 - 660.0 ft		X	X	X	X																																						
		660.0 - 665.0 ft		X	X	X	X																																						
		665.0 - 670.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		670.0 - 675.0 ft		X	X	X	X																																						
		675.0 - 680.0 ft		X	X	X	X																																						
		680.0 - 685.0 ft		X	X	X	X																																						
		685.0 - 690.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		690.0 - 695.0 ft		X	X	X	X																																						
		695.0 - 700.0 ft		X	X	X	X																																						
		700.0 - 705.0 ft		X	X	X	X																																						
		705.0 - 710.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										
		710.0 - 715.0 ft		X	X	X	X																																						
		715.0 - 720.0 ft		X	X	X	X																																						
		720.0 - 725.0 ft		X	X	X	X																																						
		725.0 - 730.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
		730.0 - 735.0 ft		X	X	X	X																																						
		735.0 - 740.0 ft		X	X	X	X																																						
		740.0 - 745.0 ft		X	X	X	X																																						
		745.0 - 750.0 ft		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																										

Table 12.5-VIII

SUBSEQUENT GEOPHYSICAL INVESTIGATIONS FOR MESA TOP CHARACTERIZATION BOREHOLES

				Hydrogeological and Geochemical																	Environmental Isotopes									Open Hole Tests: Straddle Packer Tests								Open Hole Tests: Geophysics										
Sample Type	Sampling Location	Interval	Sample Identification	Gravimetric Water Content	Bulk Density	Dry Density	Porosity	Porosity (He injection)	Saturated Hydraulic Conductivity	Air Water Relative Permeability	Moisture Characteristic Curve	Clay Mineralogy	Zeolite Mineralogy	Matrix Mineralogy	Carbonate Mineralogy	Fe and Mn Mineralogy	Total Organic Compound	Cation Exchange Capacity	Slurry Ph		Chloride-35/Chloride-37	Carbon-12/Carbon-13	Strontium-86/Strontium-87	Hydrogen/Deuterium	Oxygen-16/Oxygen-18	Tritium	Carbon-14	Chloride-36		In Situ Permeability	VOA's - Pore Gas	CO2 - Pore Gas	CH4 - Pore Gas	C-12/C-13 - Pore Gas	Relative Humidity - Pore Gas	SF6		Thermal Neutron (moisture)	Gamma Gamma (density)	Caliper	Axial Borehole Video	EM Induction (Geonics EM-39)	Magnetic Susceptibility	Natural Gamma	Spectral Gamma (U, Th, K)	Prompt Fission Neutron	Geochemical (Californium-252)	Side Scan Video
Fracture Contingency Sample				C								C	C	C	C	C	C	C	C																													
				C								C	C	C	C	C	C	C	C																													
				C								C	C	C	C	C	C	C	C																													
				C								C	C	C	C	C	C	C	C																													
				C								C	C	C	C	C	C	C	C																													

Table 12.6-I

SPRINGS SAMPLING INITIAL INVESTIGATION

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Surface Water																																		
Seasonal	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
	5																						X	X	X		X	X	X	X			X	X
DP Spring																																		
Monthly	1																						X	X	X		X	X	X	X			X	X
Field Duplicate																							X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	2																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	3																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	4																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	5																						X	X	X		X	X	X	X			X	X

Table 12.6-I

SPRINGS SAMPLING INITIAL INVESTIGATION

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 8010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												[illegible]						
Monthly	6																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	7																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	8																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	9																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	9																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
Monthly	11																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				

Table 12.6-I

SPRINGS SAMPLING INITIAL INVESTIGATION

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging
Trip Blank													
Monthly	12												
Reagent Blank													
Field Blank													
Trip Blank													

Sample Type	Field Laboratory Measurements: Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Trip Blank															X						
Monthly										X	X	X		X	X	X	X			X	X
Reagent Blank															X	X	X				
Field Blank										X					X	X	X				
Trip Blank															X						

Table 12.6–II

PERCHED WATER SAMPLING INITIAL INVESTIGATIONS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
LADP–3																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP–4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X

TABLE 12.6-III

ESTIMATED THICKNESS OF STRATIGRAPHIC UNITS PRESENT AT PERCHED WATER HOLE LOCATIONS

Drill Hole No.[a]	Estimated Surface Elevation (ft)	Total Depth (ft)	Estimated Thickness (ft) of Stratigraphic Units in the Bandelier Formation					Estimated Total Thickness of Bandelier Formation (ft)
			Tshirege Member	Tsankawi Pumice Bed	Cerro Toledo Rhyolite	Otowi Member	Guaje Pumice Bed	
LAUZ-1	7020	200	110-140	0-2	0-30	60	not penetrated	200
LAUZ-2	7030	200	110-140	0-2	0-30	60	not penetrated	200

[a]Drill hole locations are shown in Fig. 12.5-1.

Table 12.6-IV

SUBSURFACE SAMPLING IN DP CANYON, SUBSEQUENT INVESTIGATION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
LAUZ-1																																		
Vertical Borehole	1	0.0 - 5.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		5.0 - 10.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		10.0 - 15.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		15.0 - 20.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		20.0 - 25.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
		25.0 - 30.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		30.0 - 35.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		35.0 - 40.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		40.0 - 45.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		45.0 - 50.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		50.0 - 55.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		55.0 - 60.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
		60.0 - 65.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		65.0 - 70.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		70.0 - 75.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		75.0 - 80.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		80.0 - 85.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		85.0 - 90.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		90.0 - 95.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		95.0 - 100.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Trip Blank																												X						
		100.0 - 105.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				

Table 12.6-IV

SUBSURFACE SAMPLING IN DP CANYON, SUBSEQUENT INVESTIGATION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
		105.0 – 110.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		110.0 – 115.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		115.0 – 120.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
		120.0 – 125.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		125.0 – 130.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		130.0 – 135.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		135.0 – 140.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		140.0 – 145.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		145.0 – 150.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		150.0 – 155.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
		155.0 – 160.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		160.0 – 165.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		165.0 – 170.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		170.0 – 175.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		175.0 – 180.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		180.0 – 185.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		185.0 – 190.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		190.0 – 195.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		195.0 – 200.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
Trip Blank																												X						

Table 12.6-IV

SUBSURFACE SAMPLING IN DP CANYON, SUBSEQUENT INVESTIGATION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
LAUZ-2																																		
Vertical Borehole	2	0.0 - 5.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		5.0 - 10.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		10.0 - 15.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		15.0 - 20.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		20.0 - 25.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
		25.0 - 30.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		30.0 - 35.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		35.0 - 40.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		40.0 - 45.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		45.0 - 50.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		50.0 - 55.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		55.0 - 60.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
		60.0 - 65.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		65.0 - 70.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		70.0 - 75.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		75.0 - 80.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		80.0 - 85.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		85.0 - 90.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		90.0 - 95.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		95.0 - 100.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Trip Blank																												X						
		100.0 - 105.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				

Table 12.6-IV

SUBSURFACE SAMPLING IN DP CANYON, SUBSEQUENT INVESTIGATION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: Isotopic Thorium	Laboratory Analysis: Water Quality Parameters	Laboratory Analysis: Gross Alpha/Beta
		105.0 – 110.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		110.0 – 115.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		115.0 – 120.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
		120.0 – 125.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		125.0 – 130.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		130.0 – 135.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		135.0 – 140.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		140.0 – 145.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		145.0 – 150.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		150.0 – 155.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
		155.0 – 160.0 ft						X	X		X	X	X									X	X	X	X		X	X	X	X				
		160.0 – 165.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		165.0 – 170.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		170.0 – 175.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		175.0 – 180.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		180.0 – 185.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		185.0 – 190.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		190.0 – 195.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
		195.0 – 200.0 ft						X	X		X	X	X						X			X	X	X	X		X	X	X	X				
Field Duplicate																						X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																												X	X	X				
Trip Blank																												X						

Table 12.6–V

PERCHED WATER SAMPLING SUBSEQUENT INVESTIGATIONS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low–Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
LADP–3 Year 2																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP–4 Year 2																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	[illegible]																						X	X	X		X	X	X	X			X	X
LAUZ–1 Year 2																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ–2 Year 2																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP–3 Year 3																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP–4 Year 3																																		

Table 12.6-V

PERCHED WATER SAMPLING SUBSEQUENT INVESTIGATIONS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithologic Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-1 Year 3																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-2 Year 3																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP-3 Year 4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP-4 Year 4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-1 Year 4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X

Table 12.6–V

PERCHED WATER SAMPLING SUBSEQUENT INVESTIGATIONS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-2 Year 4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP-3 Year 5																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LADP-4 Year 5																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-1 Year 5																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X
LAUZ-2 Year 5																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
	2																						X	X	X		X	X	X	X			X	X

Table 12.6-V

PERCHED WATER SAMPLING SUBSEQUENT INVESTIGATIONS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
	3																						X	X	X		X	X	X	X			X	X
	4																						X	X	X		X	X	X	X			X	X

Table 12.6–VI

SPRINGS SAMPLING SUBSEQUENT INVESTIGATIONS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low–Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
DP Spring Year 2																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
Field Duplicate																							X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	2																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	3																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	4																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
DP Spring Year 3																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
Field Duplicate																							X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	2																						X	X	X		X	X	X	X			X	X

Table 12.6-VI

SPRINGS SAMPLING SUBSEQUENT INVESTIGATIONS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	3																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	4																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
DP Spring Year 4																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
Field Duplicate																							X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	2																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	3																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	4																						X	X	X		X	X	X	X			X	X

Table 12.6-VI

SPRINGS SAMPLING SUBSEQUENT INVESTIGATIONS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	Isotopic Thorium	Water Quality Parameters	Gross Alpha/Beta
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
DP Spring Year 5																																		
Quarterly	1																						X	X	X		X	X	X	X			X	X
Field Duplicate																							X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	2																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	3																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						
	4																						X	X	X		X	X	X	X			X	X
Reagent Blank																												X	X	X				
Field Blank																							X					X	X	X				
Trip Blank																												X						

References

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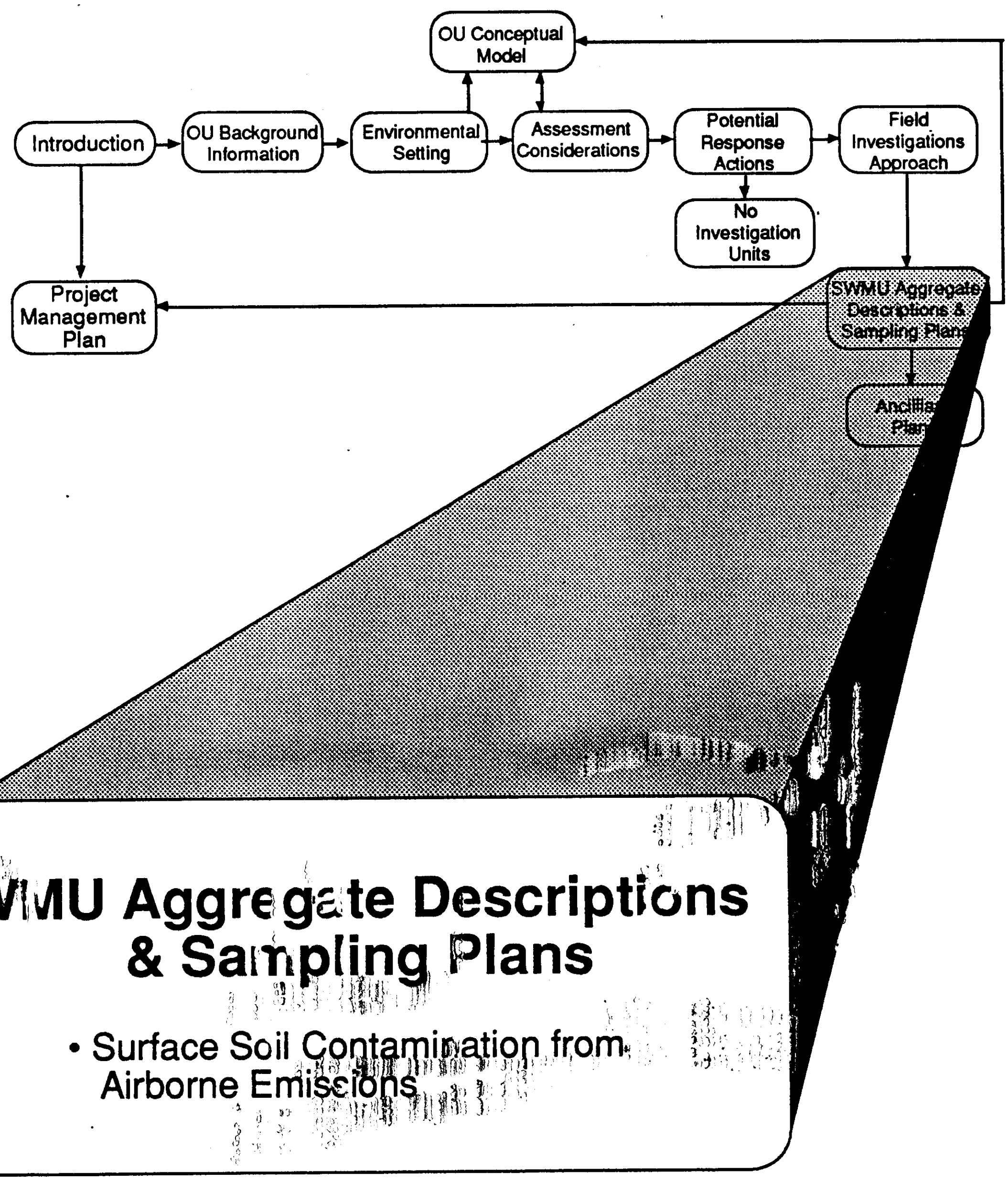
CHAPTER 13


OU Conceptual Model
Introduction
OU Background Information
Environmental Setting
Assessment Considerations
Potential Response Actions
Field Investigations Approach
No Investigation Units
Project Management Plan
SWMU Aggregate Descriptions & Sampling Plans
SWMU Aggregate Descriptions & Sampling Plans
• Surface Soil Contamination from Airborne Emissions

13 SURFACE SOIL CONTAMINATION FROM AIRBORNE EMISSIONS

13.1 Introduction

This chapter addresses general surface contamination of the TA-21 OU because of past airborne contaminant releases. The 18 SWMUs included are described in Sec. 13.2 below.

The surface soils of the OU are potentially contaminated from past airborne emissions from incinerators, stacks, and filter houses within the TA-21 area. The source term from all SWMUs together is addressed because surface contamination cannot be traced back to a specific stack. The objective of the investigation described in this chapter is to confirm the absence of localized areas of contamination resulting from stack emissions. The analysis will focus on radionuclides because historical data show that only radionuclide emissions have occurred.

Potential migration pathways at TA-21 SWMUs are discussed in Chapter 5. Surface soil is the identified contaminated media for all of the SWMUs in this chapter. In addition, subsurface soil is a contaminated medium for SWMUs 21-007, Salamanders, and 21-020(a) and (b), Decommissioned Filter Houses. The identified potential contaminant migration pathways for all of this chapter's SWMUs include atmospheric dispersion and surface run-off. Infiltration is identified as a pathway for the decommissioned filter houses. Exposure routes and potential receptors for each environmental transport pathway are identified in Chapter 6.

The criteria for potential response actions at TA-21 SWMUs are discussed in Chapter 10. Preliminary remedial alternatives that are identified for all this chapter's SWMUs are removal and disposal and removal and treatment. Depending on the results of the field investigation, the no-action alternative is identified as potentially appropriate for SWMU 21-008, Incinerator, and SWMU 21-019, Filter Houses/Exhaust Stacks.

The strategy for field investigations to characterize airborne emissions over the entire OU is presented in Fig. 13.1-1. The investigation will be performed in stages, and the results from the initial investigation will be used to determine requirements for subsequent sampling. In contrast to many sampling plans at TA-21, the subsequent investigation to characterize airborne emissions is a required activity.

The locations where samples from the deposition layer will be collected in the initial investigation are the same locations where surface soil samples will be collected for the OU-wide characterization of

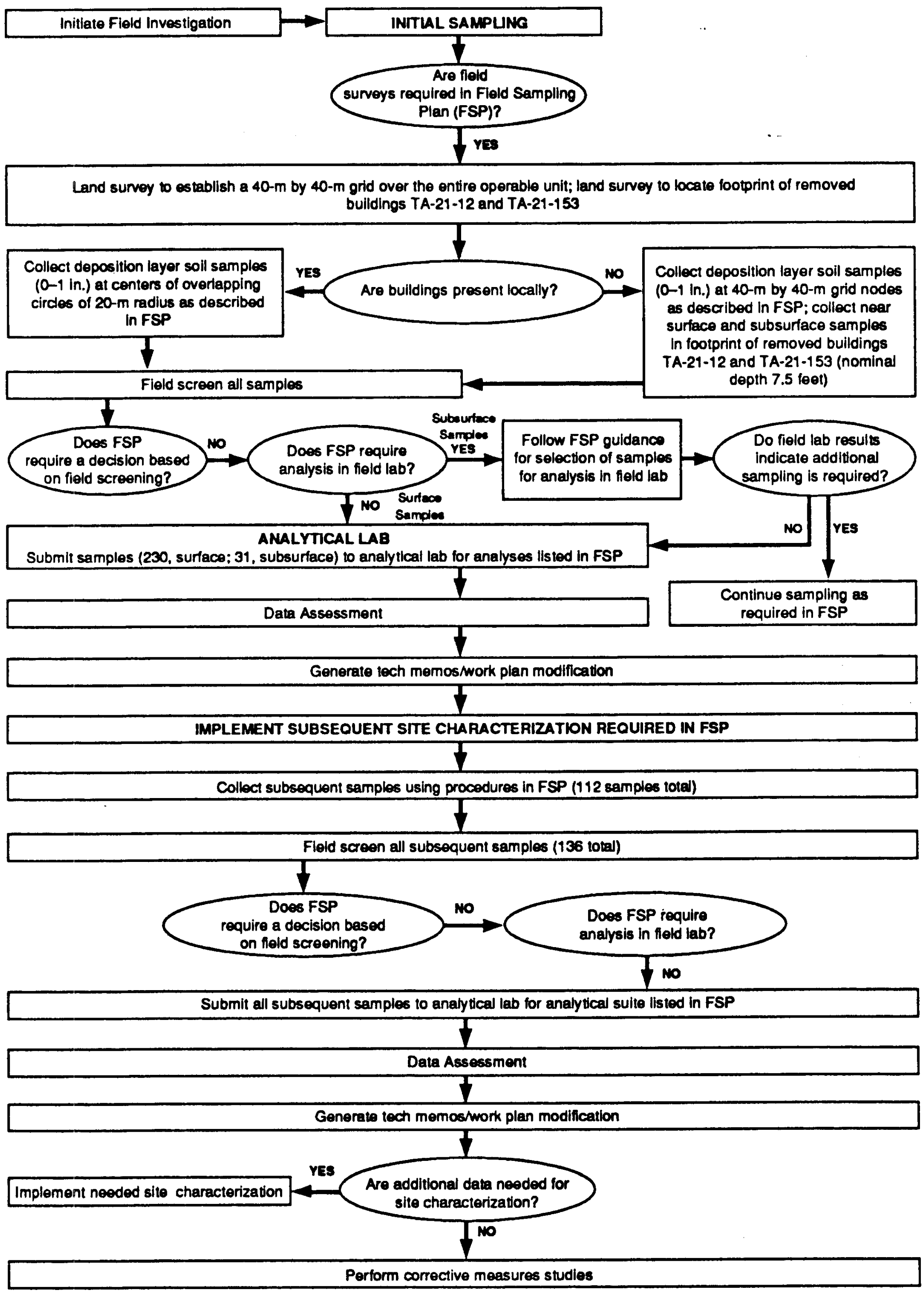


Fig. 13.1-1 Logic flow for field investigations to characterize deposition layer contamination from airborne emissions.

surface soils (see Chapter 12).

The objective of the initial phase of investigation is to locate contaminated areas greater than 3,000 m^2. The initial sampling will also investigate subsurface soil contamination in the "footprint" of the decommissioned filter houses (SWMU 21-020). The subsequent investigation will focus on characterizing the areal extent of contamination found in the initial sampling.

Measurements to be taken during the field investigations and laboratory analyses are summarized in Tables 13.1-I through 13.-IV. Methods for field measurements and laboratory analysis are

13.1–I SUMMARY OF INITIAL INVESTIGATIONS BY SECTION FOR CHAPTER 13.

		Survey Areas			Surface	Near Surface Soil Samples	
Section	Description	Land	Radiological	Geophysical	Soil Samples	No. of Locations	No. of Samples
13-2	Airborne Deposition				230		
13-2	Filter Buildings					26	130
	Total				230	26	130

		Boreholes									
		Shallow			Vertical			Angled			Q A
Section	Description	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	
13-2	Airborne Deposition										37
13-2	Filter Buildings	5	37.5	15							28
	Total	5	37.5	15							65

13.1-II SUMMARY OF SAMPLE AND ANALYSIS FOR INITIAL INVESTIGATIONS BY SECTION FOR CHAPTER 13.

	From Table: 13-2-VI		13-2-VII								Total
Field Sample Screening											
Gross Gamma	230		145								375
Gross Alpha	230		145								375
Organic Vapor	230		145								375
Combustible Gas/Oxygen			10								10
Lithological Logging			10								10
Field Laboratory Measurements											
Gross Alpha			98								98
Gamma Spectrometry			98								98
Tritium			98								98
Volatile Organics			98								98
PCB											
Soil Moisture											
Laboratory Analysis											
Gamma Spectrometry	255		41								296
Tritium	255		41								296
Total Uranium	255		41								296
Isotopic Plutonium	255		41								296
Isotopic Uranium											
Strontium 90	255		41								296
VOA (SW 8240)			41								41
Semivolatiles (SW 8270)			59								59
Metals (SW 6010)	267		49								316
PCB (SW 8080)											
TCLP Metals											

13.1-III SUMMARY OF SUBSEQUENT INVESTIGATIONS BY SECTION FOR CHAPTER 13.

		Survey Areas			Surface	Near Surface Soil Samples	
Section	Description	Land	Radiological	Geophysical	Soil Samples	No. of Locations	No. of Samples
13-2	Airborne Deposition				112		
	Total				112		

		Boreholes									
		Shallow			Vertical			Angled			Q A
Section	Description	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	Number	Total Footage	No. of Samples	
13-2	Airborne Deposition										19
	Total										19

13.1–IV SUMMARY OF SAMPLE AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS BY SECTION FOR CHAPTER 13.

	13–2										Total
Field Sample Screening											
Gross Gamma	112										112
Gross Alpha	112										112
Organic Vapor	112										112
Combustible Gas/Oxygen											
Lithological Logging											
Field Laboratory Measurements											
Gross Alpha											
Gamma Spectrometry											
Tritium											
Volatile Organics											
PCB											
Soil Moisture											
Laboratory Analysis											
Gamma Spectrometry	125										125
Tritium	125										125
Total Uranium	125										125
Isotopic Plutonium	125										125
Isotopic Uranium											
Strontium 90	125										125
VOA (SW 8240)											
Semivolatiles (SW 8270)											
Metals (SW 6010)	131										131
PCB (SW 8080)											
TCLP Metals											
Isotopic Thorium											

described in Chapter 11.

13.2 Airborne Emissions

13.2.1 Site Description

The SWMUs in this chapter address potential surface soil contamination from past airborne emissions from incinerators, stacks, and filter houses within the TA-21 area and near-surface contamination at the former location of Filter Buildings 12 and 153 (SWMU 21-020). Table 13.2-I gives a description of each of the stacks that may have contributed to surface contamination at the TA-21 OU. SWMUs 21-007, -008, -019 (a)–(m), -020(a), (b), and -021 are addressed herein as a single potential release site addressing surface contamination for the entire TA-21 OU. Where known, stack, filter house, and incinerator locations are shown in Fig. 13.2-1. SWMU 21-021 is not shown because documentation on specific stacks is lacking. Stack locations are shown because they may help determine most likely areas of surface contamination at the TA-21 OU.

13.2.1.1 Site History

Detailed history of stack, filter house, incinerator locations, and the materials they burned are presented in Nyhan (1990). Because this chapter addresses surface and near-surface soil contamination at the TA-21 OU, specific stack information is not summarized herein.

13.2.1.2 Existing Information

SWMU 21-007, Salamanders

Studies on use of salamanders and components of their emissions (Christenson et al. no date) found that no contamination of the ground surrounding the burner occurred. Soot in the stack and burner ash contained $^{239/240}$Pu. The ash was sent to radioactive waste burial pits, assumed to be MDA G. The objective of using salamanders at MDA T was to incinerate "waste oils and organics in salamander heaters to reduce their volumes and to convert them to a form which would mix with cement" (Christenson 1975).

The HSE-7 records on the amounts of oils burned in the salamanders and radionuclide assays on the ashes are detailed in Nyhan 1990, Table XIII. Approximately 1102.25 gal. of TCP and 156 gal. of TBP oils were burned in the salamanders between 1964 and 1967 and between 1970 through 1972. Based on Group HSE-7 records, the $^{239/240}$Pu releases for the years 1970, 1971,

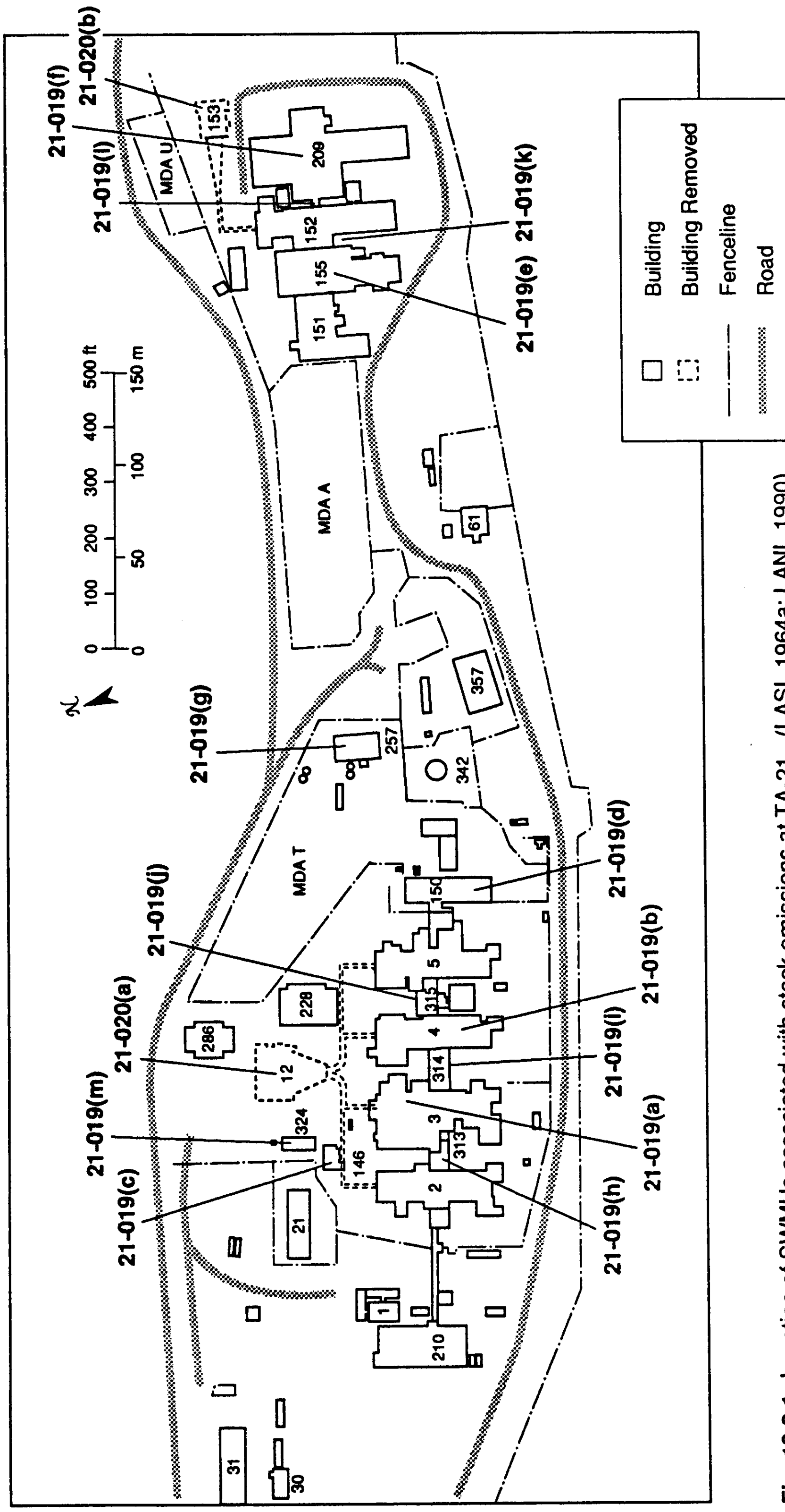


Fig. 13.2-1 Location of SWMUs associated with stack emissions at TA-21. (LASL 1964a; LANL 1990)

TABLE 13.2-I DESCRIPTION OF INCINERATORS, STACKS AND FILTER HOUSES AT TA-21.

SWMU	Short Description	Period of Use[a]	Available information on emissions that may be present in surface soil contamination.
21-007	Salamander incinerators at TA-21 used to burn oils and fats; three located within MDA T, other locations unknown	1964-1972	Material incinerated was tricresylphospate phosphate (TCP) contaminated with ^{239}Pu (approximately 10^3 dpm/m) and diluted with one-half part kerosene
21-008	Scrap incinerator in TA-21-2 Rag incinerator in TA-21-3, Room 313, hood 2	1945?-1962 1945?-1970?	plutonium waste rags for recovery of ^{235}U oxide
21-019(a)	Exhaust stack at TA-21-3	1945?-Present	^{235}U, ^{238}U
21-019(b)	Exhaust stack at TA-21-4	1945?-Present	^{239}Pu
21-019(c)	Filter house TA-21-146 immediately north of TA-21-3	1960-Present	Unknown
21-019(d)	Exhaust stack at TA-21-150	1962-Present	^{239}Pu
21-019(e)	Exhaust stack at TA-21-155 (TSTA: formerly Building 55)	1949?-Present	Tritium
21-019(f)	Exhaust stack at TA-21-209	1965-Present	Tritium (gas)
21-019(g)	Exhaust stack at TA-21-257	1967-Present	^{239}Pu
21-019(h)	Exhaust stack at TA-21-313	1945-Present	^{239}Pu, ^{38}D
21-019(i)	Exhaust stack at TA-21-314	1945-Present	^{239}Pu
21-019(j)	Exhaust stack at TA-21-315	1945-Present	Pu

SWMU	Short Description	Period of Use	Available information on emissions that may be present in surface soil contamination.
21-019(k)	Exhaust stack at TA-21-322	1971-Present?	radionuclides
21-019(l)	Exhaust stack at TA-21-323	1971-Present?	radionuclides
21-019(m)	Filter house TA-21-324	1974-Present	^{239}Pu, ^{235}Pu, ^{238}Pu
21-020(a)	Filter house TA-21-12 for DP west rooms and processes; was immediately north of TA-21-4	1945-1972	radionuclides; 239/240Pu present at 30-cm depth when buidling was decommissioned in 1973
TA-020(b)	Filter house TA-21-153 for DP east operations; was immediately south of MDA U	1945-1970	radionuclides, ^{227}Ac present in building when it was decommissioned
21-021	Stack emissions throughout TA-21 to the airport (300,000 m^2 area)	1945?-Present	

[a]Although some stacks are still active, only the potential surface soil contamination resulting from past stack emissions is of concern herein. Present stack emissions are monitored as part of the Laboratory's routine environmental surveillance program.

and 1972 are estimated to be 0.5, 29.4 and 0.8 dpm/m^3 (Valentine 1990). This corresponds to a total release for these three years of 30.7 dpm/m^3, or 6.51 µCi of $^{239/240}$Pu (Valentine 1990).

SWMU 21-008, Incinerator

No data exist regarding contamination in the area of either the scrap incinerator previously located in TA-21-2 or the rag incinerator located in TA-21-3, Room 313.

SWMU 21-019, Filter Houses/Exhaust Stacks

Detailed information on each stack and radionuclide emissions from 1951 through 1989 are presented in Nyhan 1990, and summarized here in Tables 13.2-II and 13.2-III. The amount of radionuclides emitted with time fluctuated greatly. However, in 1988 and 1989, volumes and radionuclide concentrations were less than in previous years. Also, after Building 12 ceased operation in 1973, the total quantity of radionuclides discharged decreased dramatically.

The only available nonradionuclide emission quantity data are from a toxic air pollutant emissions survey conducted in 1987 and 1988 for each TA-21 building (see Nyhan 1990, Fig. 21-58). The survey found no values above limits in the Air Quality Control Regulation 752—Registration of Existing Toxic Air Pollution Sources. However, because this regulation does not address "typical" air pollutants, such as sulfur dioxide and lead, the survey did not analyze for these pollutants. Although these air pollutants may be present at TA-21, radionuclide emissions predominate.

SWMU 21-020, Decommissioned Filter Houses

SWMU 21-020(a): TA-21-12

Stack emission data for TA-21-12 are detailed in Nyhan 1990, Tables XIV and XV. These data show that TA-21-12 made a significant contribution to stack emissions of plutonium at TA-21. For example, for the years 1951, 1952, and 1953, Building 12 accounted for 32, 38, and 24% of the annual stack emissions for all of DP West of 2.04, 2.85, and 2.14 Ci of $^{239/240}$Pu, respectively (Nyhan 1990, Table XV). Although Building 12 continued in service until February 1973, the 1973 Laboratory records (Valentine 1974) show that its four stacks emitted a total of 1370.50 µCi $^{239/240}$Pu for that year (Nyhan 1990, Table XIV) — considerably less than in the 1940s and 1950s. In comparison, all of the other stacks at TA-21 emitted only 6.41 Ci $^{239/240}$Pu in 1973.

Upon the decommissioning of this building in 1973, the 8-in. concrete floor was removed, and the underlying soil was removed to an approximate depth of 30 cm. Core samples were taken and analyzed; the readings indicated 1.3 to 70 pCi/g of $^{239/240}$Pu. The area was backfilled with soil,

TABLE 13.2-II
TA-21 RADIOACTIVE AIRBORNE EFFLUENT RELEASE SUMMARIES, 1951–1971[a]

Year	Total Alpha Activity Discharged d/m/year X 10E10	Total for July d/m/8 hr X 10E10	
1951	452 (8/8)[b]		
1952	632 (8/8)		
1953	474 (8/16)	0.4 (8/16)	
1954	68 (4/4)		
	Total Pu Discharged d/m/M^3	**Total Fission Products Discharged d/m/M^3**	**Total ^{235}U Discharged d/m/M^3**
1963	938 (7/11)	22 (1/11)	790 (3/11)
1964	7084 (7/11)	435 (1/11)	6631 (3/11)
1965	2791 (7/11)	56 (1/11)	34526 (3/11)
1966	3425 (7/11)	5 (1/11)	27217 (3/11)
1967	4036 (6/11)	8 (1/11)	12013 (3/11)
1968	900 (6/11)		1142 (3/11)
1969	7768 (6/11)		
1970	210124 (13/15)	488473 (13/15)	385 (13/15)
	Total uCi Discharged		
1971	2486 (8/8)		

[a]CRM–12 Monthly Reports.
[b](6/11) = Measurements made on six of eleven stacks samples.

TABLE 13.2-III
TA-21 RADIOACTIVE AIRBORNE EFFLUENT RELEASE SUMMARIES, 1973-1989

Year	Gross Volume (m³) Discharged	Total µCi of 239/240Pu Discharged	Total µCi of 238Pu,239/240Pu Discharged	Total µCi of 238Pu Discharged	Total µCi of 235U Discharged	Total µCi of MFP[a] Discharged	Total µCi of Tritium Discharged	Total µCi of Tritium gas Discharged	Total µCi of Tritium HTO[b] Discharged	Total µCi of 241Am Discharged
1973	4.17 E+09 (24/24)[c]	1376.92 (12/24)	4.9 (4/24)	1.6 (1/24)	907.6 (7/24)	1 (1/24)	4.00 E+06 (1/24)			
1974	3.70 E+09 (20/20)	2.71 (8/20)	2.4 (4/20)	0.6 (1/20)	46.49 (7/20)	2.9 (1/20)	0.00 E+00 (1/20)			
1975	3.47 E+09 (21/21)	6.61 (8/21)	1.62 (4/21)	2.82 (1/21)	80.68 (7/21)	1.44 (1/21)	3.06 E+08 (2/21)			
1976	3.77 E+09 (21/21)	3.55 (8/21)	8.16 (4/21)	0.45 (1/21)	870.27 (7/21)	0.55 (1/21)	9.43 E+07 (2/21)			
1977	3.49 E+09 (21/21)	7.97 (8/21)	1.76 (4/21)	0.27 (1/21)	316.62 (7/21)	3.26 (1/21)	1.33 E+08 (2/21)			
1978	3.36 E+09 (19/19)	27.15 (8/19)	3.15 (4/19)	0.43 (1/19)	305.4 (3/19)	1.03 (1/19)	7.16 E+07 (2/19)			0.034 (1/19)
1979	3.21 E+09 (16/17)	2.57 (7/17)	3.66 (4/17)	0.23 (1/17)	654.73 (3/17)	0.47 (1/17)	9.49 E+07 (1/17)			0.019 (1/17)
1980	2.97 E+09 (17/17)	0.6 (7/17)	1.67 (5/17)		633.26 (3/17)	4.18 (1/17)	1.06 E+08 (1/17)			0.061 (1/17)
1981	3.33 E+09 (15/15)	7.28 (5/15)	5.82 (5/15)		1021.33 (3/15)	2.8 (1/15)	1.08 E+08 (1/15)			0.029 (1/15)
1982	2.83 E+09 (14/14)		15.84 (10/14)		1042.82 (3/14)	0.44 (1/14)		1.69 E+08 (1/14)		
1983	2.73 E+09 (14/14)		9.92 (10/14)		706.15 (3/14)	0.8 (1/14)		1.80 E+08 (1/14)		
1984	2.66 E+09 (14/14)		17.34 (9/14)		990.38 (3/14)	0.31 (1/14)		8.02 E+08 (2/14)		
1985	2.74 E+09 (14/14)		10.57 (9/14)		381.88 (3/14)	0.36 (1/14)		3.67 E+08 (2/14)		
1986	2.77 E+09 (13/13)		3.57 (9/13)		212.3 (2/13)	0.32 (1/13)		4.48 E+08 (2/13)	1.36 E+06 (1/13)	
1987	2.47 E+09 (13/13)		1.43 (9/13)		207.3 (2/13)	0.19 (1/13)		5.81 E+08 (2/13)	1.45 E+07 (1/13)	
1988	1.85 E+09 (12/12)		0.71 (8/12)		58.8 (2/12)	0.15 (1/12)		4.76 E+08 (2/12)	3.35 E+07 (1/12)	
1989	1.76 E+09 (12/12)		1.39 (8/12)		28.93 (2/12)	0.03 (1/12)		4.20 E+08 (2/12)	3.43 E+07 (1/12)	

[a]MFP is Mixed Fission Products
[b]HTO is Tritiated Water Vapor
[c](12/24) = measurements made on twelve of twenty-four stacks sampled.

a composite of which contained 1.3 +/- 0.1 pCi/g plutonium (Christensen et al. 1975). The area remains vacant with the exception of DP-402, an open shed along the northernmost line of the previous location of Building 12. The area is covered with dirt and has a small driveway across its breadth for access to DP-286.

SWMU 21-020(b): TA-21-153

Stack emission data for TA-21-153 are detailed in Nyhan 1990, Tables XIV and XV. Upon decommissioning in 1978, soil under and around this facility was removed until the entire area was measured to less than 30 pCi gross alpha/g soil (the detection limit of the Laboratory's ZnS system), according to the final Laboratory report (Harper and Garde 1981).

SWMU 21-021, Stack Emissions

Table 13.2-IV presents the range and average concentrations of ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, and $^{239/240}$Pu/^{90}Sr activity ratio in referenced soils that could be attributed to worldwide fallout in the area.

Surface soil samples were collected from 12 locations across TA-21 in 1970 as shown in Fig. 13.2-2 (Kennedy and Purtymun 1971). The samples were taken from flat, undisturbed areas to avoid concentration or dilution of contaminants by wash from any storm run-off or contribution by spills from past Laboratory activities. The samples were collected from a 4- by 4-in. area to a depth of 2 in. The analytical results for ^{238}Pu indicated that samples from locations 3, 4, 5, 8, and 11 contained concentrations of ^{238}Pu in excess of that expected from worldwide fallout. The locations of these sampling stations indicate that the source of the ^{238}Pu may be from stack emissions at TA-21.

The analytical results for $^{239/240}$Pu indicated that samples from locations 1, 2, 3, 5, 8, 9, 12, and perhaps 7, contained concentrations of $^{239/240}$Pu in excess of that expected from worldwide fallout. The location of the sampling stations in relation to the concentrations indicates that stack emissions may be the source of the $^{239/240}$Pu. The concentrations decrease with increased distance from the stacks.

Initially, the ^{90}Sr analyses were performed to distinguish worldwide fallout from local material by activity ratio $^{239/240}$Pu/^{90}Sr. The ratio method proved invalid for this area because of traces of ^{90}Sr added to the soils by activities in the area many years ago. Short-lived gamma-emitting isotopes were used as tracers in atmospheric release experiments performed before 1962.

TABLE 13.2-IV
WORLDWIDE FALLOUT DATA[a]

Isotope or Activity Ratio	Number of Samples	Concentrations dpm/g Range	Average
^{238}Pu	19	0.001-0.008	0.003
^{239}Pu	20	0.001-0.051	0.021
^{90}Sr	18	0.152-1.921	0.711
$^{239}Pu/^{90}Sr$	18	0.003-0.138	0.038

[a](Kennedy and Purtymun 1971)

TABLE 13.2-V
PROBABILITY OF NOT FINDING AN EXISTING CONTAMINATED AREA (b)
AS THE GRID SIZE INCREASES.

Grid Size (m)	b (%)
44	0
49	5
52	10
55	20
59	25

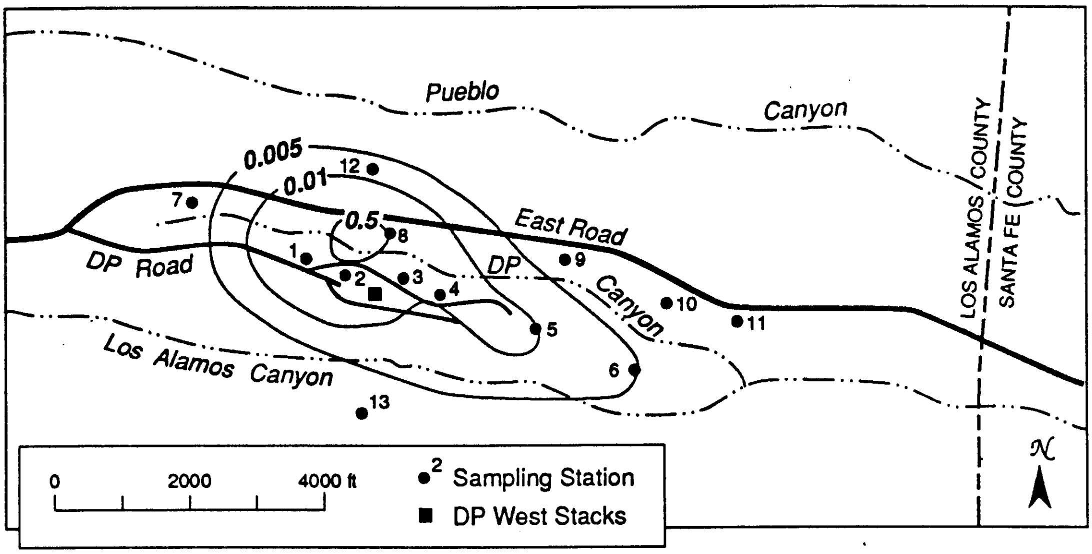


Fig. 13.2-2 Isoplutonium plutonium-239/240 contours around DP West stacks, contour values in µCi/m².

These were separated from mixed fission products and contained a trace of ^{90}Sr that was carried over into the experiment. This same ^{90}Sr was also released to the atmosphere along with the gamma tracer. Any ^{90}Sr found locally is under suspicion of originating from sources other than worldwide fallout. Samples from locations 4 and 5 contain concentrations of ^{90}Sr that cannot be attributed to worldwide fallout or stack emissions from TA-50.

The $^{239/240}Pu/^{90}Sr$ activity ratios in samples from locations 6, 7, 9, 10, and 11 are generally equivalent to ratios found by other laboratories in worldwide fallout. The activity ratios in samples from locations 1, 2, 3, 8, and 12 reflect the $^{239/240}Pu$ emissions from stacks at TA-21. The ratio from the samples from locations 4 and 5 are anomalous because of excessive ^{90}Sr.

An estimate of the $^{239/240}Pu$ deposition in soils was made by using average concentrations in µCi/m² of the two sets of samples collected at each location during 1970. Iso-plutonium contours were constructed at 0.005, 0.01, and 0.05 µCi/m² (Fig. 13.2-2). The estimated deposition of $^{239/240}Pu$ within the 0.005 µCi/m² contour was 0.026 Ci or about 0.42 g.

13.2.1.3. Source Term

Stack emissions. The source terms from all SWMUs in this chapter are addressed together because surface contamination cannot be traced back to a specific stack. Available data suggest a minimum of approximately 2 Ci $^{239/240}Pu$ per year exited all TA-21 stacks in the 1950s. High values occurred in 1973 when TA-21-12 emitted 1370 µCi $^{239/240}Pu$ itself. However, in 1989, TA-21 stacks emitted 1.39 Ci $^{239/240}$Pu. Additionally, ^{235}U and tritium vapor and gas have been released from TA-21 stacks (Nyhan 1990). No data are available on nonradionuclide air emissions. However, given knowledge of processes conducted at TA-21, radionuclide emissions are of greater concern.

Previous sampling has shown that $^{239/240}$Pu concentration in the top 2 in. of soil is elevated above worldwide fallout levels (Kennedy and Purtymun 1971) well beyond TA-21 (see Fig. 13.2-2). Their data suggest decreasing concentrations with increasing distance from TA-21 stacks. However, their sampling was solely north of TA-21. Whether similar conditions exist in all directions from TA-21 stacks is unknown.

Filter buildings. Subsurface soil contamination was documented when both filter buildings, TA-21-12 and TA-21-153, were removed in 1973 and 1978, respectively. Plutonium-239/240 contamination at TA-21-12 was present in concentrations as high as 70 pCi/g to a depth of 30 cm (12 in.); gross alpha contamination at TA-21-153 was less than 30 pCi gross alpha/gm soil, the as-low-as-practicable level (Harper and Garde 1981). The extent of contamination at either filter building is unknown.

13.2.2 Objectives and Data Needs

Stack emissions. The purpose of this investigation is to document the presence of areas of elevated radionuclide deposition in surface soil at the TA-21 OU resulting from airborne emissions. The preferred remedial alternative is to use data collected in this investigation to document (with sampling results and, as needed, a risk assessment) that surface soils at the TA-21 OU do not present a significant risk to human health or the environment. The specific data required to attain this objective are as follows:

1. Identify the presence of surface soil contamination from radionuclide airborne emissions within the TA-21 operable unit, bounded by DP and Los Alamos canyons.

2. If contamination is identified, determine the concentration of indicator contaminant species in soils through evaluation of sample analysis results.

3. If contaminants are identified, determine vertical and lateral extent of contaminant migration by first evaluating data in conjunction with surface soil sampling conducted at the same sampling points in Chapter 12. If needed, conduct additional surface and subsurface soil sampling and analysis.

4. If contaminants are identified, define the presence of any potential surface soil contaminant plumes from stack emissions.

5. If contaminant migration is identified, determine primary migration pathways

through evaluation of sample analysis results.

Filter buildings. The objective of this investigation is to define the extent of remaining contamination at the location of the former filter buildings. Specific data required to assess contamination at SWMU 21-020 include the following:

1. Determine the location of the former filter buildings by examining old drawings to determine survey location.
2. Identify the presence of contaminants in surface and subsurface samples using Level II/III data. It is known that the former location of Building TA-21-12 was backfilled to cover known contamination present at a depth of 30 cm.
3. Determine the lateral and vertical extent of contaminant migration by subsurface soil sampling using Level II/III field laboratory analyses initially, followed by Level III/IV analytical laboratory data on a subset of the samples.

13.2.3 Sampling/Investigation Rationale

Stack emissions. The objective of this soil sampling plan is to determine if there are localized areas of contamination resulting from stack emissions. Because historical data show that only radionuclide emissions have occurred, analysis will focus on these analytes.

Because little information exists regarding the presence of stack plumes or contamination resulting from emissions anywhere in the TA-21 OU, the preliminary investigation will look for broad areas of elevated radionuclide deposition, assuming no prior information. The only assumption will be that those areas are larger than 3,000 m^2. These area estimates are from the Waste Information Network (WIN) data base.

A two-phase sequential surface sampling plan will be employed. The objective of the initial investigation of surface sampling is to locate localized contaminated areas greater than 3,000 m^2. The subsequent surface sampling will focus on characterizing the extent of any contaminated areas found in the initial investigation. For the method of deposition-layer surface soil sampling to be performed during the initial and subsequent investigation, see Sec. 11.5.2.4.

A full suite of radionuclides will be measured in the analytical laboratory for each sample.

There are three implicit assumptions in the sampling rationale. The first assumption is that current TA-21 stack emissions are monitored and are not contributing significantly to surface contamination. The second is that the other 23 OUs at the Laboratory are not sources for contamination found at the TA-21 OU. The third assumption is that other SWMUs at TA-21 are not sources of contamination that will interfere with the goals of this investigation. While the first two assumptions are likely to be valid, the third assumption may not be valid. This assumption may require evaluation through comparisons to SWMU-specific results (Chapter 14–18) and to the OU-wide surface soil sampling results (Chapter 12).

Filter buildings. The initial investigation consists of near-surface and shallow borehole soil sampling to determine the levels of radionuclides at the former filter building locations. These samples will be analyzed in the field laboratory for radionuclides, and a percentage will be submitted to an analytical laboratory for confirmatory analyses. In addition, a percentage of the samples submitted for analytical laboratory analysis will be subjected to a full analytical suite to assess presence of other contaminants.

At TA-21-12, $^{239/240}Pu$ is the major contaminant expected. At TA-21-153, ^{227}Ac is the major contaminant. Sample analyses for ^{227}Ac will be based on gamma spectrometry for its decay progeny.

An initial investigation is expected to be sufficient at both filter buildings. Any subsequent investigation would include additional near-surface, shallow borehole, and borehole sampling to further define the lateral and vertical extent of contamination.

13.2.4 Sampling Plan

13.2.4.1 Initial Investigation

Stack emissions. The objective of the initial investigation is to identify, with high confidence, local areas of contamination greater than 3,000 m^2. These potential large areas of contamination are from incinerator and other stack emissions. The sampling technique to be used (Gilbert 1982) assumes that the contaminated areas are described by an ellipse whose semimajor axis (L) is twice the semiminor axis, which gives a "skinny" ellipse. This approach is conservative compared with the assumption of a circular distribution of contaminants (Gilbert 1982). For an area of 3,000 m^2, this assumption gives L = 44 m. For this case, assuming the worst orientation of the ellipse with respect to the grid, a square grid of 40 by 40m gives a zero probability of missing the contaminated area. Gilbert (1982) derived the probability of missing the target as a function of the grid and ellipse size, averaging over all orientations of the ellipse. Some of those results are given in Table 13.2-V. Note that averaging over all orientations gives a somewhat larger grid size compared to the worst case assumption.

Possible sample locations are displayed in Fig. 13.2-3 (for method see Sec. 11.5.2.4). The

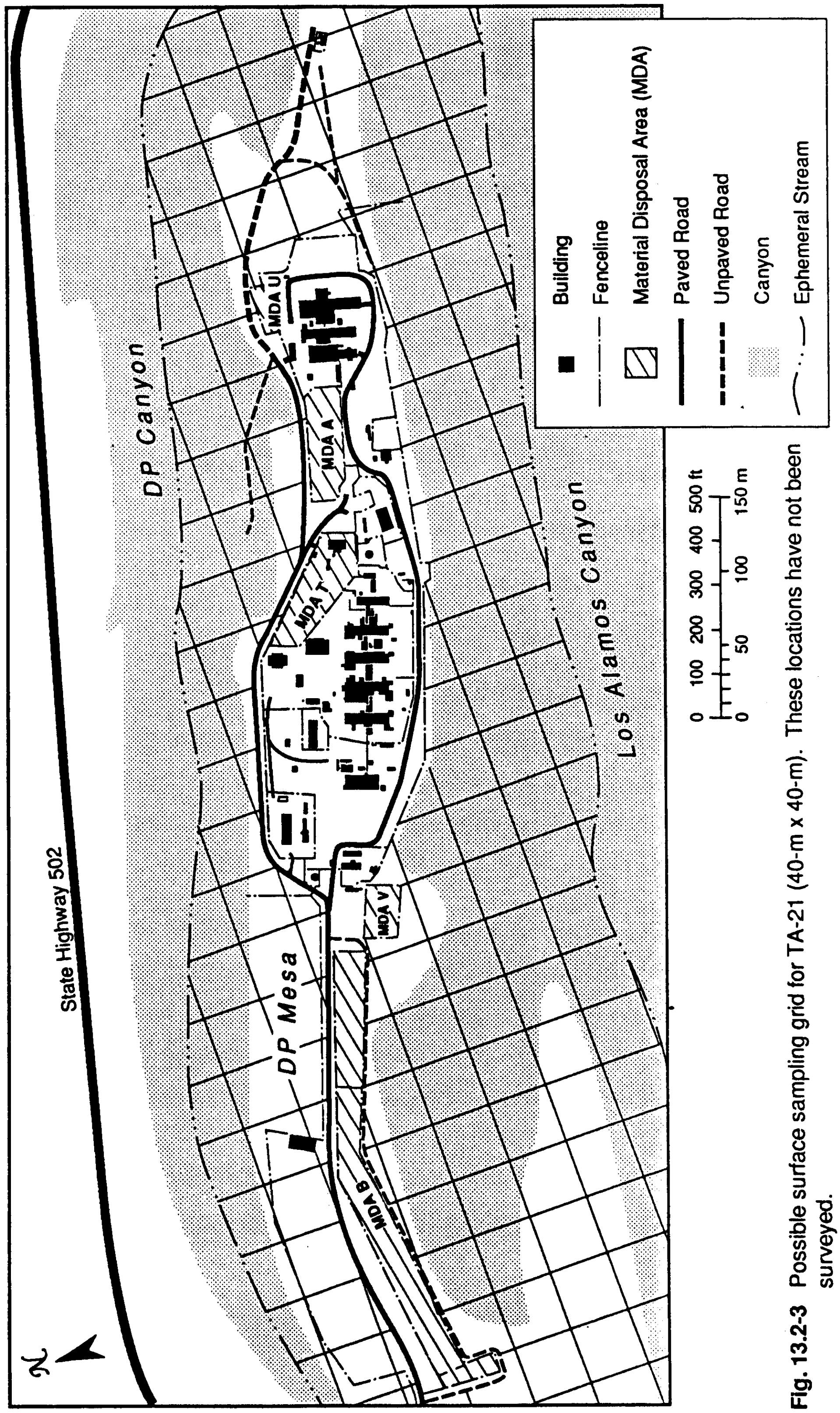


Fig. 13.2-3 Possible surface sampling grid for TA-21 (40-m x 40-m). These locations have not been surveyed.

number of sample points required is approximately 180. This approach makes no assumptions about the plume dispersion patterns from the emissions. Actual grid locations will be defined by choosing a random starting point and then surveying in all grid points prior to sampling (for method see Sec. 11.3.3).

The grid technique is not appropriate for the areas with buildings. For these areas, sample points are the centers of overlapping circles with radii of 20 m (the semiminor axis). Thirty proposed sampling locations are shown in Fig. 13.2-4 (for method see Sec. 11.5.2.4). This technique guarantees that areas of contamination under the previously described assumptions will not be missed.

TA-21 will be stratified into four areas that include

- DP Canyon side
- Los Alamos Canyon side
- Mesa top — building area
- Mesa top — no buildings

These areas were chosen because, in combination with the MDAs, they represent the diversity of conditions at TA-21. Twenty additional samples will be taken at a distance of 10 m from the 20 grid sampling locations, five in each area selected for stratification. This additional sampling will enable estimation of local variability for spatial prediction surfaces such as kriged surfaces. The stratification makes it possible to determine if the local variability differs between areas.

All samples obtained from the initial investigation will be deposition-layer soil samples, as defined in Sec. 11.5.2.4. They will be submitted for analytical laboratory analysis and will be analyzed for gamma spectometry, tritium, total uranium, isotopic plutonium, ^{90}Sr, and metals. Although no existing data show metals associated with stack emissions, metals are commonly associated with the radionuclides in the processes that produced these stack emissions. No VOAs are planned for these samples because they are surface samples. Table 13.2-VI identifies the screening and analysis requirements for the samples to be collected during the initial investigation.

Filter buildings. Initial investigations at the previous locations of both filter buildings will consist of near-surface soil samples and shallow boreholes.

TA-21-12. The initial investigation around the former location of TA-21-12 will include near-surface soil samples at 16 locations where samples will be taken at 6-in. intervals from 12 to 30

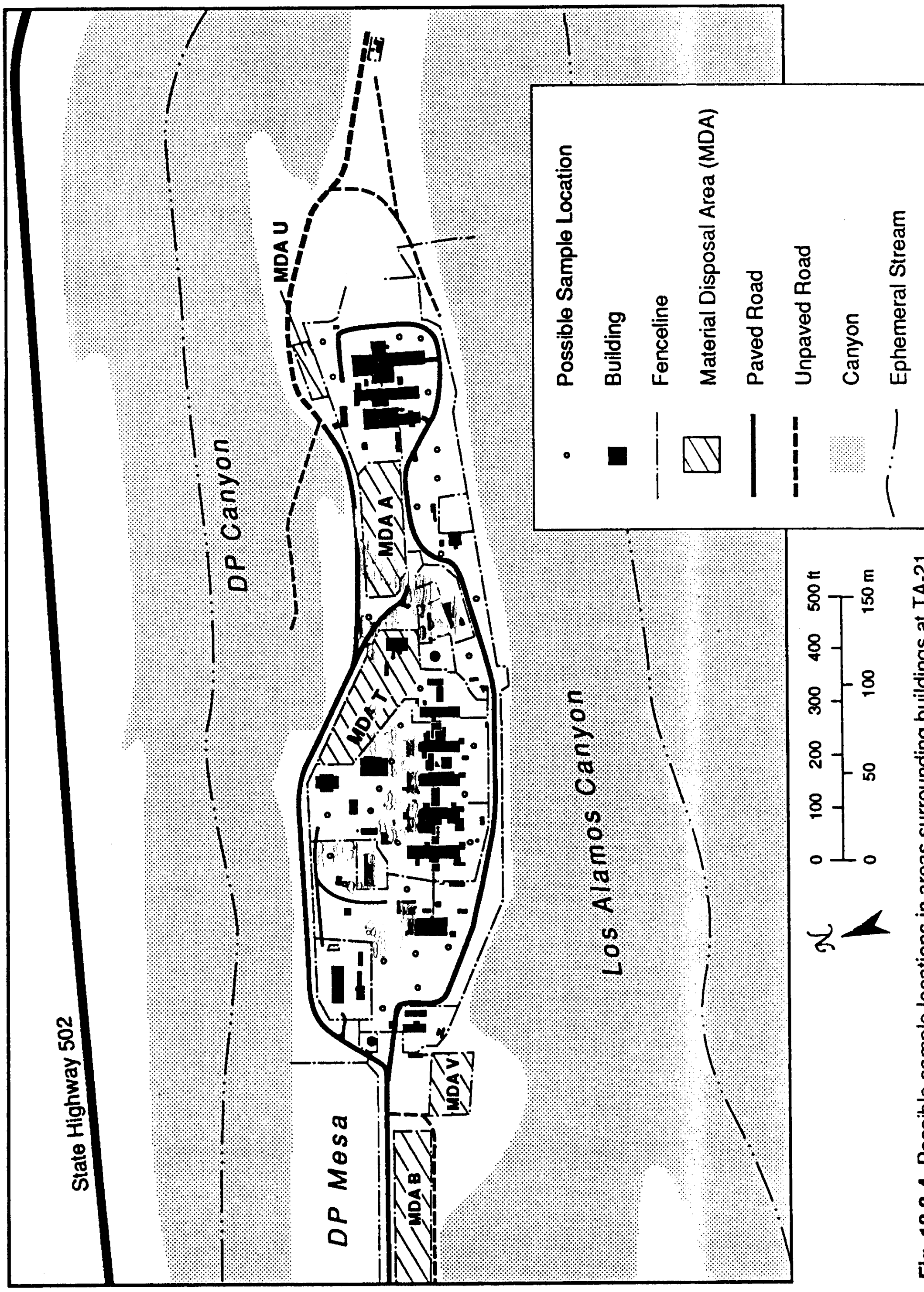


Fig. 13.2-4 Possible sample locations in areas surrounding buildings at TA-21.

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging
Airborne Deposition Sampling												
Surface Soil Sample	1	0.0 - 1.0 in						X	X	X		
	2	0.0 - 1.0 in						X	X	X		
	3	0.0 - 1.0 in						X	X	X		
	4	0.0 - 1.0 in						X	X	X		
	5	0.0 - 1.0 in						X	X	X		
Field Duplicate												
	6	0.0 - 1.0 in						X	X	X		
	7	0.0 - 1.0 in						X	X	X		
	8	0.0 - 1.0 in						X	X	X		
	9	0.0 - 1.0 in						X	X	X		
	10	0.0 - 1.0 in						X	X	X		
Rinsate Blank												
Field Blank												
	11	0.0 - 1.0 in						X	X	X		
	12	0.0 - 1.0 in						X	X	X		
	13	0.0 - 1.0 in						X	X	X		
	14	0.0 - 1.0 in						X	X	X		
	15	0.0 - 1.0 in						X	X	X		
	16	0.0 - 1.0 in						X	X	X		
	17	0.0 - 1.0 in						X	X	X		
	18	0.0 - 1.0 in						X	X	X		
	19	0.0 - 1.0 in						X	X	X		
	20	0.0 - 1.0 in						X	X	X		
	21	0.0 - 1.0 in						X	X	X		

Sample Type	Sampling Location	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals
Airborne Deposition Sampling																		
Surface Soil Sample	1							X	X	X	X		X			X		
	2							X	X	X	X		X			X		
	3							X	X	X	X		X			X		
	4							X	X	X	X		X			X		
	5							X	X	X	X		X			X		
Field Duplicate								X	X	X	X		X			X		
	6							X	X	X	X		X			X		
	7							X	X	X	X		X			X		
	8							X	X	X	X		X			X		
	9							X	X	X	X		X			X		
	10							X	X	X	X		X			X		
Rinsate Blank								X	X	X	X		X			X		
Field Blank																X		
	11							X	X	X	X		X			X		
	12							X	X	X	X		X			X		
	13							X	X	X	X		X			X		
	14							X	X	X	X		X			X		
	15							X	X	X	X		X			X		
	16							X	X	X	X		X			X		
	17							X	X	X	X		X			X		
	18							X	X	X	X		X			X		
	19							X	X	X	X		X			X		
	20							X	X	X	X		X			X		
	21							X	X	X	X		X			X		

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	22	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	23	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	24	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	25	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	26	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	27	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	28	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	29	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	30	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	31	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	32	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	33	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	34	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	35	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	36	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	37	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	38	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	39	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	40	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	41	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	42	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	43	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	44	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
Field Duplicate																						X	X	X	X		X			X				
	45	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	46	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	47	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	48	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	49	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	50	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	51	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	52	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	53	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	54	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	55	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	56	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	57	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	58	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	59	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	60	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	61	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	62	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	63	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	64	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	65	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	66	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	67	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	68	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	69	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	70	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	71	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	72	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	73	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	74	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	75	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	76	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	77	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	78	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	79	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	80	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	81	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	82	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	83	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	84	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	85	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	86	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	87	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	88	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	89	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	90	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	91	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	92	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	93	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	94	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	95	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	96	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	97	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	98	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	99	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	100	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	101	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	102	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	103	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	104	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	105	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	106	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	107	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	108	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	109	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	110	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	111	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	112	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	113	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	114	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	115	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	116	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	117	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	118	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	119	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	120	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	121	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	122	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	123	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	124	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	125	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	126	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	127	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	128	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	129	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	130	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	131	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	132	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	133	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
Field Duplicate																						X	X	X	X		X			X				
	134	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	135	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	136	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	137	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	138	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	139	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	140	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	141	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	142	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	143	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	144	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	145	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	146	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	147	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	148	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	149	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	150	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	151	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	152	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	153	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	154	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	155	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals	Laboratory Analysis:	Laboratory Analysis:
	156	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	157	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	158	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	159	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	160	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	161	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	162	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	163	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	164	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	165	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	166	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	167	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	168	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	169	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	170	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	171	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	172	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	173	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	174	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	175	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	176	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	177	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	178	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2–VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low–Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	179	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	180	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	181	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	182	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	183	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	184	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	185	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	186	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	187	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	188	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	189	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	190	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	191	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	192	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	193	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	194	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	195	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	196	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	197	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	198	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	199	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	200	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				
	201	0.0 – 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electr magnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	202	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	203	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	204	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	205	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	206	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	207	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	208	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	209	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	210	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	211	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	212	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	213	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	214	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	215	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	216	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	217	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	218	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	219	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	220	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	221	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	222	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	223	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	224	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VI

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	225	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	226	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	227	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	228	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	229	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	230	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				

in. (for method see Sec. 11.5.2.2). Samples will be taken from inside and outside of the previous building location (see Fig. 13.2-5). All samples deeper than 12 in. (48 samples) will be analyzed in the field laboratory. Thirty percent of these samples will be analyzed in the analytical laboratory for the full analytical suite. Because this investigation presupposes that this area is contaminated, the purposes of sending samples to the analytical laboratory is twofold: (1) to define the source term and (2) to define the edges of the contaminant plume. Therefore, samples sent to the analytical laboratory for confirmatory analysis will include "hot" samples to define the source term and samples from the edges of the plume to confirm absence of contamination.

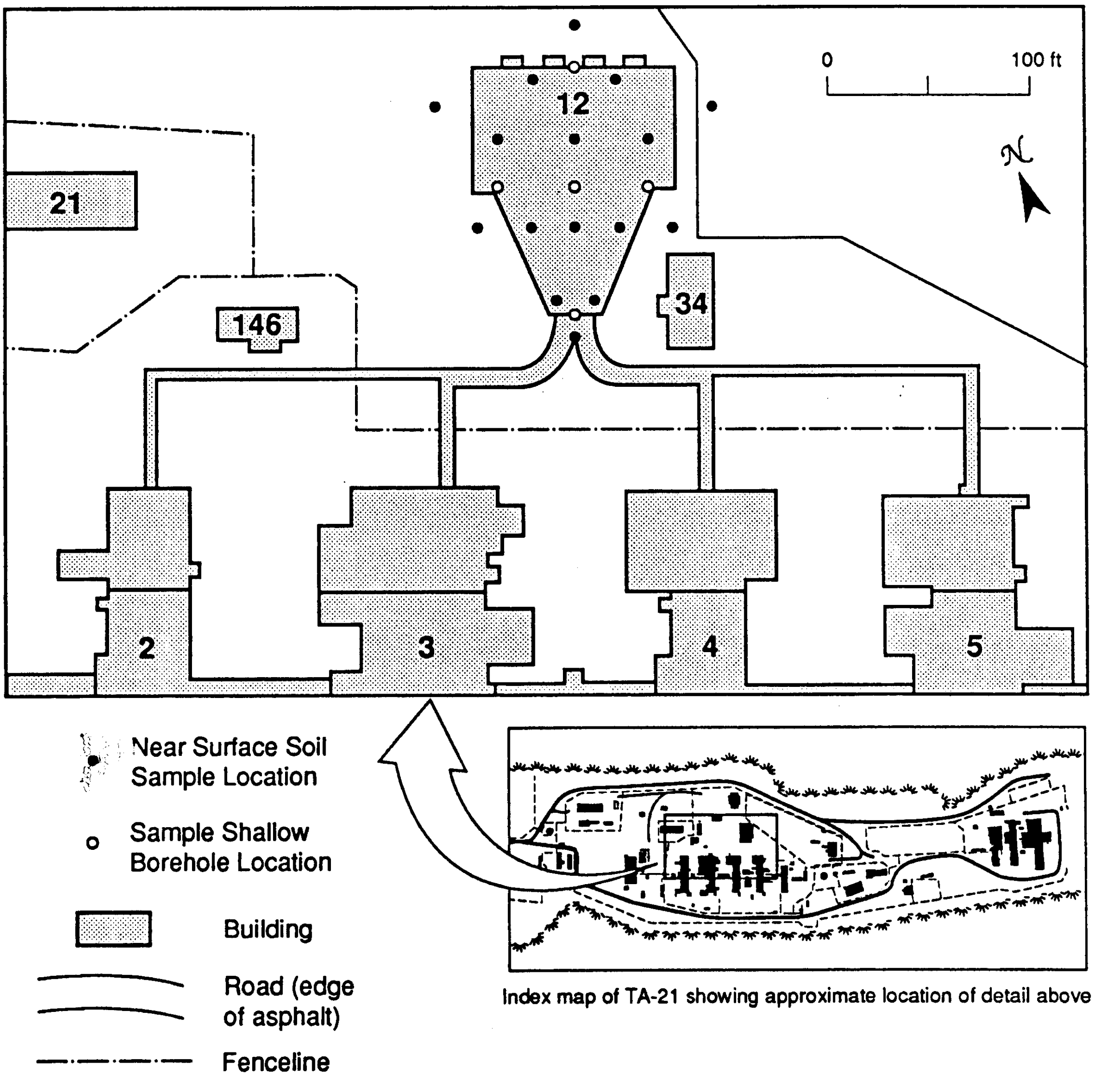


Fig. 13.2-5 Location of former filter building TA-21-12 showing initial investigation sample locations. (LASL 1964a; Christensen et al. 1975)

Field laboratory results from near-surface soil samples will assist in placement of five shallow boreholes at locations where contamination is greatest at the 24- to 30-cm depth. If the area is uniformly contaminated, these boreholes will be placed in the center and at the perimeter of the former building location as shown in Fig.13.2-5.

For planning purposes, it is assumed five shallow boreholes to a nominal depth of 7.5 ft will be drilled. Samples for analysis will only be taken beyond the 2.5-ft depth. The criteria defined above will be used to determine which samples will be sent to the analytical laboratory. All samples will be sent to the field laboratory, and 5 of the 10 samples will be sent to the analytical laboratory.

The screening and sample analysis requirements for the initial investigation are shown in Table 13.2-VII.

TA-21-153. Initial investigation around the former location of TA-21-153 will consist of near-surface soil samples at 10 locations where samples will be taken at 6-in. depth intervals from 6 to 30 in. (Fig. 13.2-6). The initial 6-in. layer will not be sampled because the site has been contoured and revegetated. If this interval field screens "hot," samples will be taken for field laboratory analysis. All 40 samples will be analyzed in the field laboratory. Using the rationale described for TA-21-12, 30% of the samples will be sent to an analytical laboratory for confirmatory analyses. The screening and sample analyses requirements for the initial investigation are shown in Table 13.2-VII.

13.2.4.2. Subsequent Investigations

Stack emissions. A subsequent investigation will be used to characterize the extent of contamination if contamination is found in the initial investigation (for method see Sec. 11.5.2.4). Initial sampling results will be used to determine the appropriate area to be sampled and the necessary grid size. Replicate data from the initial investigation will give information about the spatial correlation structure and determine if kriging techniques can be employed to predict contamination levels at locations not sampled. Sampling under the subsequent investigation will involve refined grid or depth sampling as needed, depending upon initial sampling results.

Any plume dispersion patterns from emissions found from initial sampling results will be modeled (if appropriate), and that information will be taken into account when planning subsequent sampling.

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis													
				Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals			
TA-21-12																																			
Near Surface Soil (bias)	1	0.0 - 6.0 in						X	X		X																								
		6.0 - 12.0 in						X	X		X																								
		12.0 - 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					
		18.0 - 24.0 in						X	X		X			X	X	X	X																		
		24.0 - 30.0 in						X	X		X			X	X	X	X																		
	2	0.0 - 6.0 in						X	X		X																								
		6.0 - 12.0 in						X	X		X																								
		12.0 - 18.0 in						X	X		X			X	X	X	X																		
		18.0 - 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					
Rinsate Blank																						X	X	X	X		X	X	X	X					
Field Blank																													X	X					
		24.0 - 30.0 in						X	X		X			X	X	X	X																		
	3	0.0 - 6.0 in						X	X		X																								
		6.0 - 12.0 in						X	X		X																								
		12.0 - 18.0 in						X	X		X			X	X	X	X																		
		18.0 - 24.0 in						X	X		X			X	X	X	X																		
		24.0 - 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					
Trip Blank																													X						
	4	0.0 - 6.0 in						X	X		X																								
		6.0 - 12.0 in						X	X		X																								
		12.0 - 18.0 in						X	X		X			X	X	X	X																		
		18.0 - 24.0 in						X	X		X			X	X	X	X																		
		24.0 - 30.0 in						X	X		X			X	X	X	X																		
	5	0.0 - 6.0 in						X	X		X																								

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
		6.0 – 12.0 in						X	X		X																							
		12.0 – 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		18.0 – 24.0 in						X	X		X			X	X	X	X																	
		24.0 – 30.0 in						X	X		X			X	X	X	X																	
	6	0.0 – 6.0 in						X	X		X																							
		6.0 – 12.0 in						X	X		X																							
		12.0 – 18.0 in						X	X		X			X	X	X	X																	
		18.0 – 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																													X	X				
		24.0 – 30.0 in						X	X		X			X	X	X	X																	
Trip Blank																													X					
	7	0.0 – 6.0 in						X	X		X																							
		6.0 – 12.0 in						X	X		X																							
		12.0 – 18.0 in						X	X		X			X	X	X	X																	
		18.0 – 24.0 in						X	X		X			X	X	X	X																	
		24.0 – 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
	8	0.0 – 6.0 in						X	X		X																							
		6.0 – 12.0 in						X	X		X																							
		12.0 – 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		18.0 – 24.0 in						X	X		X			X	X	X	X																	
		24.0 – 30.0 in						X	X		X			X	X	X	X																	
	9	0.0 – 6.0 in						X	X		X																							
		6.0 – 12.0 in						X	X		X																							
		12.0 – 18.0 in						X	X		X			X	X	X	X																	
		18.0 – 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vap	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals	Laboratory Analysis:	Laboratory Analysis:	Laboratory Analysis:
		24.0 – 30.0 in						X	X		X			X	X	X	X																		
Trip Blank																													X						
	10	0.0 – 6.0 in						X	X		X																								
		6.0 – 12.0 in						X	X		X																								
		12.0 – 18.0 in						X	X		X			X	X	X	X																		
		18.0 – 24.0 in						X	X		X			X	X	X	X																		
Rinsate Blank																						X	X	X	X		X	X	X	X					
Field Blank																													X	X					
		24.0 – 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					
	11	0.0 – 6.0 in						X	X		X																								
		6.0 – 12.0 in						X	X		X																								
		12.0 – 18.0 in						X	X		X			X	X	X	X																		
		18.0 – 24.0 in						X	X		X			X	X	X	X																		
		24.0 – 30.0 in						X	X		X			X	X	X	X																		
	12	0.0 – 6.0 in						X	X		X																								
		6.0 – 12.0 in						X	X		X																								
		12.0 – 18.0 in						X	X		X			X	X	X	X																		
		18.0 – 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					
Field Duplicate																						X	X	X	X		X	X	X	X					
		24.0 – 30.0 in						X	X		X			X	X	X	X																		
Trip Blank																													X						
	13	0.0 – 6.0 in						X	X		X																								
		6.0 – 12.0 in						X	X		X																								
		12.0 – 18.0 in						X	X		X			X	X	X	X																		
		18.0 – 24.0 in						X	X		X			X	X	X	X																		
		24.0 – 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E					

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	14	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X																							
		12.0 - 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																													X	X				
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
	15	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X																							
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
Trip Blank																													X					
	16	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X																							
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
Shallow Borehole (bias)	1	0.0 - 2.5 ft						X	X		X																							
		2.5 - 5.0 ft						X	X		X	X	X	X	X	X	X																	
		5.0 - 7.5 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				
	2	0.0 - 2.5 ft						X	X		X																							
		2.5 - 5.0 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				
		5.0 - 7.5 ft						X	X		X	X	X	X	X	X	X																	
	3	0.0 - 2.5 ft						X	X		X																							
		2.5 - 5.0 ft						X	X		X	X	X	X	X	X	X					E	E	E	E		E	E	E	E				

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:
		5.0 - 7.5 ft						X	X		X	X	X	X	X	X	X				
Rinsate Blank																					
Field Blank																					
	4	0.0 - 2.5 ft						X	X		X										
		2.5 - 5.0 ft						X	X		X	X	X	X	X	X	X				
		5.0 - 7.5 ft						X	X		X	X	X	X	X	X	X				
	5	0.0 - 2.5 ft						X	X		X										
		2.5 - 5.0 ft						X	X		X	X	X	X	X	X	X				
		5.0 - 7.5 ft						X	X		X	X	X	X	X	X	X				
Trip Blank																					
TA-21-153																					
Near Surface Soil (bias)	1	0.0 - 6.0 in						X	X		X										
		6.0 - 12.0 in						X	X		X			X	X	X	X				
		12.0 - 18.0 in						X	X		X			X	X	X	X				
		18.0 - 24.0 in						X	X		X			X	X	X	X				
		24.0 - 30.0 in						X	X		X			X	X	X	X				
	2	0.0 - 6.0 in						X	X		X										
		6.0 - 12.0 in						X	X		X			X	X	X	X				
		12.0 - 18.0 in						X	X		X			X	X	X	X				
		18.0 - 24.0 in						X	X		X			X	X	X	X				
		24.0 - 30.0 in						X	X		X			X	X	X	X				
	3	0.0 - 6.0 in						X	X		X										
		6.0 - 12.0 in						X	X		X			X	X	X	X				
		12.0 - 18.0 in						X	X		X			X	X	X	X				
		18.0 - 24.0 in						X	X		X			X	X	X	X				
Rinsate Blank																					

Sample Type	Sampling Location	Interval	Sample Identification	Laboratory Analysis: Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals			
		5.0 - 7.5 ft															
Rinsate Blank				X	X	X	X		X	X	X	X					
Field Blank											X	X					
	4	0.0 - 2.5 ft															
		2.5 - 5.0 ft															
		5.0 - 7.5 ft		E	E	E	E		E	E	E	E					
	5	0.0 - 2.5 ft															
		2.5 - 5.0 ft		E	E	E	E		E	E	E	E					
		5.0 - 7.5 ft															
Trip Blank											X						
TA-21-153																	
Near Surface Soil (bias)	1	0.0 - 6.0 in															
		6.0 - 12.0 in															
		12.0 - 18.0 in		E	E	E	E		E	E	E	E					
		18.0 - 24.0 in															
		24.0 - 30.0 in															
	2	0.0 - 6.0 in															
		6.0 - 12.0 in		E	E	E	E		E	E	E	E					
		12.0 - 18.0 in															
		18.0 - 24.0 in															
		24.0 - 30.0 in		E	E	E	E		E	E	E	E					
	3	0.0 - 6.0 in															
		6.0 - 12.0 in															
		12.0 - 18.0 in															
		18.0 - 24.0 in		E	E	E	E		E	E	E	E					
Rinsate Blank				X	X	X	X		X	X	X	X					

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals	Laboratory Analysis:	Laboratory Analysis:
Field Blank																													X	X				
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
Trip Blank																													X					
	4	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X																	
		12.0 - 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
	5	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
	6	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X																	
		12.0 - 18.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
Trip Blank																													X					
	7	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X																	
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																													X	X				
		24.0 - 30.0 in						X	X		X			X	X	X	X																	

Table 13.2-VII

SCREENING AND ANALYSIS FOR INITIAL INVESTIGATIONS AT SWMU 21-020(A) AND (B), FILTER BUILDINGS.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	8	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X																	
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
	9	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X																	
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
Trip Blank																													X					
	10	0.0 - 6.0 in						X	X		X																							
		6.0 - 12.0 in						X	X		X			X	X	X	X																	
		12.0 - 18.0 in						X	X		X			X	X	X	X																	
		18.0 - 24.0 in						X	X		X			X	X	X	X					E	E	E	E		E	E	E	E				
		24.0 - 30.0 in						X	X		X			X	X	X	X																	
Field Duplicate																						X	X	X	X		X	X	X	X				
Rinsate Blank																						X	X	X	X		X	X	X	X				
Field Blank																													X	X				
Trip Blank																													X					

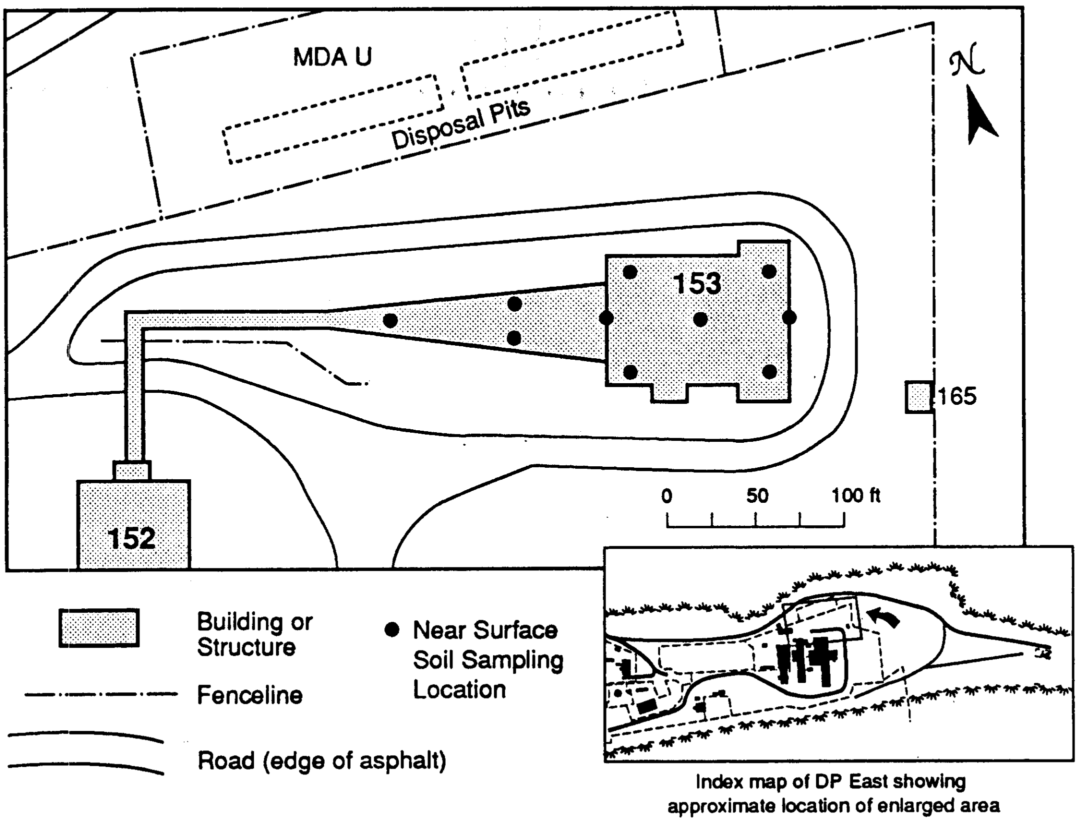


Fig. 13.2-6 Location of former filter buidling TA-21-153 showing initial investigation sampling locations (LASL 1958).

As appropriate, all samples in the subsequent investigation will be submitted to an analytical laboratory for analysis of a focused analytical suite determined using the results of initial sampling. For planning purposes, it is assumed that the subsequent investigation will require analysis of 112 samples, approximately 50% of the initial effort. The screening and analysis requirements for the subsequent investigation, assuming the same analytical suite as that used during initial investigation, are shown in Table 13.2-VIII.

Filter buildings. A subsequent investigation is not planned at either filter building. If results of initial investigations suggest that further sampling is required, additional field activities will be planned.

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals	Laboratory Analysis:	Laboratory Analysis:
Airborne Deposition Sampling																																		
Surface Soil Sample	1	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	2	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	3	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	4	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	5	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	6	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	7	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	8	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	9	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	10	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	11	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	12	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	13	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	14	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	15	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	16	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	17	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	18	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	19	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	20	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	21	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	22	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	23	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	24	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	25	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	26	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	27	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	28	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	29	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	30	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	31	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	32	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	33	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	34	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	35	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	36	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	37	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	38	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	39	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	40	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	41	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	42	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	43	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	44	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

Sample Type	Sampling Location	Interval	Sample Identification	Field Surveys: Gross Gamma	Field Surveys: Low-Energy Gamma	Field Surveys: Electromagnetic	Field Surveys: Land Survey	Field Screening: Gross Gamma	Field Screening: Gross Alpha	Field Screening:	Field Screening: Organic Vapor	Field Screening: Combustible Gas/Oxygen	Field Screening: Lithological Logging	Field Laboratory Measurements: Gross Alpha	Field Laboratory Measurements: Gamma Spectrometry	Field Laboratory Measurements: Tritium	Field Laboratory Measurements: Volatile Organics	Field Laboratory Measurements: PCB	Field Laboratory Measurements: Soil Moisture	Field Laboratory Measurements:	Field Laboratory Measurements:	Laboratory Analysis: Gamma Spectrometry	Laboratory Analysis: Tritium	Laboratory Analysis: Total Uranium	Laboratory Analysis: Isotopic Plutonium	Laboratory Analysis: Isotopic Uranium	Laboratory Analysis: Strontium 90	Laboratory Analysis: VOA (SW 8240)	Laboratory Analysis: Semivolatiles (SW 8270)	Laboratory Analysis: Metals (SW 6010)	Laboratory Analysis: PCB (SW 8080)	Laboratory Analysis: TCLP Metals	Laboratory Analysis:	Laboratory Analysis:
Field Duplicate																						X	X	X	X		X			X				
	45	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	46	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	47	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	48	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Rinsate Blank																						X	X	X	X		X			X				
Field Blank																														X				
	49	0.0 - 1.0 in						X	X		X											X	X	X	X									
	50	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	51	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	52	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	53	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	54	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	55	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	56	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	57	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	58	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	59	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	60	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	61	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	62	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	63	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	64	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				
	65	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	66	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening					
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging
	67	0.0 - 1.0 in						X	X		X		
	68	0.0 - 1.0 in						X	X		X		
	69	0.0 - 1.0 in						X	X		X		
	70	0.0 - 1.0 in						X	X		X		
	71	0.0 - 1.0 in						X	X		X		
	72	0.0 - 1.0 in						X	X		X		
Rinsate Blank													
Field Blank													
	73	0.0 - 1.0 in						X	X		X		
	74	0.0 - 1.0 in						X	X		X		
	75	0.0 - 1.0 in						X	X		X		
	76	0.0 - 1.0 in						X	X		X		
	77	0.0 - 1.0 in						X	X		X		
	78	0.0 - 1.0 in						X	X		X		
	79	0.0 - 1.0 in						X	X		X		
	80	0.0 - 1.0 in						X	X		X		
Field Duplicate													
	81	0.0 - 1.0 in						X	X		X		
	82	0.0 - 1.0 in						X	X		X		
	83	0.0 - 1.0 in						X	X		X		
	84	0.0 - 1.0 in						X	X		X		
Rinsate Blank													
Field Blank													
	85	0.0 - 1.0 in						X	X		X		
	86	0.0 - 1.0 in						X	X		X		
	87	0.0 - 1.0 in						X	X		X		

		Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	67									X	X	X	X		X			X				
	68									X	X	X	X		X			X				
	69									X	X	X	X		X			X				
	70									X	X	X	X		X			X				
	71									X	X	X	X		X			X				
	72									X	X	X	X		X			X				
Rinsate Blank										X	X	X	X		X			X				
Field Blank																		X				
	73									X	X	X	X		X			X				
	74									X	X	X	X		X			X				
	75									X	X	X	X		X			X				
	76									X	X	X	X		X			X				
	77									X	X	X	X		X			X				
	78									X	X	X	X		X			X				
	79									X	X	X	X		X			X				
	80									X	X	X	X		X			X				
Field Duplicate										X	X	X	X		X			X				
	81									X	X	X	X		X			X				
	82									X	X	X	X		X			X				
	83									X	X	X	X		X			X				
	84									X	X	X	X		X			X				
Rinsate Blank										X	X	X	X		X			X				
Field Blank																		X				
	85									X	X	X	X		X			X				
	86									X	X	X	X		X			X				
	87									X	X	X	X		X			X				

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis													
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals			
	88	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	89	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	90	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	91	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	92	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	93	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	94	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	95	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
Field Duplicate																						X	X	X	X		X			X					
	96	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	97	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	98	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	99	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	100	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	101	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	102	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	103	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	104	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
Rinsate Blank																						X	X	X	X		X			X					
Field Blank																														X					
	105	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	106	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	107	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	108	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	109	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					
	110	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X					

Table 13.2-VIII

SCREENING AND ANALYSIS FOR SUBSEQUENT INVESTIGATIONS FOR AIRBORNE DEPOSITION.

				Field Surveys				Field Screening						Field Laboratory Measurements								Laboratory Analysis												
Sample Type	Sampling Location	Interval	Sample Identification	Gross Gamma	Low-Energy Gamma	Electromagnetic	Land Survey	Gross Gamma	Gross Alpha		Organic Vapor	Combustible Gas/Oxygen	Lithological Logging	Gross Alpha	Gamma Spectrometry	Tritium	Volatile Organics	PCB	Soil Moisture			Gamma Spectrometry	Tritium	Total Uranium	Isotopic Plutonium	Isotopic Uranium	Strontium 90	VOA (SW 8240)	Semivolatiles (SW 8270)	Metals (SW 6010)	PCB (SW 8080)	TCLP Metals		
	111	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
	112	0.0 - 1.0 in						X	X		X											X	X	X	X		X			X				
Field Duplicate																						X	X	X	X		X			X				

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