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HSWA LANL 1/1106/21-
LA-UR-95-3856

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87501

SUBJECT: SAMPLING AND ANALYSIS PLAN FOR POTENTIAL RELEASE SITES 21-017 (a, b and c)

Dear Mr. Garcia:

Enclosed please find the Sampling and Analysis Plan for Potential Release Sites 21-017 (a, b and c) (Former OU 1106, FU 1). We are submitting it to the New Mexico Environment Department in accordance with the Fiscal Year 1998 Work Schedule.

If you have any questions, please call Dave McInroy at (505) 667-0819 or Joe Mose at (505) 667-5808.

Sincerely,

Julie A. Canepa, Program Manager
Environmental Restoration

Sincerely,

Theodore J. Taylor, Program Manager
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Enclosure: Sampling and Analysis Plan for Potential Release Sites 21-017 (a, b and c)

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Sampling and Analysis Plan for Potential Release Sites 21-017 (a, b, and c)

Environmental Restoration Project
A Department of Energy Environmental Cleanup Program

Los Alamos
NATIONAL LABORATORY
Los Alamos, NM 87545

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Sampling and Analysis Plan for Potential Release Sites 21-017 (a, b, and c)

Produced by the Material Disposal Areas Focus Area

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1.0 INTRODUCTION

This sampling and analysis plan (SAP) describes the Phase I subsurface Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) planned for Material Disposal Area (MDA) U, Potential Release Sites (PRSs) 21-017(a, b, and c). This investigation is part of Los Alamos National Laboratory's (Laboratory's) Environmental Restoration (ER) Project. PRSs 21-017 (a, b, and c) are solid waste management units (SWMUs) under the Hazardous and Solid Waste Amendment and are listed in Module VIII of the Laboratory's hazardous waste facility permit. MDA U is located on the east side of DP Mesa in Technical Area (TA) 21 and consists of two absorption beds [PRSs 21-017 (a and b)] that were used for subsurface disposal of radioactively contaminated liquid wastes and an associated distribution box [PRS 21-017(c)], TA-21-164, that was located between the two beds. The MDA was in operation from 1948 to 1968. A Phase I surface soil RFI was completed in 1994 to define the extent of contaminant migration in surface and near surface soils and to determine if contaminants in these soils were migrating from the area through or into the MDA U drainage. A field report summary of the investigation and analytical data was submitted to the Laboratory in a letter report dated September 22, 1997 (ERM Program Management Company 1997, 58979). This Phase I subsurface soil investigation will provide the additional data needed to determine the nature and extent of contamination beneath MDA U. This SAP is consistent with the subsurface sampling approach outlined in Section 1.5.2, Chapter 16, of the TA-21 work plan (LANL 1991, 7529, p. 16-7).

MDA U is one of approximately 25 MDAs at the Laboratory that can be described as engineered subsurface waste disposal units. These sites offer unique challenges to the ER Project because of complexities associated with inventory, source terms, transport mechanisms, and risk. MDA U was used for the disposal of Manhattan Project era waste; the inventory is poorly documented. The inventory, as well as the nature and extent of potential releases, are difficult to characterize by sampling and analysis because the inventory is below ground surface. While present-day risk to human health and the environment is low, there is a potential future risk if contamination is made accessible by way of one or more transport pathways, including subsurface groundwater transport and biological perturbation. Recognizing that risk will remain low so long as contamination is inaccessible, alternative final remedies include

- inventory removal (and disposal elsewhere) and confirmatory sampling or
- stabilization in place and long-term monitoring.

The MDA core document is being developed, with direct involvement of the New Mexico Environment Department and the Department of Energy (DOE), to standardize and expedite the corrective action process for MDAs and similar PRSs. The core document will prescribe streamlined site characterization and final remedy selection/evaluation. The RFI activities undertaken to characterize nature and extent of contamination at all MDAs and similar sites will be focused on information that is necessary and sufficient to support the corrective action for MDA U. This information includes data needed to perform fate and transport and risk assessment modeling to evaluate alternative remedies to ensure enduring protection of human health and environment.

In the interim, before the core document is completed and approved, RFI activities at MDAs, including those at MDA U, will proceed based on guidance from the MDA core document team to ensure consistency in approach. As a result of such guidance, the objective of this SAP is to reduce uncertainties by collecting sufficient field information to construct the conceptual model of

the site. This includes data related to both nature and extent of contamination (in a bounding sense) as well as environmental setting.

The Laboratory is a multidisciplinary research facility owned by the DOE and managed by the University of California. The Laboratory is located in north-central New Mexico approximately 60 miles northeast of Albuquerque and 20 miles northwest of Santa Fe (Figure 1-1). The Laboratory covers 43 square miles of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons that run from west to east and contain ephemeral and intermittent streams. Mesa tops range in elevation from approximately 6200 ft to 7800 ft. The eastern portion of the plateau stands 300–900 ft above the Rio Grande. TA-21 is located at the northern end of the Laboratory south of State Road 502 and east of the main portion of the Los Alamos townsite (Figure 1-2).

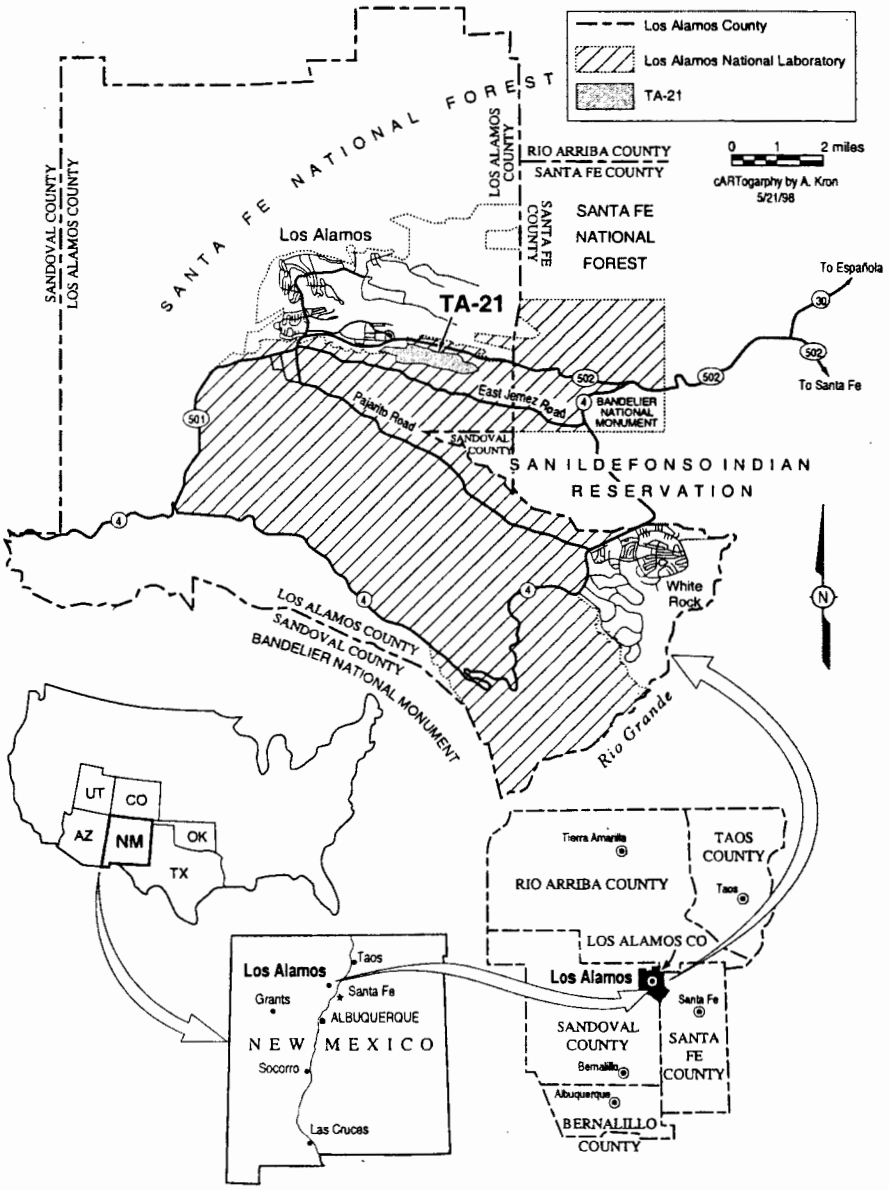


Figure 1-1. Location map of TA-21 within Los Alamos National Laboratory, Los Alamos County, New Mexico.

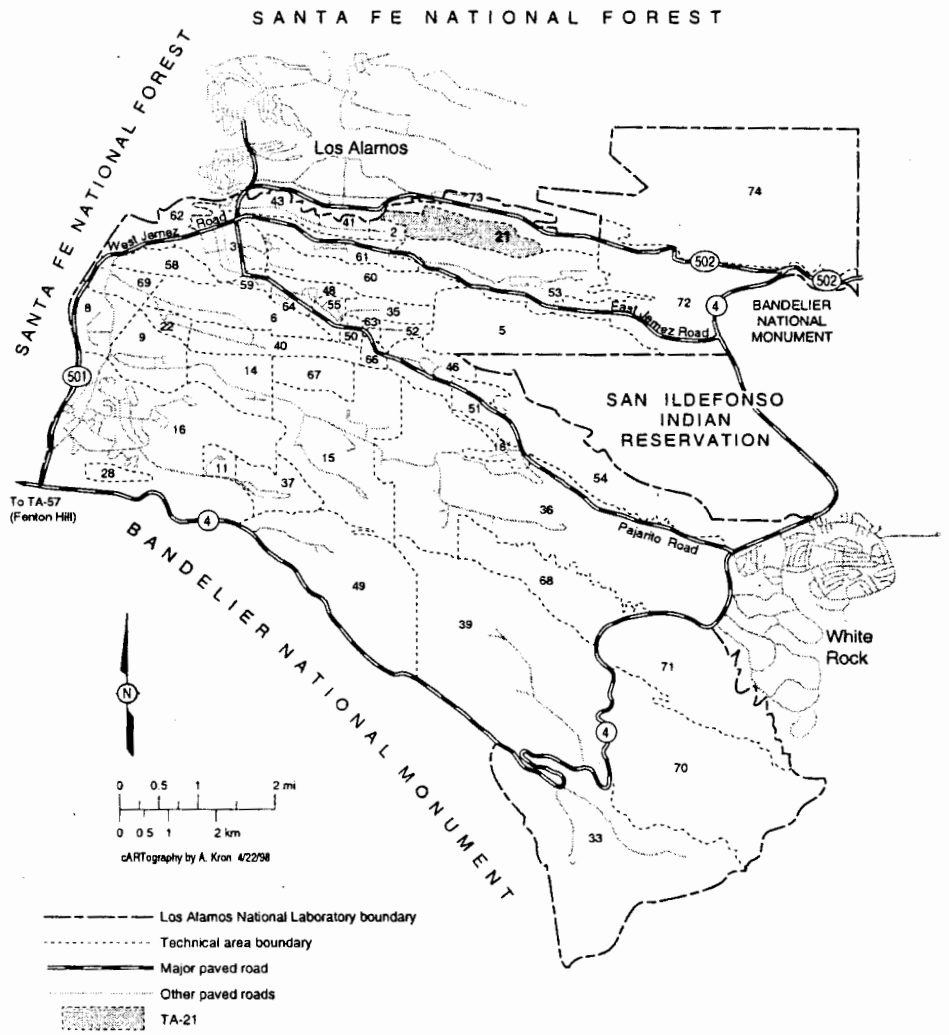


Figure 1-2. Location of TA-21 with respect to Laboratory TAs and surrounding land holdings.

This SAP is organized in four sections. Section 1.0 contains the introduction; Section 2.0 contains detailed information about the site, including a description, operational history, conceptual model, and proposed sampling plan; Section 3.0 presents the data collection design and procedures; and Section 4.0 presents project management details. Appendix A contains acronyms and abbreviations.

1.1 Objectives and Scope

The objective of this investigation is to collect and analyze data to support/allow cleanup decisions at this site. This will be accomplished by

- determining the nature and extent of contamination beneath MDA U,
- determining the volume of contaminated material in the absorption beds,
- investigating the potential presence and effect of a paleochannel in the vicinity,
- providing data to update the MDA U conceptual model, and
- collecting data that will be used to screen alternative remedies for corrective actions at MDA U.

MDA U is within an area surrounded by the Tritium Systems Test Assembly (TSTA), TA-2 (Omega West Reactor), and TA-53 (Los Alamos Neutron-Scattering Center), all potential sources of tritium contamination. Because of the proximity to other sources of tritium, the extent of tritium contamination outside of the boundary of this field investigation will not be pursued. All tritium data obtained in this investigation will be used when tritium is evaluated as a global issue.

Additionally, surface soil samples will be collected to fill in data gaps from the 1994 evaluation of contaminant migration from overflow of the absorption beds.

1.2 Approach and Implementation

This field investigation of the tuff/soil beneath the absorption beds will include vertical borehole drilling to determine the nature and extent of the subsurface contamination. Vertical borehole drilling will also be used to obtain core samples that will be evaluated for fractures under the absorption beds and, if fractures are present, to determine if the they are a pathway for contaminant migration. The core samples from the boreholes will be screened for radionuclides and organics, logged, and analyzed for metals, radionuclides, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and volatile organic compounds (VOCs).

A review of data in Geomorphic Studies at DP Mesa and Vicinity (Broxton and Eller 1995, 58207, pp. 68 and 69) indicates the potential presence of paleochannels across the plateau. A large paleochannel, approximately 30 feet deep by 35 feet wide, that may intersect the MDA U absorption bed was identified during the 1996-97 field work conducted at MDA T. During the MDA U field investigation, core from boreholes along the eastern boundary of MDA U will be investigated for the presence of rounded alluvial material (sand to cobbles) that would indicate the presence of the paleochannel.

Additional surface soil sampling will also be part of this field investigation. Surface soils will be collected and analyzed for actinium daughter products, which were not quantified in the Phase I surface soil investigation. These sampling data will be used to determine whether or not contaminants were released to the surface from the MDA and the extent of potential overflows from the MDA.

1.3 Background Issues

1.3.1 Regulatory Requirements

This investigation, which includes sampling and analysis of SWMUs, is conducted under requirements of Module VIII of the Laboratory's Hazardous Waste Facility Permit, which was issued on May 23, 1990, (EPA 1990, 1585) and modified on May 19, 1994.

An additional standard for radiological contaminants is contained in DOE Order 5400.5, Radiation Protection of the Public and the Environment. In 1993, this DOE order was issued as a proposed rule [proposed 10 Code of Federal Regulation (CFR) 834] in the Federal Register. It covers, among other topics, establishment of dose limits to the public from radiation and radionuclides associated with DOE operations (58 Federal Register 16268). Although radionuclides are regulated by the DOE and are not regulated under RCRA, it is more efficient and cost effective to investigate all types of potential contamination during a single site characterization. Therefore, radiochemical concerns are addressed as part of this SAP.

1.3.2 Other Issues

TA-21 is part of a proposed land transfer. It is expected that land transfer issues will include land-use projections that will affect risk evaluation scenarios, cleanup levels, and stabilization options.

1.4 Data Quality Objectives Process

Data quality objectives (DQOs) are specified in planning sample collection activities to ensure that the appropriate data are collected to support decisions about the corrective action alternatives being evaluated for the site. Determining the DQOs depends upon the following inputs:

- a description of the problem,
- the desired decisions,
- information required to make the decisions about corrective action alternatives for this site, and
- physical boundaries to which the decisions apply.

These inputs are described below.

MDA U contains principally radioactively contaminated liquids that were disposed of in absorption beds (Section 2.1.2). The beds are dry now and have been covered with clean crushed tuff. No data exist on source concentrations in the beds. No subsurface sampling has been done beneath the absorption beds. Data are required to reduce the uncertainties for future decision making at this site including determining

- the nature and extent of any potential releases beneath MDA U,
- whether there was any surface migration, and
- the presence of a paleochannel as a potential transport mechanism.

These data and existing geochemical and mineralogical data of the MDA U area will be used to support the conceptual model for MDA U and TA-21 and to screen alternatives for corrective action at the site. A potential list of alternatives include no further action, placing a final cover over MDA U, excavation and disposal elsewhere of all contaminated material at MDA U, or a combination of the above.

No Further Action or Final Cover Alternatives. To screen a no further action or final cover alternative, it will be necessary to calculate the extent of a release, evaluate how contaminants could migrate from MDA U in time with or without a final cover, and estimate whether or not these alternatives would be protective of humans and ecological receptors. If a final cover is placed over MDA U, it should be designed to limit percolation or rain water through MDA U, limit intrusion, limit the accumulation of moisture under the final cover and therefore limit any existing contaminant migration from the MDA. Future migration rates with and without a final cover will be simulated using data from this sampling program as input to computer models, such as the Finite Element Heat and Mass (FEHM) computer code used in the performance assessment for MDA G. The output of the model will be used by risk assessors to estimate the protectiveness of a final cover.

The data needed to support the computer model include a determination of mineralogical and geochemical properties of the subsurface under MDA U, whether or not contaminants have migrated beneath MDA U, and whether or not fractures are a pathway for contaminant migration.

Existing data on mineralogical and geochemical properties from Borehole 21-2523, near MDA V, will be used in modeling simulations for MDA U (Section 2.2.1.2). MDA V is located on DP Mesa

approximately 3000 feet west of MDA U. No additional data on mineralogical and geochemical properties of the MDA U area will be collected during this subsurface investigation. This subsurface investigation is based on obtaining representative samples within and under each of the absorption beds to characterize the nature and extent of contamination on the soil surface and in the subsurface.

Excavation Alternative. The data required to screen an excavation alternative include nature and extent and volume estimates of contaminated material at MDA U for final disposition/disposal.

Boundary Investigation. The boundary of this investigation for determining the nature and extent of potential subsurface contamination is the area directly beneath and adjacent to MDA U where the greatest chance would be to detect the presence or absence of contaminant migration from MDA U. This field investigation will examine the nature and extent (spatial trends) of contamination beneath and downgradient of MDA U. In addition, the investigation will provide data to assess current human health and ecological receptor hazards and to assess pathways for contaminant migration, including fracture flow. The extent of migration will be evaluated and estimated by studying decreasing trends in contaminant concentrations in and between boreholes.

In 1994, surface soils surrounding the beds were sampled to see if contamination was migrating from them to the drainage north of MDA U. Analytical data suggest that there has been no significant migration of radionuclides on the surface of MDA U and the associated drainage area (Section 2.2.1.2). The boundaries of this investigation for determining surface soil contamination are areas to the north of MDA U where data gaps exist from the 1994 surface sampling program.

The information gathered from this field investigation will be used in the following evaluations:

1. Will the selected alternatives be protective of human health and ecological receptors, and what are the cost/benefit differences among alternatives?
2. What type and extent of final cover is required if a cover is the selected remedy? What benefit is the final cover to achieve?
3. What is the volume of the remaining contaminated material within and beneath the absorption beds, if excavation is the selected remedy?
4. Is further field investigation required?

2.0 PRSs 21-017(a, b, and c), MDA U

2.1 Characterization and Setting

2.1.1 Site Description

MDA U [PRSs 21-017 (a, b, and c)] is an inactive disposal site located north of Buildings 152 and 153 on DP Mesa (Figure 2.1-1); the MDA is fenced on all sides. MDA U covers an area of approximately 0.2 acres (1200 m^2) and contains two absorption beds [PRSs 21-017(a) and (b)]. The TA-21 work plan states that the absorption beds were used for subsurface disposal of radioactively contaminated liquid wastes from 1948 to 1968, and as constructed, the two absorption beds had a surface area of approximately 1800 square feet with an estimated volume of about 18,000 cubic feet (LANL 1991, 7529, p. 16-198). An associated distribution box, TA-21-164 [PRS 21-017(c)], was located between the two beds. The location of the PRSs at MDA U is shown on Figure 2.1-2. The distribution box [PRS 21-017(c)] and associated distribution lines in PRSs 21-017(a and b) were removed in 1985.

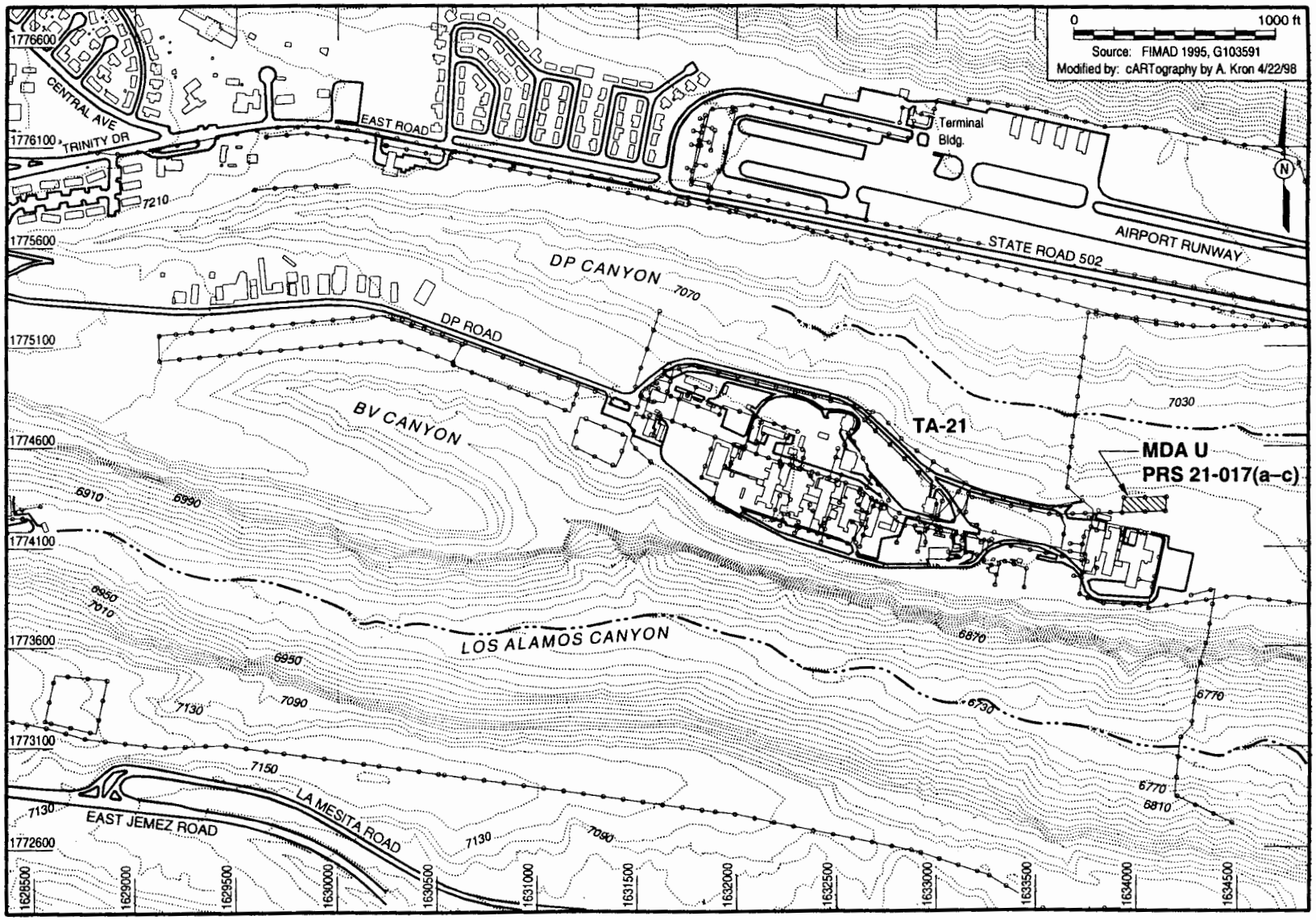


Figure 2.1-1. Location and topography of MDA U at TA-21.

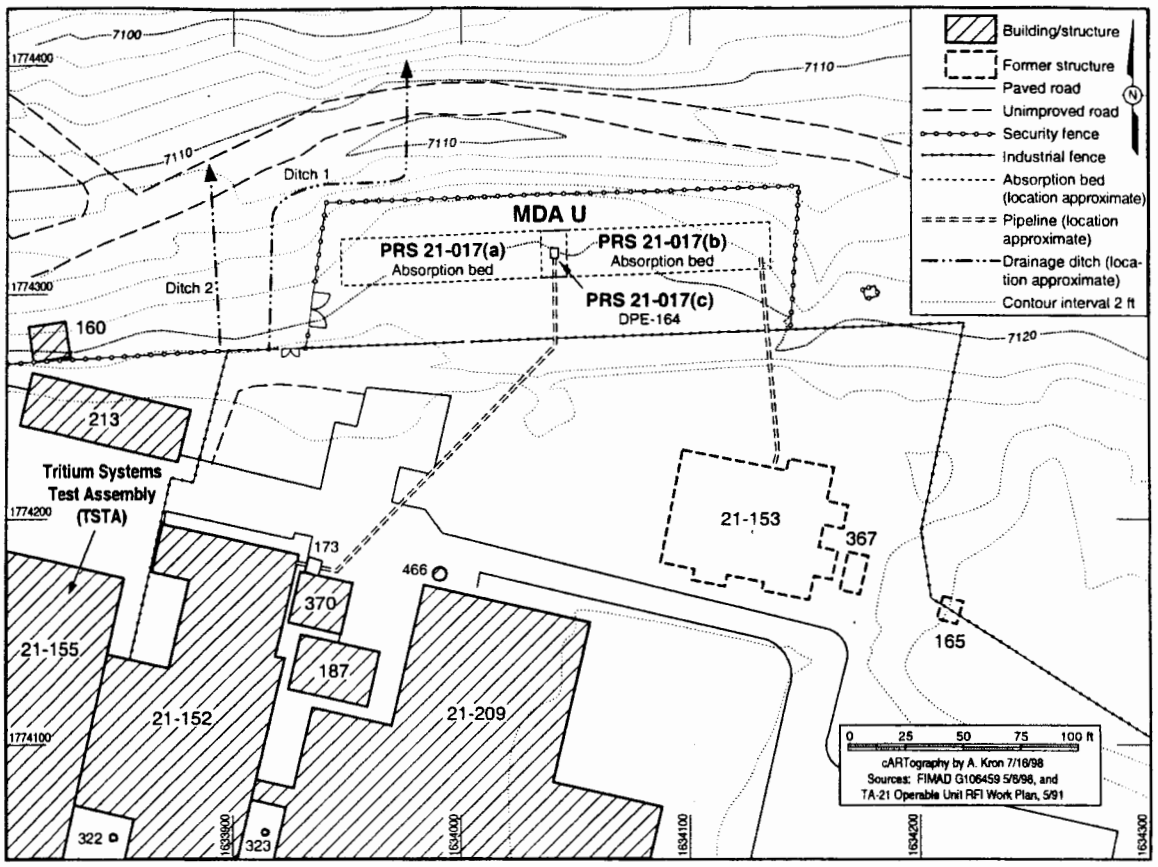


Figure 2.1-2. Locations of PRSs at MDA U, TA-21.

Geologic Setting. Reports of geological studies at TA-21 are presented in Broxton and Eller (1995, 58207). A summary of that information, emphasizing conditions relevant to MDA U, is presented below.

TA-21 is located on DP Mesa at an elevation of 7120–7150 ft, approximately 1200 ft above the regional aquifer. The mesa is bounded on the north by DP Canyon and on the south by Los Alamos Canyon. The generalized stratigraphy of TA-21 is presented in Figure 2.1-3. MDA U is cut into Cooling Unit 3 of the Upper Member (Tshirege) of the Bandelier Tuff. Unit 3 is a cliff-forming, nonwelded to partially welded unit. At this location, the Bandelier Tuff is approximately 710 ft thick. Units exposed on the canyon walls on either side of TA-21 are poorly welded and rather easily eroded in areas near the mesa top and are strongly welded cliff-forming units in the lower areas. The strongly welded units exhibit well-developed fracturing.

Soils. At undisturbed areas at TA-21, moderately to well-developed soils overlie Bandelier Tuff and alluvium. Soils belong to either the Hackroy or Nyjack soil series (Nyhan et al. 1978, 5702). The Hackroy series consists of very shallow to shallow, well-drained soils that have an A-Bt-R profile. Soil textures range from sandy loam to clay. The Nyjack series consists of moderately deep, well-drained soils that have an A-Bt-C-R profile. Texture ranges from gravely sandy loam to clay loam. In the TA-21 area, the R horizon is highly fractured Bandelier Tuff that shows signs of incipient weathering.

Most of TA-21 has been disturbed by construction and 50 years of site operations, with the result that natural soil profiles are, in general, not well preserved. For MDA U, the natural soil profiles

have been disturbed by construction of absorption beds and subsequent site stabilization activities.

Hydrology. The engineering drawing for MDA U (LASL 1945, 1093) shows that the area was graded to route surface drainage around MDA U north into DP Canyon.

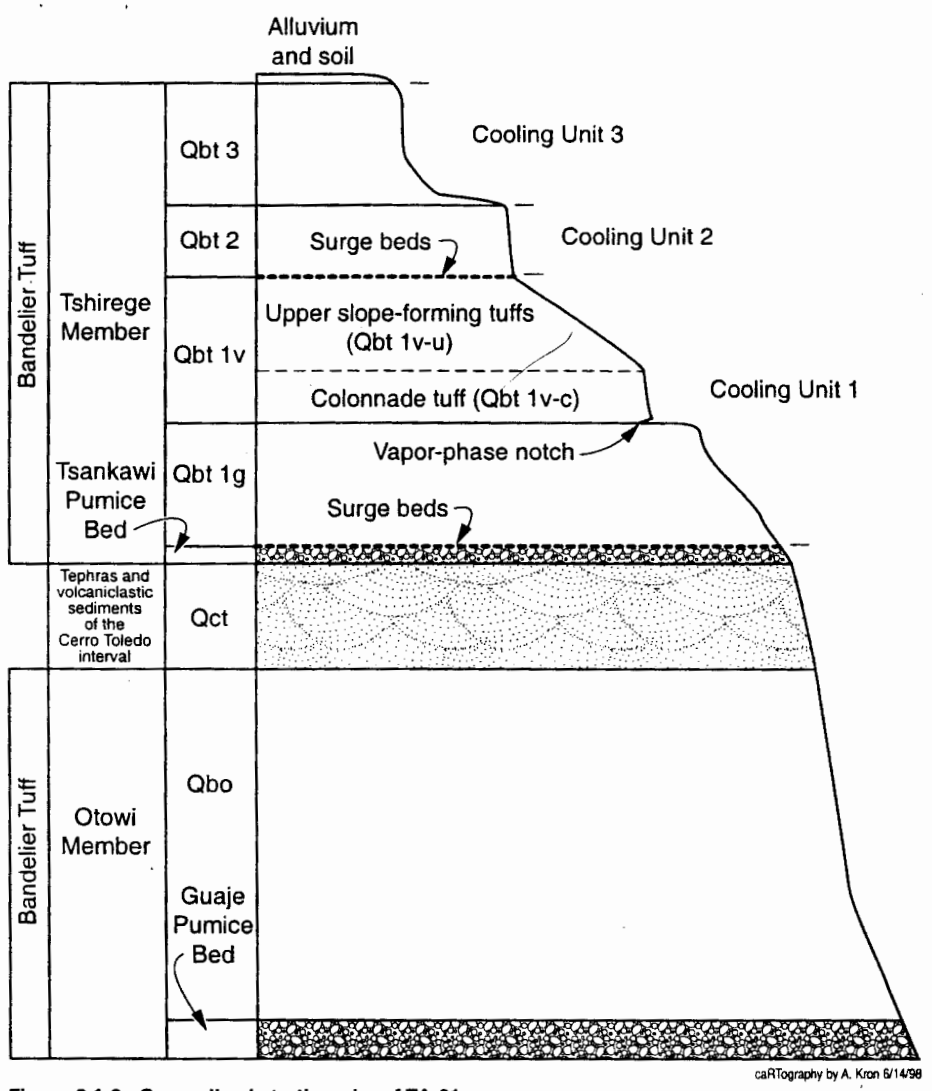


Figure 2.1-3. Generalized stratigraphy of TA-21.

The regional aquifer beneath TA-21 is at an elevation of approximately 5900 ft (determined in Test Well 2 in Pueblo Canyon and in Otowi 4 in Los Alamos Canyon), chiefly within sediments of the Puye and Tesuque Formations (Purtymun 1995, 45344; Broxton and Eller 1995, 58207). Well R-9 was also completed in 1998 at the mouth of Los Alamos Canyon. Thus, for mesa-top sites at TA-21, such as MDA U, more than 1200 ft of tuff and volcaniclastic sediments separate the surface from the regional aquifer. In addition to the regional aquifer, a shallow alluvial aquifer exists in the sediments of Los Alamos Canyon and DP Canyon.

Surface Water Assessment. At the Laboratory, storm water runoff and sediment transport are among the potential migration pathways by which contaminants might be transported to off-site

receptors. Soil erosion is dependent on several factors, including soil properties, the amount of vegetative cover, the slope of the contaminated area, exposure, the intensity and frequency of precipitation, and seismic activity.

The Laboratory's ER Project has assessed sediment transport and erosion concerns at specific PRSs. Surface water assessments (formerly known as 4.5 assessments) provide a basis for prioritizing and scheduling actions to control erosion of potentially contaminated soils at specific PRSs. The procedure is a two-part evaluation. Part A is a compilation of existing PRS analytical data, site maps, and knowledge-of-process information. Part B is an assessment of the erosion/sediment transport potential at the PRS. Erosion potential is numerically rated from 1 to 100 using a matrix system. PRSs that score below 40 have a low erosion potential; those that score from 40 to 60 have a medium erosion potential; and those that score above 60 have a high erosion potential.

A surface water assessment of PRSs 21-017(a, b, and c) was conducted on June 16, 1998. The assessment yielded a score of 8.8 for each PRS. The calculated score included 8.8 for site setting, 0.0 for surface water runoff factors, and 0.0 for surface water run-on factors. This score indicates low erosion potential.

Biological Surveys. Comprehensive plant and animal inventories are required by the Federal Endangered Species Act of 1973; the New Mexico Wildlife Conservation Act; Executive Order 11990, Protection of Wetlands; Executive Order 11988, Floodplain Management; Title 10 CFR Part 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements; and DOE Order 5400.1, General Environmental Protection Program. The MDA U area was addressed in a 1992 biological evaluation (Bennett 1996, 58236).

The preurban natural overstory for this portion of the mesa was a ponderosa pine forest and piñon-juniper woodland ecozone. The understory currently comprises grasses and forbs commonly found in disturbed soils (western wheat grass, Canada bluegrass, bottlebrush squirreltail, cheat grass, sand dropseed, summer cypress, prickly lettuce, and horseweed). There are no threatened or endangered species in the immediate vicinity of this site.

Cultural Surveys. In compliance with Section 106 of the National Historic Preservation Act of 1966 as implemented by 36 CFR 800, Protection of Historic Properties, the subsurface investigation at MDA U was reviewed for possible impacts to archaeological and other cultural resources. According to the information provided in ESH-ID Review 98-0072, the following determination was made on April 27, 1998.

- The area of potential impact is in a previously surveyed location. A cultural resource survey report covering this area has been sent to the State Historic Preservation Office, and concurrence has been received. No known intact archaeological sites remain in the project area. The project can proceed without affecting any known cultural resources. If any buried archaeological artifacts or features are uncovered during sampling, work will stop, and ESH-20 archaeologists will be notified immediately.

2.1.2 Operational History

The following is summarized from information in the TA-21 RFI work plan (LANL 1991, 7529, pp. 16-198 through 16-199).

The DP East area began operation in 1945 at Buildings TA-21-151, -152, and -153. These facilities were used to process polonium and actinium and to produce weapon components. Process waste produced in the various research and production activities consisted of solid and liquid physical form waste. In the late 1940s and early 1950s, it was found that the natural soils and clays at TA-21 were effective in separating radioactive contaminants from waste liquids. Therefore, absorption beds were used, and process effluent was emptied into trenches filled with absorption material consisting of cobble, gravel, and fine sand (LASL 1945, 1093). One of the areas at which the absorption beds were located was MDA U.

The TA-21 work plan (LANL 1991, 7529) references a 1945 memorandum (Veltman 1945, 1305) that described in some detail what are believed to be the design requirements for the MDA U absorption beds. The memorandum stated the requirements as follows:

"...provision would be made to handle the so-called process sewage from Buildings 2, 3, 4, 5 and 52 in the following manner. A pit will be dug on the north side of the mesa approximately 6-ft deep and 10 x 50 ft in area for Building 52. A graded gravel bed will fill this pit with relatively large stones in the bottom and ordinary soil on top. This arrangement will allow satisfactory draining of process sewage."[1]

A portion of a Laboratory engineering drawing (LASL 1945, 1093), which illustrates the design of the MDA U absorption beds, is shown in Figure 2.1-4.

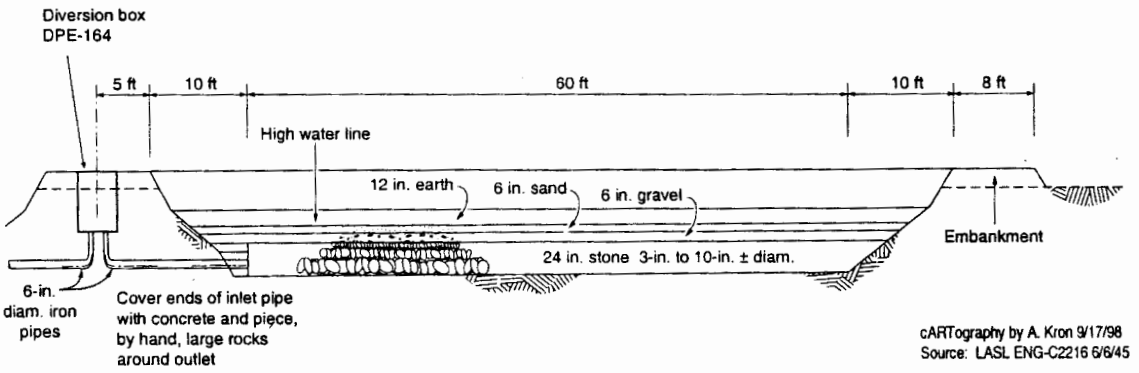


Figure 2.1-4 Section view of MDA U absorption bed.

Liquid effluents from Buildings 21-152 and 21-153 and from the TSTA were drained to the MDA U absorption beds. In addition, oil from precipitrons was disposed of at MDA U (Drager 1946, 1562). Historical records for MDA U state that the primary contaminant released to MDA U was polonium-210 (Christenson 1973, 0940), which has a half-life of 138.4 days and would have since decayed to undetectable levels. A 1946 memorandum (Tribby 1946, 1540) indicates that plutonium, as well as polonium, was measured in effluent. Records also indicate that about 2.5 Ci of actinium-227 was discharged into the MDA U absorption beds in 1953 (Christenson 1973, 0940). The actinium came primarily from the effluents of Building 21-153, a filter building where actinium-227 was scrubbed out of the air from several process buildings at TA-21 (DOE 1979,

[1] Buildings 52 and 53 were renumbered to 152 and 153. This quote is referring to what is called Building 152 in this section.

8610). A drain line from the TSTA cooling tower was found in the west absorption bed [PRS 21-017(a)] (Mayfield 1985, 1172).

In 1968, disposal of liquid effluents at MDA U from Buildings 21-152 and 21-153 ceased (Hakonson 1987, 7422). The absorption beds continued to receive cooling water effluent from the TSTA cooling tower until sometime after 1976 (Purtymun 1976, 1107). In 1985, site stabilization efforts began. The distribution box and pipelines within the beds and a portion of the line from the cooling tower were excavated and taken to MDA G at TA-54 (Figure 2.1-5). The material above the pipelines was excavated, stockpiled, and used to backfill the pipeline trench. The area between the top of the beds and the embankments surrounding the beds was backfilled with uncontaminated tuff. A plastic lining was placed in the beds to indicate the boundary between clean and contaminated material; the area was covered with 6 in. of top soil, regraded to address several drainage problems, and revegetated (M. Salazar, Los Alamos National Laboratory, personal communication with J. Hopkins, June 18, 1998).

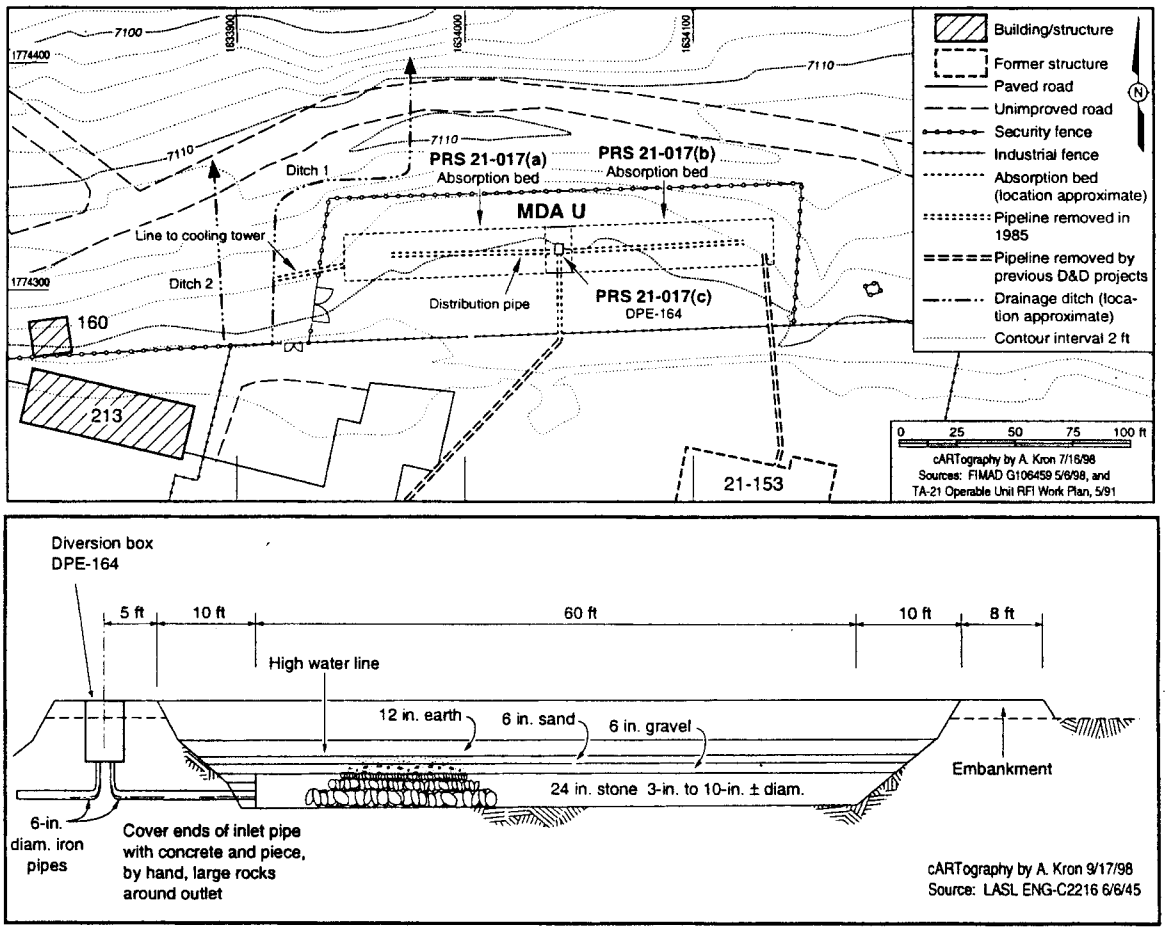


Figure 2.1-5. Schematic of 1985 stabilization activities at MDA U.

In 1987, additional site stabilization was completed including the construction of ditches along the south fence of MDA U to prevent run-on, the placement of topsoil and mulch, and reseeding inside the fence. Four brass markers were placed at the corners of the MDA. In 1990, additional run-on controls were constructed to prevent runoff from the surrounding area from flowing across

MDA U (T. E. Hakonson, Los Alamos National Laboratory, personal communication with W. Polzer, April 16, 1990).

2.1.3 Waste Characteristics

This section addresses the potential contaminants that may be present at this PRS, based on the information contained in Section 2.2, Site Description, and Section 2.1.2, Operational History. The following information was published in the TA-21 RFI work plan (LANL 1991, 7529, p. 16-199).

"Existing information on waste discharge is scant. It is known that the primary contaminant of waste discharged to the two beds was 210Po (Christenson 1973). Although the amount of 210Po discharged is unknown, its half-life of 138.4 days indicates that it has decayed to undetectable levels. Christenson (1973) also stated that these beds received 2.5 Ci of 227Ac in 1953. Actinium-227 came principally from the effluents of filter building 153, which scrubbed 227Ac out of the air in several process buildings at TA-21 (Department of Energy 1979). Identification of other wastes at MDA U must come from sampling data. 227Ac has a half life of about 21.8 years. A rough decay correction of two half-lives indicates the 1953 release to MDA U would have decayed to about 0.63 Ci of 227Ac by 1996.

A Purtymun (1976) memo stated that on December 18, 1975, water from a cooling process was being released into the west pit from a nearby building. At that time, there appeared to be permanent water in the west pit, although no overflow into the adjacent drainage was observed."

Information on polonium-210 and actinium-227 decay is shown in Figures 2.1-6 and 2.1-7. In addition, the operational history indicates the presence of tritium, plutonium, uranium-235, gamma radiation, and contaminated oils from precipitrons. The sampling investigation will include analysis for PCBs in case PCBs were present in oils.

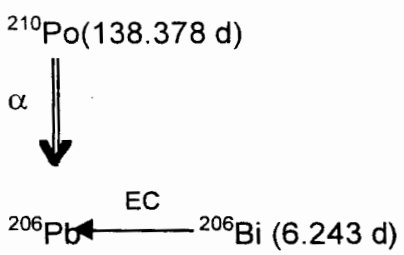


Figure 2.1-6. Information on polonium-210 decay.

2.2 Investigatory Approach

2.2.1 Existing Data

2.2.1.1 Nonsampling Investigations

Geologic Field Investigations. During 1992 and 1993, geologic field investigations were conducted to support the RFI of TA-21. The investigations included studies of the site geology, fractures, stratigraphy, petrography, mineralogy, and geomorphology. These investigations are summarized in the report Broxton and Eller (1995, 58207). The results pertaining to fractures and cliff retreat are summarized below.

- A total of 1662 fractures was documented and measured along a 7312-ft section of Los Alamos Canyon on a line parallel to MDA B through MDA U. NE-striking fractures are

approximately 30% more abundant than NW-striking fractures. Furthermore, the NE-striking fractures are over three times more abundant than south-dipping ones. Hence, as a first approximation, slant drilling in the direction S48E should optimize fracture intersections.

- Available data on the cliff-retreat process at TA-21 confirm that MDA U is more than 50 ft from the cliff edge. The potential for exposure of buried waste resulting from the retreat of the slopes is unlikely within the next 10,000 years or more.

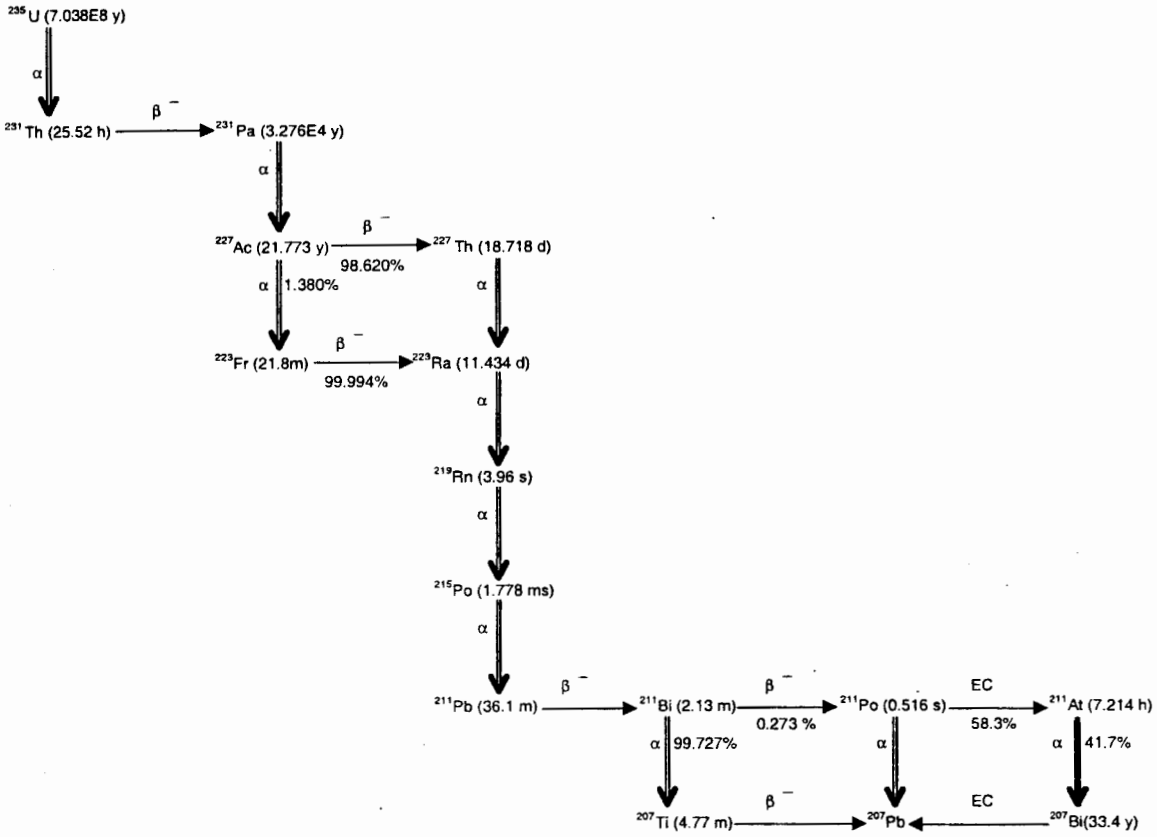


Figure 2.1-7. Information on actinium-227 decay.

Characterization of Mineralogy and Geochemical Parameters. A report on the geohydrology of TA-21, including borehole 21-2523 near MDA V (a 300-ft borehole referred to as V-DP in the work plan), is under preparation. Data (from the geohydrology report) on mineralogy and geochemistry of the TA-21 area will be used to support any future conceptual modeling required to analyze remedial alternatives for MDA U.

2.2.1.2 Sampling

Surface Soil Investigations. In 1976, soil samples were collected outside and within the absorption beds, which were still uncovered at the time. These samples (Table 2.2-1) indicated elevated gross alpha levels both inside and outside the fence (LANL 1991, 7529).

In 1980, soil, tar, and vegetation samples were collected from three locations at MDA U: at the west end of the west absorption bed [PRS 21-017(a)], at the east end of the east absorption bed [PRS 21-017(b)], and at the northeast corner just outside the fenced area (LANL 1991, 7529).

The data (Table 2.2-2) show low levels of plutonium contamination (17.5 pCi/g) on the west absorption bed and actinium-227 daughters in the tar on the east absorption bed. The tar may have originated from oil from precipitrons (Drager 1946, 1562). Tritium was also observed in elevated concentrations (37,000 pCi/L) in soil from the east absorption bed. Uranium concentration was highest on the west absorption bed (26 μg/g). Tritium concentrations in vegetation from the absorption beds indicated levels of contamination of 7200 pCi/L. Gamma radiation on absorption bed surfaces ranged up to ten times the background level used for the study.

TABLE 2.2-1
1976 ANALYTICAL RESULTS FOR GROSS ALPHA AT MDA U

Group H-7 Analysis (12-12-75)		
Description	**Gross Alpha[a] (d/m/g)**	**Gross Alpha (pCi/g)**
Soil 0–2 in. (east pit)	7360	3345
Soil 2–4 in. (east pit)	730	331
Muck surface (west pit)	1990	904
Soil surface (outside fence)	12.5	6
Soil surface (drain 2)	7.4	3
Water (west pit)	40	18
Water (drain 2)	148	67
Group H-8 Soil Analyses (12-22-75)		
Description	**Gross Alpha[b] (d/m/g)**	**Gross Alpha (pCi/g)**
Surface (drain 1)	<44	<20
Surface (same H-7 location 4)	120	55
Surface (same H-7 location 3)	<44	<20
Surface (composite road)	<44	<20
Surface (slope)	<44	<20

a. Acid leach
b. Direct soil counting with zinc sulfide gross alpha detection system

In 1984, soil samples were collected at 12 locations around MDA U. Only one location was within the fence. Samples were collected at three depths: 0–1 cm, 1–10 cm, and 10–30 cm. Samples were analyzed for tritium, uranium, and plutonium-239/240 (Figures 2.2-1, 2.2-2, and 2.2-3); however, not all locations and depths were analyzed for each radionuclide. In the 0–1-cm profile, the maximum background study levels for tritium, uranium, and plutonium-239/240 were exceeded in 42, 83, and 100 percent of the samples, respectively. Contour maps generated from

these data illustrate that tritium concentrations were greatest at the southeast end, outside of MDA U. Concentrations of uranium were greatest inside MDA U. Plutonium-239/240 concentrations were greatest to the north of MDA U. Generally, for all three radionuclides, contaminants present in the 0–1-cm depth were also present in the 1–10-cm depth. However, in the 10–30-cm-depth interval, plutonium-239/240 contamination exceeded maximum study background levels in only one sample indicating that the plutonium in the shallower intervals is from airborne dispersion. Uranium was present at the same concentrations in all three depth intervals. No data were available for tritium in the 10–30-cm interval.

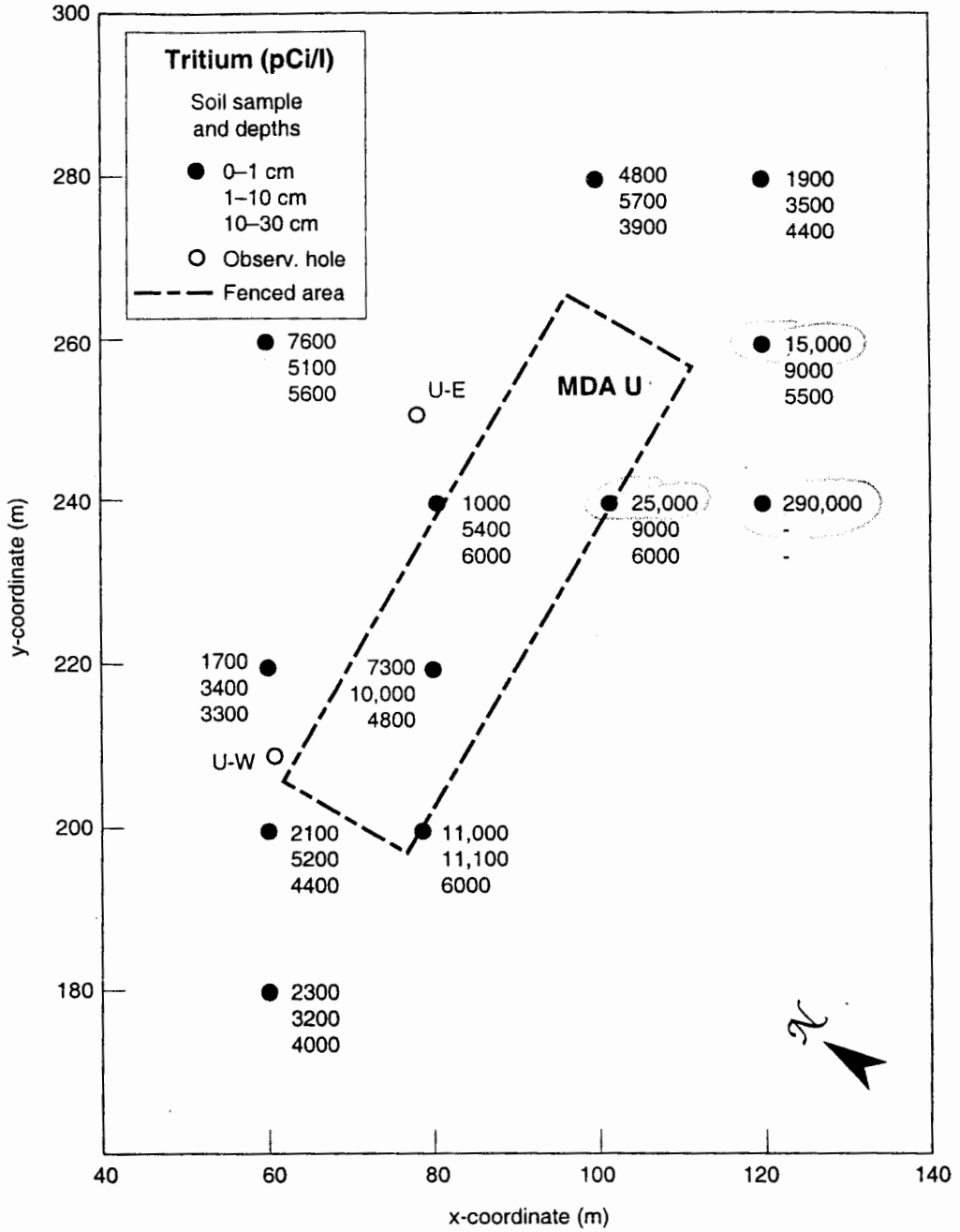
TABLE 2.2-2
SELECTED RADIONUCLIDE ANALYSES FOR 1980 SOIL AND VEGETATION SAMPLES

Soil					
Location	**Depth (cm)**	**Tritium (pCi/L[a]) 7200[b]**	**Total Uranium (μg/g[c]) 3.4[b]**	**Plutonium-239/240 (pCi/g[c]) 0.023[b]**	**Gamma Spectroscopy**
U-1	0–1	2700±400	26.1±2.6	Tracer swamped	Total uranium is highly enriched with uranium-235
	1–10	3900±400	25.6±2.6	17.5±0.3	
	10–30	3800±400	10.9±1.1	2.2±0.0	
U-2	0–1	37200±800	7.0±0.7	2.4±0.1	Actinium-227 daughters in great abundance
	1–10	11800±500	6.3±0.6	2.2±0.1	
	10–30	27300±700	4.3±0.5	0.1±0.0	
U-3	0–1	10600±500	4.7±0.5	1.6±0.0	Normal
	1–10	6500±500	4.4±0.5	2.5±0.1	Normal
	10–30	5400±500	4.5±0.5	2.0±0.1	Normal

Vegetation			
Location	**Species**	**Tritium (pCi/L[d]) 800+[e]**	**Plutonium 239/240 (pCi/g[f]) .00023[g]**
U-1	Salix sp.(willow)	7200±400	0.8±0.1
U-2	Pinus pon. (ponderosa)	5800±300	0.6±0.0
	Bromus tec. (downy chess)	-9800±1300	1.1±0.1
U-3	Guttierezia s. (snakeweed)	3300±300	0.2±0.0
	Bromus tec (downy chess)	-800±300	2.3±0.1
	Artemesia car. (wormwood)	300±300	1.8±0.0

a. Liter of soil moisture
b. Upper limit background levels from Purtymun et al. (1987, 6687)
c. Gram of soil
d. Liter of tissue moisture
e. Background value from Purtymun et al. (1987, 6687)
f. Gram of ash
g. Upper limit background level from the Environmental Surveillance Group (ESG 1987, 7431.2)

In 1985 and 1987, the distribution box and lines at MDA U were removed, and the beds were covered with clean tuff. Therefore, previous surface data now represent the area beneath the clean tuff.



soil backgrou.
760 pCi/kg

Figure 2.2-1. MDA U tritium data for soils (pCi/l) from 1984.

In 1994, a Phase I RFI surface investigation of MDA U was conducted to identify areas of surface contamination at MDA U and between MDA U and the edge of DP Canyon and to determine if contaminants are migrating from the area through or into the drainage channel. The 1994 investigation also evaluated the effectiveness of the 1985 and 1987 stabilization activities and provided information about erosion patterns. The locations of samples taken during the 1994

investigation are shown on Figure 2.2-4. A radiological survey of MDA U was performed, 62 soil samples were collected in a grid covering the entire MDA and extending to the DP Canyon edge, and 15 sediment samples were collected in the drainage. Seventy-seven soil and sediment samples were sent to a fixed laboratory for analysis for radionuclides (tritium, total uranium, plutonium isotopes, strontium-90, and gamma-emitting radionuclides by gamma spectroscopy), SVOCs, and inorganic chemicals (ERM Program Management Company 1997, 58979). The data are summarized in Table 2.2-3 (Appendix B). The analytical data are included in the Phase I RFI field summary report (ERM Program Management Company 1997, 58979). The conclusions and recommendations from the report are stated below.

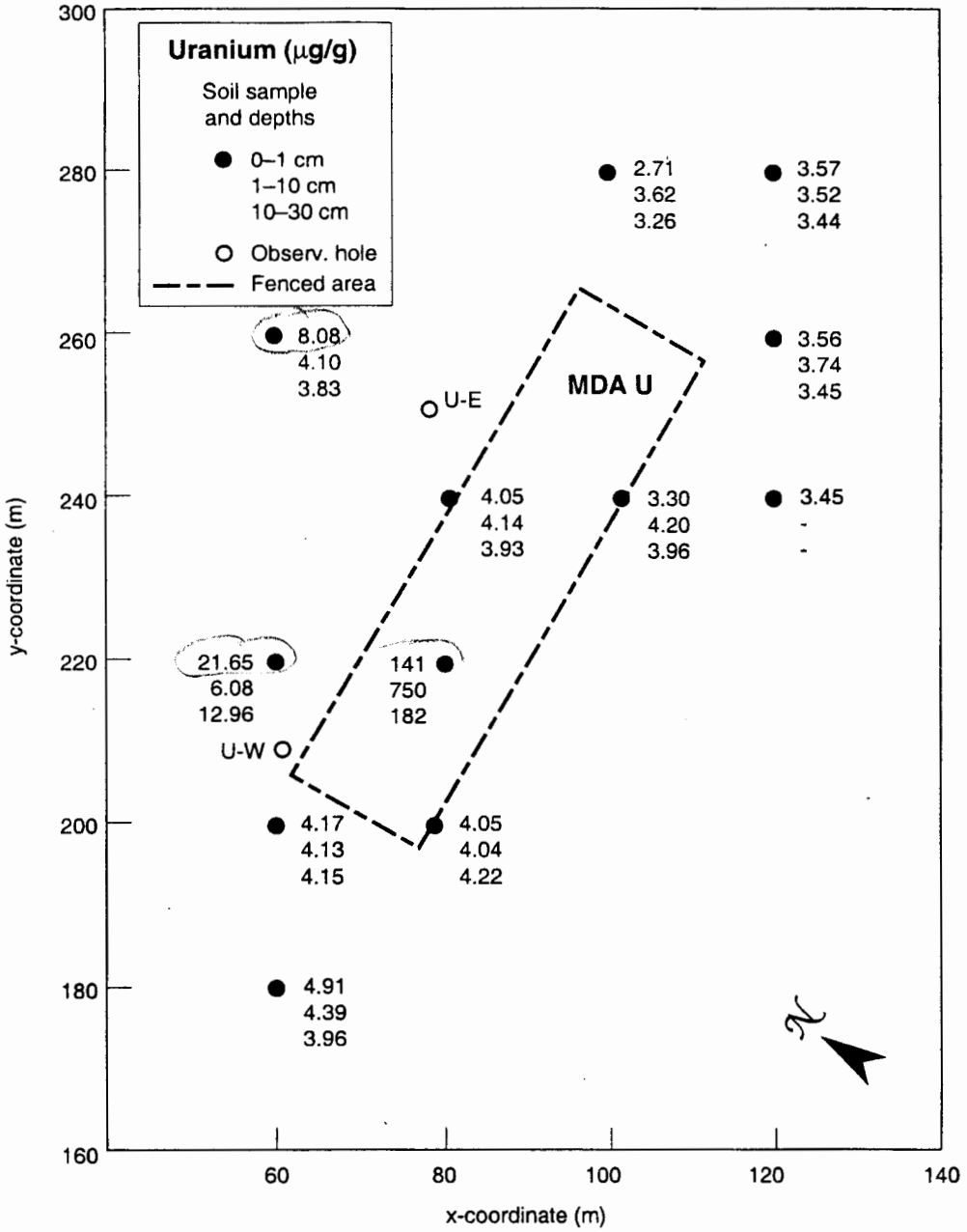
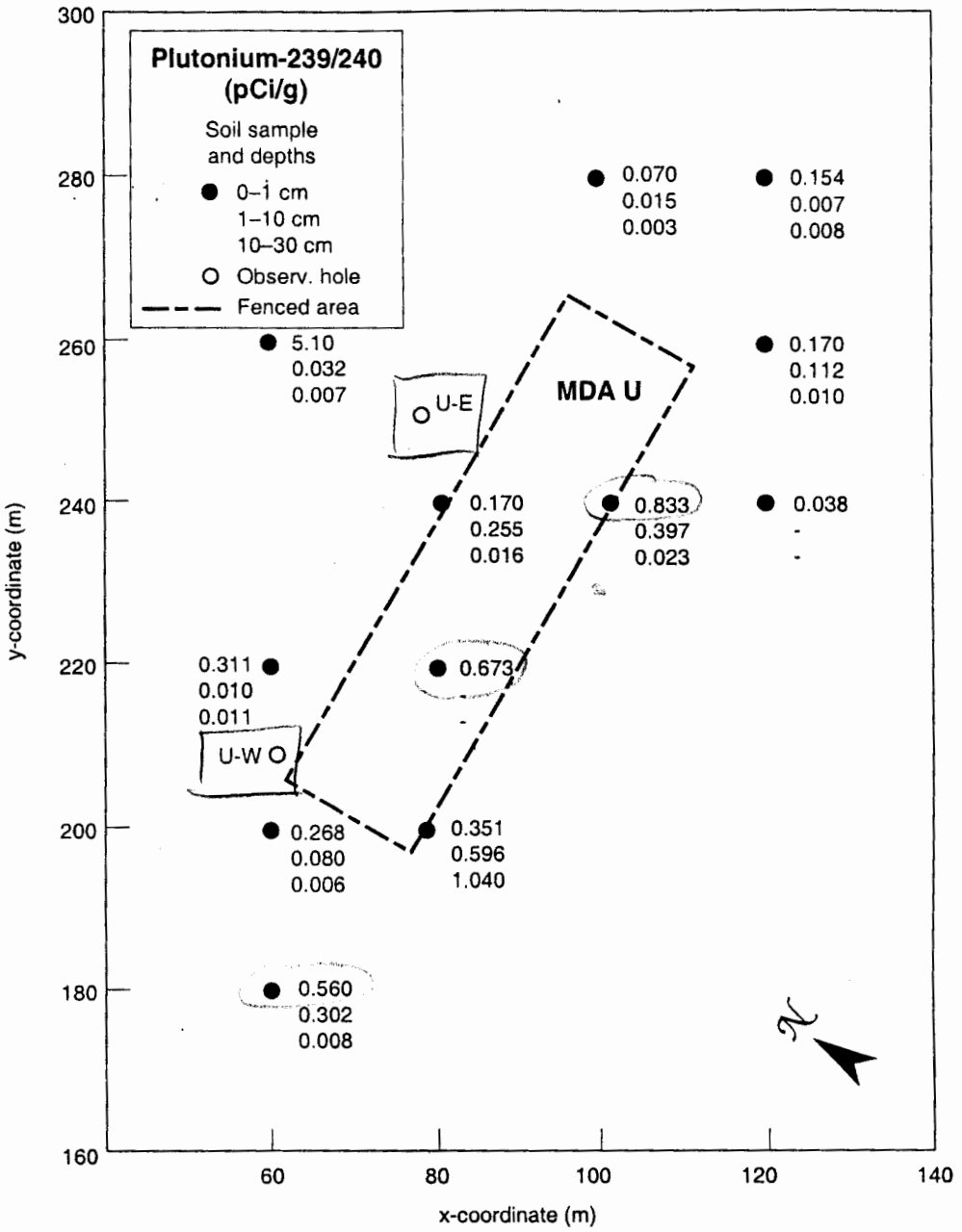


Figure 2.2-2. MDA U uranium data for soils (µg/g) from 1984.



soil backgrou.
0.054 pC

Figure 2.2-3. MDA U plutonium-239/240 data for soils (pCi/g) from 1984.

"Results of the radiation survey do not suggest radioactive contaminant migration across the surface of MDA U. Preliminary review of the results of laboratory analyses confirm radiation survey results and suggest that there has been no significant migration of radionuclides on the surface of MDA U and the associated drainage area; however, specific information on concentrations of actinium-227 daughters is not available. Although actinium-227 daughters may not be present because MDA U was covered with clean tuff in 1985 (which is supported by results of the radiation survey), this determination requires analytical data. To resolve the issue, it is recommended that additional surface samples be collected during the subsurface investigation and analyzed specifically for actinium-227 daughters.

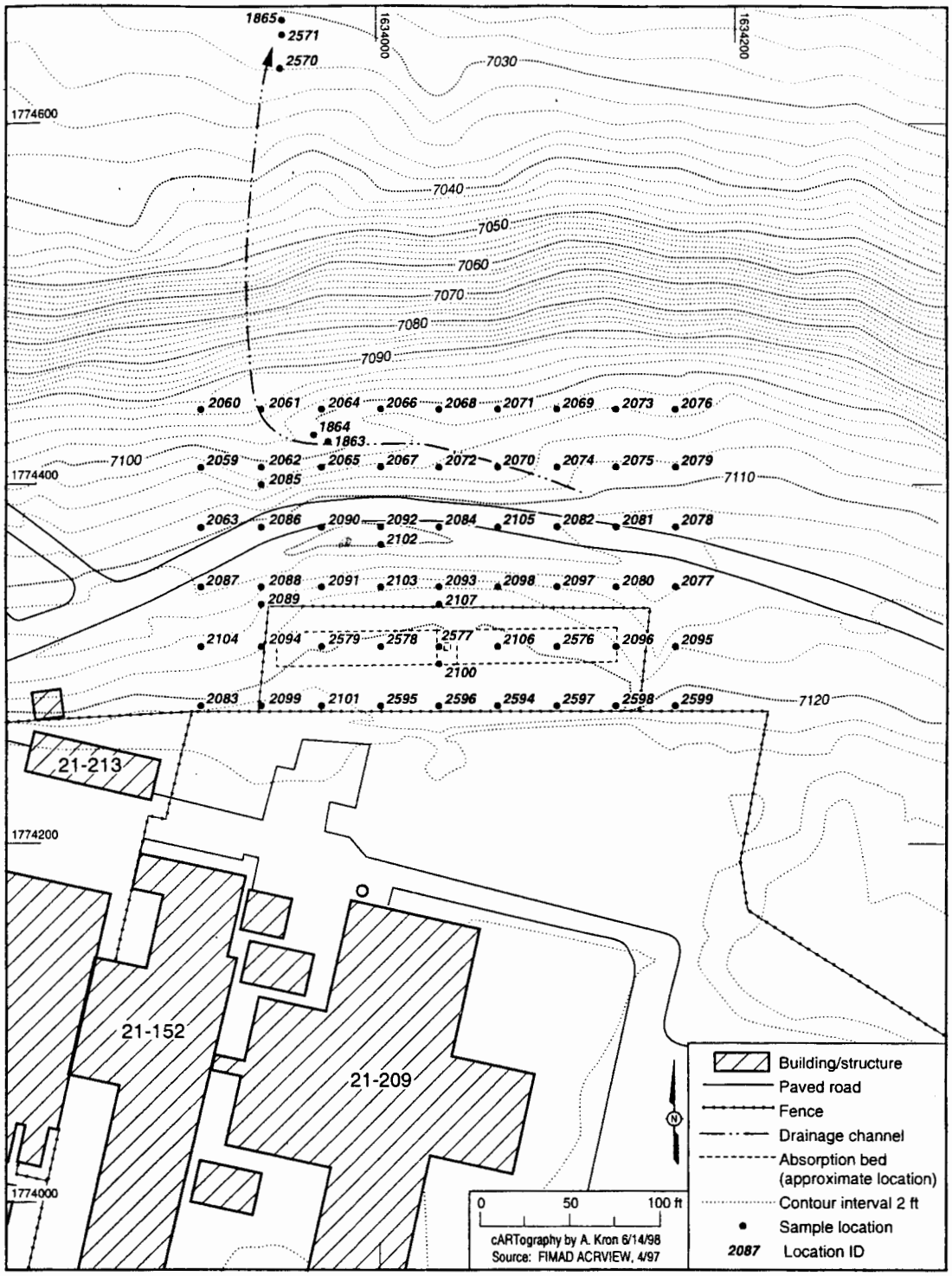


Figure 2.2-4. Surface soil sampling locations at MDA U in 1994. TRITIUM

Preliminary review of the results of laboratory analyses also suggests that there has been no significant migration of inorganic or semivolatile organic compounds on the surface of MDA U and the associated drainage area.

Based on these results, initial investigations at MDA U surface and drainage areas indicate that previous stabilization activities were effective in preventing contaminant migration and that significant concentrations of contaminants have not eroded from the MDA U surface into the associated drainage area."

Subsurface Soil Investigations. A 1983 subsurface sampling study collected samples from two boreholes immediately north of MDA U (LANL 1991, 7529, pp. 16–201, 209, 215, and 221). At each location, samples were collected at 12 depths ranging from 0 to 16.2 m. The samples were analyzed for tritium, uranium, and cesium-137 (Table 2.2-4). Locations of test holes U-E and U-W are shown on Figures 2.2-1, 2.2-2, and 2.2-3. Tritium values in both holes at all depths exceeded the maximum study background level. In the east hole, tritium levels increased with depth, ranging from 19,000 to 78,000 pCi/L. In both holes, uranium values exceeded the maximum study background level in over 80 percent of the samples, and concentrations did not vary appreciably with depth. All cesium-137 values were below the maximum study background level. Apparently, samples were not analyzed for actinium-227 daughters.

2.2.2 Conceptual Model

Water and liquid wastes are perceived as the key components for contaminant release and migration at MDA U. The beds received liquid wastes for 20 years and then cooling water for an additional eight years. Contaminants that may be found beneath MDA U are a result of any releases from the unit during its operational period. Potential transport mechanisms are surface migration before cover placement, direct migration in tuff, and flow in fractures beneath the beds during the MDA U operational period or flow in a paleochannel that may be beneath MDA U. Any migration of contaminants in tuff or in fractures since operations ended (from precipitation and infiltration) would be minor compared to a release caused by the pressure head of water in the beds during operation.

In 1985, the area between the beds and the embankments surrounding the beds was backfilled with uncontaminated tuff, which significantly reduced the probability of contaminated surface soil migrating and reduced the potential for infiltration. Because of its low surface water assessment score, near-term erosion is not considered a key component for contaminant migration at MDA U. Water that infiltrates into the remaining contaminated material in the absorption beds can lead to enhanced percolation of water and associated waste solutes out of the burial environment.

2.2.2.1 Nature and Extent of Contamination

The nature and extent of potential contaminants within and beneath MDA U are not currently known. Records of the materials that were disposed of at MDA U consist of employee interviews and reports from the operational history of facilities at TA-21. No sampling of the material remaining in or under the absorption beds or the area under the distribution box has been conducted. Two vertical bores drilled north of MDA U in 1983 (Section 2.2.1.2) indicated tritium contamination at depth downgradient of absorption beds and some possible uranium contamination.

The boundaries of the extent of any potential subsurface contaminant migration at MDA U range from being only within the sand, gravel, and cobbles in the absorption beds to the tuff immediately beneath the absorption beds and potentially to a paleochannel in the area. The absorption beds received liquids from 1945 through 1976. Any migration from the absorption beds would have been water driven and could have resulted in migration into the tuff below the absorption beds.

TABLE 2.2-4

1983 VERTICAL DISTRIBUTION OF SELECTED RADIONUCLIDES IN TEST HOLES NORTH OF MDA U

Test Hole U-E			
Depth (m)	**Tritium (pCi/L) 7200***	**Total Uranium (μg/g) 3.40***	**Cesium-137 (pCi/g) 1.09***
0–0.9	19000±2000	3.79±0.18	0.18±0.07
0.9–1.5	11700±1200	3.76±0.18	0.10±0.04
1.5–2.4	10100±1000	3.46±0.18	0.09±0.04
2.4–4.0	13500±1400	3.75±0.18	0.03±0.03
4.0–5.5	10200±1000	3.49±0.18	0.08±0.04
5.5–7.0	17700±1800	3.65±0.18	0.06±0.05
7.0–8.5	11100±1100	3.19±0.18	0.04±0.07
8.5–10.1	18100±1800	3.09±0.18	0.02±0.03
10.1–11.6	31000±3000	3.75±0.18	0.06±0.03
11.6–13.1	47000±5000	3.41±0.18	0.06±0.03
13.1–14.6	66000±7000	3.67±0.18	0.08±0.04
14.6–16.2	78000±8000	3.48±0.18	0.09±0.05
Test Hole U-W			
Depth (m)	**Tritium (pCi/L) 7200***	**Total Uranium (μCi/g) 3.40***	**Cesium-137 (pCi/g) 1.09***
0–0.9	7800±800	4.75±0.18	0.16±0.07
0.9–2.4	9200±1000	3.88±0.18	0.01±0.04
2.4–4.0	39000±4000	3.70±0.18	0.02±0.07
4.0–5.5	9000±900	3.80±0.18	0.07±0.03
5.5–7.0	9300±1000	3.63±0.18	0.06±0.05
7.0–8.5	8300±900	3.27±0.18	0.10±0.05
8.5–10.1	9600±1000	3.70±0.18	0.02±0.04
10.1–11.6	9300±1000	3.52±0.18	0.06±0.03
11.6–13.1	7100±700	3.51±0.18	0.08±0.04
13.1–14.6	8900±900	3.55±0.18	0.16±0.06
14.6–16.2	11400±1200	3.51±0.18	0.04±0.03
16.2–17.6	8900±900	3.11±0.18	0.04±0.03

~53'

~58'

* Upper limit background levels from Purtymun et al. (1987, 6687)

Contaminated oil from precipitrons was disposed of at MDA U. Although no records are available on the nature of this oil, PCBs will be included in the analytical suite for surface and subsurface soils.

2.2.2.2 Fate and Transport

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 moisture to enter the subsurface regime.

Movement of liquids in the Bandelier Tuff is dominated by unsaturated flow processes because of the typically low moisture contents that exist. 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. 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. Fractures may affect liquid transport. Their role is hypothesized to be dependent on the soil water content. Above a critical water content, fractures may facilitate flow and transport. Below the critical water content, rock matrix properties will dominate the hydraulic response.

As part of a performance assessment report prepared for MDA G, computer simulations of groundwater flow and radionuclide transport in the vadose and saturated zones beneath MDA G were performed (LANL 1997, 57523). It was estimated that a nuclide with a distribution coefficient (a measurement of the affinity of a groundwater solute to sorb onto the soil matrix) greater than 2.5 milligrams per liter would not reach the saturated zone within 10,000 years. Batch sorption tests performed on Bandelier Tuff samples resulted in a distribution coefficient of Kd of approximately 4 milligrams per liter for plutonium and 130 milligrams per liter for actinium. Therefore, plutonium and actinium, because of their large affinity to sorb to the soil matrix and very low water solubility, may be considered virtually immobile. The subsurface conditions at MDA G are similar to those at MDA U, and the estimates on contaminant transport would also be similar.

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, atmospheric pressure changes, and ventilation of subsurface rock units. Fractures may be facilitators of gas exchange both within the rock and with the atmosphere.

Information on the fate of chemicals of potential concern (COPCs) at MDA U, which were identified in the TA-21 work plan, is summarized below.

Radionuclides. Certain radionuclides behave similarly in the environment because of their chemical properties. Radionuclides suspected to be present at MDA U can be grouped as nonmetals and actinides. The following information is summarized from Whicker and Schultz (1982, 58209, pp. 147–162).

Tritium, a nonmetal isotope of hydrogen, has a half-life of about 12 years. In the form of tritiated water, tritium generally follows the hydrologic cycle. Tritium released in liquid form can be diluted

by water and is subject to physical dispersion, percolation, and evaporation. Tritium readily enters plants by way of the roots.

Cesium-137 is a light metal. Cesium-137 has a half-life of about 30 years. Soils and sediments of high clay content can effectively immobilize cesium by chemical binding, thus acting as a sink for cesium-137. Sandy soils with a low cation exchange capacity allow for the cycling of cesium through the system for long periods of time. The physiological and ecological behavior of cesium-137 is similar to that of potassium, an essential nutrient. A scarcity of potassium in the environment will usually lead to an increase in cesium-137 accumulation in the biota.

Actinium, americium, plutonium, and uranium are all actinides. In general, the actinide nuclides form comparatively insoluble compounds in the environment and are not considered biologically mobile. The actinides are transported in ecosystems mainly by physical and sometimes chemical processes. Uptake of actinides by plants from soil is generally considered to be low. Plutonium in the environment undergoes hydrolysis and oxidation with plutonium oxide as a common form. Under most environmental conditions, plutonium occurs in forms that are poorly transferred across biological membranes; therefore, movement of plutonium from soil and sediments to plants and animals is greatly inhibited.

Polonium is generated by the natural decay of thorium-232, uranium-238, and uranium-235. Most radioisotopes of polonium are very short-lived with the exception of polonium-210, which has a half-life of about 138 days.

Organic Chemicals. The only organic chemical that may have been disposed of at MDA U is PCBs, which could have been associated with oil or tar from the precipitrons. PCBs are not very soluble and tend to exist sorbed to surfaces, so, if present, they would most likely be found in soils and cobbles in the absorption bed and in the tuff immediately below the absorption beds and not mobilized into the subsurface. No SVOCs were detected in the 1994 Phase I surface sampling investigation.

Chemical properties, such as water solubility, adsorption coefficient (Koc), the octanol water partition coefficient (Kow), and vapor pressure, of organic chemicals help determine the fate and transport of such chemicals. Water solubility is perhaps the most important chemical characteristic used to assess chemical mobility, stability or breakdown, accumulation, bioaccumulation, and sorption. Soil sorption, chemical sorption, or bound chemicals in soil may be expressed as the extent to which an organic chemical partitions between a solid phase and a liquid phase. This value is known as the adsorption coefficient (Koc). Volatilization of a chemical into the air is an important migration pathway. The vapor pressure of a chemical provides an indication of whether a chemical will volatilize into the air. The octanol water partition coefficient (Kow) is an indicator of the bioaccumulation or bioconcentration potential of a chemical in the fatty tissue of living organisms. The Kow is an indicator of water solubility, mobility, sorption, and bioaccumulation. The following information is summarized from Ney (1995, 58210).

The higher the water solubility of a chemical, the more likely it is to be mobile and less likely it is to be accumulative, bioaccumulative, volatile, and persistent. A highly soluble chemical (greater than 1000 ppm or mg/L) is prone to biodegradation and metabolism that may detoxify the parent chemical. The lower the water solubility of a chemical (less than 10 ppm or mg/L), the more likely it is that it will be immobilized by way of adsorption, and because it is less mobile, it is more accumulative or bioaccumulative, persistent in the environment, and slightly prone to

biodegradation and may be metabolized in plants and animals. A chemical with a low vapor pressure (less than 0.000001 torr) is less likely to volatilize into the air. A chemical with high vapor pressure (greater than 0.01 torr) is more likely to volatilize into the air. Chemicals with a high Koc of greater than 10,000 will adsorb to soil organic carbon. Chemicals with a low Koc of 1000 will not adsorb to soil organic carbon. A chemical with a high Kow (greater than 1000) is indicative of low water solubility, immobility, nonbiodegradability, and a chemical that is bioaccumulative, accumulative, persistent, and sorbed in soil. A chemical with a low Kow (less than 500) is indicative of high water solubility, mobility, little or no bioaccumulation or accumulation, and degradability by microbes, plants, and animals.

PCBs, which may have been disposed of at MDA U, have a water solubility of 0.0027 to 0.34 ppm, which indicates that they should not leach, should be absorbed to soil organic matter, should not be biodegraded, and could bioaccumulate. The vapor pressure of 0.0000771 to 0.00406 torr indicated that volatility should not be a problem, and a Kow of 647 to 21,700 indicates that bioaccumulation and food chain contamination are likely.

Inorganic Chemicals. No inorganic chemicals are suspected or known to have been disposed of at MDA U.

2.2.2.3 Data Gaps

The current understanding of the site remains incomplete because of the lack of data on

- the transport mechanism(s),
- the nature and extent of subsurface contamination, and
- the volume of contaminated material remaining in the absorption beds.

Data are also lacking on the presence or absence of actinium daughters in surface soil. Work performed under this SAP (core samples taken within, beneath, and adjacent to the absorption beds) will determine if contaminants have migrated beneath the beds and will simultaneously determine the nature and extent of contamination. Additional data from surface soil samples within and north of MDA U will be used to evaluate if there has been a release to surface soil and drainages from MDA U.

2.2.3 Sampling Activities

A backhoe will be used to open up one end in each of the absorption beds to determine the depth of contaminated material remaining in the beds below the plastic cover that was installed in 1985 so that the volume can be estimated. During the excavation, the external coating on the cobbles will be sampled and described in the field log book. Samples will be analyzed for radionuclides. The excavation will be done in a north-south direction.

Eight vertical boreholes will be drilled through and adjacent to the absorption beds to a depth of 75 ft in the approximate locations shown on Figure 2.2-5. Drilling locations will be sited outside of the disturbed areas in the central part of the beds to sample the portions of the beds as they were during operational periods. The boundary of this disturbed area, where the pipe was removed in 1985, will be determined by visual observation; it will be recorded, along with reasons for siting drilling locations, in the field log book. One borehole will be drilled in the east and west ends of each bed to evaluate the distribution of COPCs from the various effluent lines that discharged to the absorption beds as shown on Figure 2.1-5. One borehole will be drilled approximately 5 feet north and near the middle of each bed to evaluate the effect of subsurface contaminant migration [the grade was constructed to slope to the north, as shown on a LASL drawing (LASL 1945,

1093)]. One borehole will be drilled to the east of the eastern absorption bed (outside of the bed within the fence line) to evaluate subsurface migration from the absorption beds as the subsurface geologic features dip to the east, and any subsurface migration should be found in this area. One borehole will be drilled to the west of the western absorption bed to bound the extent of contamination to the west, in the event that the beds overflowed to the west. The core from each borehole below the depth of the beds will be inspected for the presence of rounded alluvial material (sand to cobbles) that would indicate the presence of a paleochannel.

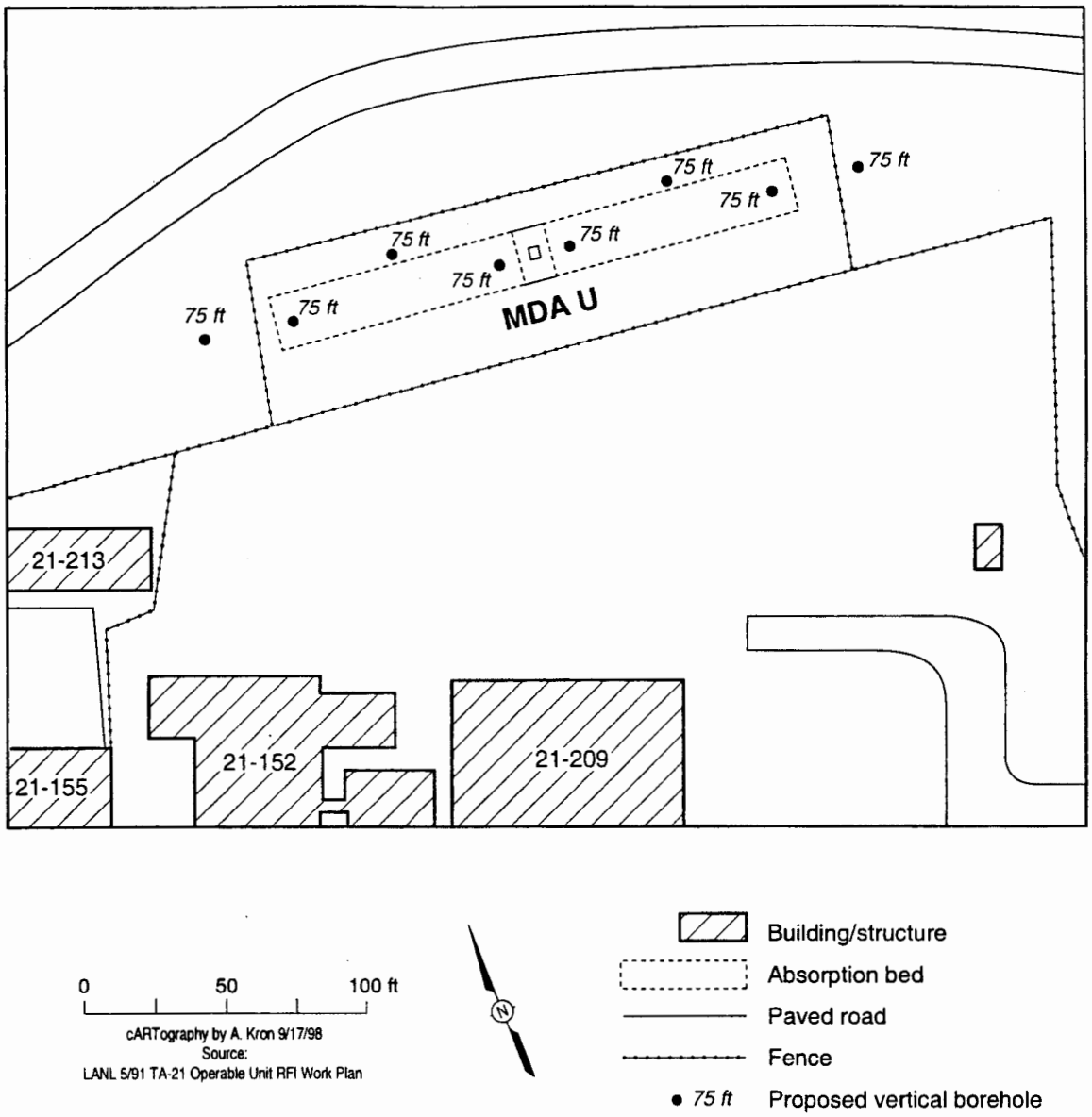


Figure 2.2-5. Proposed locations for vertical boreholes at MDA U.

As part of the characterization of the paleochannel that daylights in a small side tributary to DP Canyon, two surface soil samples will be collected in the area where it daylights and analyzed for

radionuclides and metals to determine whether the paleochannel is a potential transport mechanism from PRSs in TA-21.

As stated earlier, there is evidence that actinium daughters may have been disposed of in the absorption beds. Previous sampling and analysis did not account for this isotope and its daughter products. Therefore, 10 surface soil samples (0–6 in.) will be collected representing the areas inside and outside the fence line, and 10 surface soil samples will be collected in the drainage channel. The samples will be sent to an analytical laboratory for a special gamma speciation analysis. Because the actinium series are progeny of uranium-235 and there are no isotopic uranium data, the 20 soil samples will also be analyzed for isotopic uranium. All 20 surface soil samples will also be analyzed for PCBs.

Based on the sampling design discussion above and in Sections 2.2.3.1 and 2.2.3.2, the samples to be collected are presented in Table 2.2-5 (Appendix C), and the sampling locations are shown on Figure 2.2-5 for subsurface sampling and Figure 2.2-4 for surface sampling.

Core samples from the boreholes will be screened for radionuclides and organics, logged, and sent for analysis at an analytical laboratory. Borehole samples will be measured for water content and analyzed for tritium, metals, radionuclides, PCBs, SVOCs, and VOCs based on historical data on material that may have been disposed of at MDA U.

The first borehole sample interval listed in Table 2.2-5 (Appendix C) will be from the sand/gravel layer directly above the large cobbles in the two boreholes within each absorption bed to determine the nature and extent of contamination remaining in each bed. The second borehole sample interval will be in the area directly beneath the cobbles in the tuff below each absorption bed to determine the nature and extent of contamination that migrated directly beneath each bed.

2.2.3.1 Contaminant Source

The nature of the source term will be determined based on review of analytical data of core samples taken within and beneath the absorption beds. See Section 2.1.2, Operational History, for more information.

2.2.3.2 Media Characterization

Media characterization at MDA U will include

- sampling of subsurface material within, beneath, and adjacent to the absorption beds to determine the nature and extent of the contamination and
- sampling of surface soil north of MDA U to fill in data gaps from the 1994 investigation.

3.0 DATA COLLECTION DESIGN AND PROCEDURES

3.1 Data Quality Objectives

Analytical data for these PRSs will be compared, as follows, to determine if contaminants are naturally occurring or related to MDA U releases. For inorganic chemicals and radionuclides, the data review will determine whether chemicals are present at levels exceeding background and/or fallout concentrations (surface only for radionuclides). For organic chemicals, the data review will identify which organic chemicals have been detected at the PRSs.

Precision will be addressed by collecting one sample in duplicate from each 20 core samples; accuracy will be assessed by laboratory spike and recovery of known concentrations of standards in one sample and the analysis of a blind sample.

When the fixed laboratory data are available, a chemist will determine the quality and usability of the data through a routine data validation process described in Section D1 of the ER Project quality assurance project plan (QAPP) (LANL 1996, 55574, Chapter 4.0). The data validation process includes data verification, which is a series of administrative checks to assure data users that the required data have been provided by the laboratories and that the data packages supplied by the laboratories are complete. Data verification is followed by the actual validation process, which requires quality control (QC) data generated during analysis to be reviewed against numerical acceptance criteria. The data may then be subjected to a focused validation procedure, outlined in Section D2 of the Laboratory ER Project QAPP (LANL 1996, 55574, Chapter 4.0). The field data will be reviewed for accuracy and completeness by the field team at the time of collection as well as by the person responsible for entering the data into the field database.

When the data usability is determined by a chemist, the data may be subjected to a qualitative and quantitative analysis to assess their sufficiency to support the decisions outlined in Section 1.4. Analyses may include statistical data preparation, exploratory data analysis (EDA), and qualitative and/or quantitative statistical analyses. Statistical data preparation may include the creation of subsets of the original data set that will be used for various statistical analyses. EDA involves graphical examination of the data to detect patterns, anomalies, or outliers in the data.

3.2 Quality Assurance/Quality Control

Quality assurance (QA) samples will be collected to assess the quality of sampling and measurement techniques and will assist in meeting the following objectives:

- provide information on false negatives needed to estimate negative bias,
- estimate sample collection and total measurement variance, and
- evaluate whether the data are complete, representative, and comparable.

One of every twenty core sections will be sampled in duplicate to determine the variance associated with all aspects of this effort (i.e., collection, location, handling, and analytical variances).

In addition to the field QA sample, the analytical laboratories will provide standard QC measurements, including method and calibration blanks, surrogates, spikes, and internal standards, as specified by the statement of work with the analytical laboratory. Analytical data packages will contain all reported results, including all QA/QC information. The analytical data will be compared to standard detection limits to determine if the data are usable and whether there are any issues associated with the sample matrix and analysis.

Field QC samples, such as duplicates, rinsate blanks, and trip blanks, will be collected in accordance with current Laboratory ER QAPP (LANL 1996, 55574).

3.3 Field Activities

Surface and Subsurface Sample Collection. Surface samples (0–6 in.) will be collected using the spade and scoop method and LANL-ER-SOP-06.09 (most recent version), Spade and Scoop Method of Collection of Soil Samples. All samples will be collected following the applicable ER Project standard operating procedures (SOPs) for the collection, preservation, identification,

storage, transport, and documentation of environmental samples, as described in Quality Assurance Project Plan Requirements for Sampling and Analysis (LANL 1996, 53450).

Eight boreholes will be drilled with a drill rig equipped with 8.25-inch-o.d. hollow-stem augers. Continuous 3.125-inch-o.d. core samples will be retrieved using 2.5-ft or 5-ft stainless steel split-barrel samplers in conjunction with a wire-line retrieval system. The drilling program will be completed in accordance with LANL-ER-SOP-04.01 (most recent version), Drilling and Drill Site Management. The drill rig and downhole drilling and sampling equipment will be decontaminated in accordance with LANL-ER-SOP-01.08 (most recent version), Field Decontamination of Drilling and Sampling Equipment. Other applicable SOPs for drilling operations and borehole sampling are listed in Table 3.3-1.

TABLE 3.3-1
BOREHOLE CORE SAMPLING METHOD REQUIREMENTS

Activity	LANL-ER-SOP No.
Drilling methods and drill-site management	04.01
General borehole logging	04.04
Core-barrel sampling for subsurface earth materials	06.26
Field logging, handling, and documentation of borehole samples	12.01
General Instructions for Field Investigations	01.01
Field Decontamination of Drilling and Sampling Equipment	01.08
Sample Control and Field Documentation	01.04

Wash water and other wastes generated during the sampling operation will be managed and disposed of in accordance with LANL-ER-AP-05.3 (most recent version), Management of ER Program Wastes, and a site-specific Waste Characterization Strategy form.

Each surface sample location will be marked, photographed, and assigned a unique ER sample location identification number. All samples will be field screened at the point of collection for gross radioactivity and organics; hand-held instruments will be used. Before the samples are submitted to the field support facility (FSF) for transport to a fixed-site analytical laboratory, gross alpha, beta, and gamma radiation and tritium measurements will be taken on each sample at the TA-21 Radiological Screening Laboratory (RSL) according to Department of Transportation shipping regulations.

For each borehole, core from the 2.5-ft or 5-ft interval will be screened for VOCs and radioactivity using hand-held instruments. The core interval will be dependent on recovery and depth. If radionuclides or organics are identified, each subsequent interval will be logged, photographed, and inspected for fractures. Drilling will continue in each borehole to 20 feet beyond the elevated readings identified by field instruments up to a maximum total borehole length of 75 ft. For each 10-ft interval, a core sample will be collected for laboratory analysis; location of the sample within the interval would be preferentially based on the presence of fractures, elevated radionuclides, or VOCs. If a sample is taken from a fracture, a second sample will be taken, for comparison

purposes, from an area in the core adjacent to the fracture. The reason for collecting each core sample will be recorded in the field notes and sample collection log. Core samples will first be screened at the TA-21 RSL for tritium and gross alpha, beta, and gamma radiation; their water content will also be determined. All samples will then be sent to an analytical laboratory for gamma spectroscopy analysis and analysis for isotopic plutonium, americium, isotopic uranium, tritium, SVOCs, and target analyte list metals.

Samples for vapor-phase VOC analysis will be collected at the end of the borehole and at two other locations along the borehole using the method described in Appendix D, Soil-Gas Sampling Procedure for Open Boreholes. Sample collection will be based on screening of VOCs using hand-held instruments. The reason for selecting the location for VOC sampling will be recorded in the field notes and sample collection log.

Licensed surveyors will identify state planar coordinates for boreholes and surface soil locations. All survey data will be submitted to the Facility for Information Management and Display (FIMAD). Geodetic surveys will be conducted in accordance with LANL-ER-SOP 03.01 (most recent version), Land Surveying Procedures.

Analytical Methods. All analyses will be performed at an ER Project-approved fixed-site laboratory. The analytical suites and methods for analysis of organic constituents are listed in Table 3.3-2. All analyses for organic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31733). The detailed analyte lists, estimated quantitation limits (EQLs), required QC procedures, and the acceptance criteria are found in the ER Project analytical services statement of work (LANL 1995, 49738). Analyses for PCBs will be performed according to EPA SW-846 protocols using Method 8082.

TABLE 3.3-2
ANALYTE SUITES AND ANALYTICAL METHODS FOR ANALYSIS OF ORGANIC CONSTITUENTS IN CORE SAMPLES

Analyte Suite	Analytical Method	Analytical Protocol
SVOCs	GC/Ms[a]	SW-8270
VOCs[b]	GC/MS	SW-8260

a. GC/MS = Gas chromatography/mass spectrometry
b. Samples will be analyzed for VOCs only if field screening indicated their presence.

The target analytes, estimated detection limits (EDLs), special required EDLs, and analytical methods for inorganic constituents in core samples are listed in Table 3.3-3. All analyses for inorganic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31733) using mineral acid sample extraction procedures for the inductively coupled plasma emission spectroscopy (ICPES) and graphite furnace atomic absorption (GFAA).

The target radionuclides and their half-lives, detected emissions, minimum detectable activity, and analytical methods for radionuclide constituents are listed in Table 3.3-4. Before chemical separation and counting for alpha or beta emissions, samples will undergo a complete digestion or fusion procedure. All samples submitted for tritium analysis will also be analyzed for moisture content. The analyte list for the gamma spectroscopy analysis includes long-lived activation and fission products as well as their shorter-lived daughter products. The shorter-lived daughter

products are usually included in the analyte list to verify the presence of the longer-lived parents. The shorter-lived radionuclides (half-life less than 180 days) are not considered to be COPCs because of the operational history of MDA U. Soil samples will be prepared for gamma spectroscopy measurements by homogenization and drying; no sample extraction will be performed. The required QC procedures and acceptance criteria for both the inorganic and radiochemical analyses are found in the ER Project analytical services statement of work (LANL 1995, 49738).

TABLE 3.3-3
ANALYTE LIST, EDLs, AND ANALYTICAL METHODS FOR INORGANIC CONSTITUENTS (METALS) IN CORE SAMPLES

Analyte	EDL (mg/kg)	Special Required EDL[a] (mg/kg)	Analytical Method	Analytical Protocol
Aluminum	40	–	ICPES	SW-6010B
Antimony	12	0.5	ICPES	SW-6010B or SW-6020
Arsenic	2	–	GFAA	SW-7060 or SW-6020
Barium	40	–	ICPES	SW-6010B
Beryllium	1	–	ICPES	SW-6010B
Cadmium	1	0.4	ICPES	SW-6010B
Calcium	1000	–	ICPES	SW-6010B
Chromium	2	–	ICPES	SW-6010B
Cobalt	10	2.5	ICPES	SW-6010B
Copper	5	4.0	ICPES	SW-6010B
Iron	20	–	ICPES	SW-6010B
Lead	0.6	–	GFAA	SW-7421 or SW-6020
Magnesium	1000	–	ICPES	SW-6010B
Manganese	3	–	ICPES	SW-6010B
Mercury	0.1	–	CVAA[b]	SW-7471A
Nickel	8	5.0	ICPES	SW-6010B
Potassium	1000	–	ICPES	SW-6010B
Selenium	1	0.3	GFAA	SW-7741 or SW-6020
Silver	2	0.8	ICPES	SW-6010B
Sodium	1000	500	ICPES	SW-6010B
Thallium	2	0.9	GFAA	SW-7841 or SW-6020
Vanadium	10	–	ICPES	SW-6010B
Zinc	4	–	ICPES	SW-6010B

a. These lower detection limits for these chemicals, with the exception of thallium, are required to meet background values in tuff (Qbt 2 and 3). The lower detection limit for thallium is required to meet the 1/10 noncarcinogenic screening action level.
b. CVAA = cold vapor atomic absorption spectroscopy.

TABLE 3.3-4
ANALYTE LIST, EQLs, AND ANALYTICAL METHODS FOR RADIONUCLIDE CONSTITUENTS IN SOIL AND CORE SAMPLES

Analyte	Half-Life (yr.)	Detected Emission	Minimum Detectable Activity (pCi/g)	Analytical Method
Actinium-227	21.7	β	5	γ-Spectrometry PA-231
Plutonium-238	87.7	α	0.1	α-Spectrometry
Plutonium-238/240[a]	$2.41\ 0 \times 10^4$	α	0.1	α-Spectrometry
Strontium-90	29.1	β	2.0	GPC
Tritium	12.3	β	300 pCi/L	LCS[b]
Uranium-234	2.46×10^5	α	0.1	α-Spectrometry
Uranium-235	7.04×10^8	α	0.1	α-Spectrometry
Uranium-238	4.47×10^9	α	0.1	α-Spectrometry
Gamma spectroscopy analytes	—	γ	1[c]	γ-Spectrometry
Gross alpha	—	α	10.0	GPC or LCS
Gross beta	—	β	10.0	GPC or LCS
Gross gamma	—	γ	2.0	NaI(Tl) or HPGE detection

a. The plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.
b. LCS = laboratory control sample.
c. The minimum detectable activity for americium-241 and cesium-137 is 1 pCi/g; the value for other analytes will vary.

The gravimetric moisture content of all borehole core samples and subsurface samples collected under the absorption beds will be determined using fast-turnaround analysis. The analytical method is ASTM D-4531-86 (ASTM 1997, 57501).

Sample Handling. The FSF will be consulted regarding the appropriate sample containers and preservation. All samples will be handled in accordance with LANL-ER-SOP-01.04 (most recent version), Sample Control and Field Documentation. Chain-of-custody requirements described in this SOP will be implemented; a member of the field team will maintain custody of the samples until they are delivered to the FSF. Samples will be packaged and shipped according to LANL-ER-SOP-01.03 (most recent version), Handling, Packaging, and Shipping of Samples. All samples will be shipped from the FSF to off-site laboratories.

Samples will have preassigned identification numbers from the Sample Data Management System. The sample and location identification numbers, sample depth, date and time of sample collection, and level of radioactivity and inorganic compounds (based on field screening) will be recorded on the sample collection log. When filled with sample material, sample bottles will be

capped, labeled, sealed with custody tape, and temporarily stored in a sample cooler with blue ice to <4°C.

Data Tracking. The data management scheme described in Sections A10 and B10 of the ER Project QAPP (LANL 1996, 53450) will be followed. Manually recorded data will be reviewed by the field team, as required by LANL-ER-SOP-1.01 (most recent version), General Instructions for Field Investigations; LANL-ER-SOP-01.04 (most recent version), Sample Control and Field Documentation; and LANL-ER-SOP-03.12 (most recent version), Field and Laboratory Notebook Documentation for Environmental Restoration Earth Sciences Studies. Data generated by the analytical laboratories will be submitted to the FSF following the requirements of the ER Project analytical services statement of work (LANL 1995, 49738). The reporting requirements include electronic and hard copy deliverables for routine analyses. The FSF is responsible for data verification, validation, and transmittal to FIMAD. The results of radiological screening conducted in the TA-21 RSL will be documented and sent to the FSF along with the samples.

Verification and Routine Data Validation. Data generated by the analytical laboratories will undergo the verification and baseline validation procedures described in Sections D1 and D2 of the ER Project QAPP (LANL 1996, 53450). Field data will be reviewed for accuracy and completeness by the field team at the time of collection.

4.0 PROJECT MANAGEMENT

4.1 Project Scheduling and Reporting Requirements

The MDA Focus Area TA-21 team is responsible for performing the sampling and the preparation of reports for the field activities at MDA U. Field sampling activities are scheduled to begin in calendar year 1998, and a report summarizing the results of the field activities is scheduled to be completed by September 1999.

4.2 Health and Safety Plan

A site-specific health and safety plan (Environmental Restoration Project 1998, 58704)has been developed in accordance with the ER Project health and safety plan (Environmental Restoration Project 1995, 56448).

4.3 Investigation-Derived Waste Plan

Investigation-derived waste, if any, will be handled in accordance with LANL-ER-SOP-1.06 (most recent version), Management of Environmental Restoration Project Wastes, and the site-specific Waste Characterization Strategy form.

4.4 Community Relations Plan

Community relations are governed by the Public Involvement Plan in the installation work plan (LANL 1996, 55574, Chapter 7).

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APPENDIX A
ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
COPC	Chemical of potential concern
CVAA	Cold vapor atomic absorption
DOE	Department of Energy
DQO	Data quality objective
EDA	Exploratory data analysis
EDL	Estimated detection limits
EQL	Estimated quantitation limit
ER	Environmental restoration
ESH	Environment, Safety, and Health Division
FEHM	Finite Element Heat and Mass
FIMAD	Facility for Information Management, Analysis, and Display
FSF	Field support facility
GC/MS	Gas chromatography/mass spectrometry
GFAA	Graphite furnace atomic absorption
GPC	Gel permeation chromatography
ICPES	Inductively coupled plasma emission spectroscopy
Laboratory	Los Alamos National Laboratory
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory
LSC	
MDA	Material disposal area
PCB	Polychlorinated biphenyl
PRS	Potential release site
QA	Quality assurance
QAPP	Quality assurance program plan
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RSL	Radiological Screening Laboratory
SAP	Sampling and analysis plan
SOP	Standard operating procedure
SVOC	Semivolatile organic compound
SWMU	Solid waste management unit

TA	Technical area
TSTA	Tritium Systems Test Assembly
VOC	Volatile organic compound

APPENDIX B
TABLE 2.2-3

TABLE 2.2-3
DATA FOR 1994 RFI SURFACE INVESTIGATION OF MDA U

Analyte Code Description	Frequency of Detects	Range of Analysis (mg/kg)	Background (mg/kg)
Inorganics			
Uranium	78/78	0.949–37.5	1.82
Aluminum	77/77	2210–24100	29200
Antimony	1/78	[0.21]–0.87[a]	0.83
Arsenic	56/78	[1.4]–5.2	8.17
Barium	77/78	[41.2]–175	295
Beryllium	4/78	[0.11]–1.2	1.83
Cadmium	0/78	[0.06–0.98]	0.4
Calcium	74/77	[925]–7440	6120
Chromium, Total	78/78	3.3–77.3	19.3
Cobalt	5/78	[1.6]–8.1	8.64
Copper	22/78	[1.7]–84.3	14.7
Iron	77/77	1200–15600	21500
Lead	78/78	4.4–100	22.3
Magnesium	61/77	[526]–4070	4610
Manganese	78/78	144–558	671
Mercury	26/78	[0.02]–1.2	0.1
Nickel	10/78	[2.2]–27.9	15.4
Potassium	53/77	[344]–2860	3460
Selenium	1/78	[0.52]–1.5	1.52
Silver	4/78	[0.1]–2.5	1
Sodium	9/77	[0.25]–1680	915
Thallium	0/78	[0.21–1.1]	0.73
Vanadium	62/78	[6.2]–27	39.6
Zinc	78/78	18.1–509	48.8
Radionuclides			
Americium-241	0/76	[-0.4599–0.686]	0.818
Bismuth-212	0/1	[1.619–1.619]	–[b]
Cesium-137	0/40	[0.0952–2.779]	1.65
Iodine-129	0/3	[0.0655–0.2306]	–

a. Values in square brackets indicate nondetected results.
b. No background value

TABLE 2.2-3(continued)

Analyte Code Description	Frequency of Detects	Range of Analysis (mg/kg)	Background (mg/kg)
Radionuclides			
Lead-210	0/43	[0.2941–3.999]	–
Lead-212	0/67	[0.8006–1.9]	–
Lead-214	0/63	[0.6753–1.288]	–
Neptunium-237	0/8	[0.0503–0.3624]	–
Plutonium-238	0/79	[-0.0013–2.516]	0.447
Plutonium-239	0/78	[-0.0006–4.136]	15.5
Potassium-40	0/62	[13.65–31.24]	36.8
Radium-224	0/14	[2.601–4.89]	–
Radium-226	0/38	[0.6908–1.276]	2.59
Radium-228	0/1	[1.364–1.364]	2.33
Strontium-90	0/78	[-0.3–2.96]	1.31
Thallium-208	0/31	[0.301–0.5931]	–
Thorium-228	0/4	[2.488–5.569]	2.28
Thorium-229	0/1	[0.1729–0.1729]	–
Thorium-234	0/48	[0.6363–1.997]	–
Tritium[c]	0/78	[0.00578–3.24567]	9.92
Uranium-235	0/33	[0.0355–0.3456]	0.2
Organics			
Acenaphthene	1/74	[0.34]–0.46	0.330
Acenaphthylene	0/74	[0.34–0.46]	0.330
Aniline	0/74	[0.34–0.46]	0.660
Anthracene	1/74	[0.34]–0.88	0.330
Azobenzene	0/74	[0.34–0.46]	0.660
Benzo(a)anthracene	3/74	[0.34]–0.66	0.330
Benzo(a)pyrene	2/74	[0.34]–0.81	0.330
Benzo(b)fluoranthene	3/74	[0.34]–0.61	0.330
Benzo(g,h,i)perylene	1/74	[0.34]–0.62	0.330
Benzo(k)fluoranthene	1/74	[0.34]–0.72	0.330
Benzoic Acid	0/74	[1.6–2.2]	3.300
Benzyl Alcohol	0/74	[0.34–0.46]	1.300
Bis(2-chloroethoxy)methane	0/74	[0.34–0.46]	0.330
Bis(2-chloroethyl)ether	0/74	[0.34–0.46]	0.330
Bis(2-ethylhexyl)phthalate	0/74	[0.34–0.46]	0.330

c. Units for tritium are in pCi/ml.

TABLE 2.2-3(continued)

Analyte Code Description	Frequency of Detects	Range of Analysis (mg/kg)	Background (mg/kg)
Organics			
Bromophenyl-phenylether[4-]	0/74	[0.34–0.46]	0.330
Butylbenzylphthalate	0/74	[0.34–0.46]	0.330
Chloro-3-methylphenol[4-]	0/74	[0.34–0.46]	0.660
Chloroaniline[4-]	0/74	[0.34–0.46]	1.300
Chloronaphthalene[2-]	0/74	[0.34–0.46]	0.330
Chlorophenol[2-]	0/74	[0.34–0.46]	0.330
Chlorophenyl-phenyl[4-] Ether	0/74	[0.34–0.46]	0.330
Chrysene	3/74	[0.34]–0.73	0.330
Di-n-butylphthalate	0/74	[0.34–0.46]	0.330
Di-n-octylphthalate	0/74	[0.34–0.46]	0.330
Dibenz(a,h)anthracene	0/74	[0.34–0.46]	0.330
Dibenzofuran	0/74	[0.34–0.46]	0.330
Dichlorobenzene[1,2-]	0/74	[0.34–0.46]	0.330
Dichlorobenzene[1,3-]	0/74	[0.34–0.46]	0.330
Dichlorobenzene[1,4-]	0/74	[0.34–0.46]	0.330
Dichlorobenzidine[3,3'-]	1/74	[0.34]–0.46	0.660
Dichlorophenol[2,4-]	0/74	[0.34–0.46]	0.330
Diethylphthalate	1/74	[0.34]–8.1	0.330
Dimethyl Phthalate	0/74	[0.34–0.46]	0.330
Dimethylphenol[2,4-]	0/74	[0.34–0.46]	0.330
Dinitro-2-methylphenol[4,6-]	0/74	[0.81–1.1]	1.600
Dinitrophenol[2,4-]	0/74	[0.81–1.1]	1.600
Dinitrotoluene[2,4-]	0/74	[0.34–0.46]	0.330
Dinitrotoluene[2,6-]	0/74	[0.34–0.46]	0.330
Fluoranthene	4/74	[0.34]–2.9	0.330
Fluorene	1/74	[0.34]–0.46	0.330
Hexachlorobenzene	0/74	[0.34–0.46]	0.330
Hexachlorobutadiene	0/74	[0.34–0.46]	0.330
Hexachlorocyclopentadiene	0/74	[0.34–0.46]	0.330
Hexachloroethane	0/74	[0.34–0.46]	0.330
Indeno(1,2,3-cd)pyrene	1/74	[0.34]–0.56	0.330
Isophorone	0/74	[0.34–0.46]	0.330
Methylnaphthalene[2-]	0/74	[0.34–0.46]	0.330
Methylphenol[2-]	0/74	[0.34–0.46]	0.330

TABLE 2.2-3(concluded)

Analyte Code Description	Frequency of Detects	Range of Analysis (mg/kg)	Background (mg/kg)
Organics			
Methylphenol[4-]	0/74	[0.34–0.46]	0.330
Naphthalene	0/74	[0.34–0.46]	0.330
Nitroaniline[2-]	0/74	[0.81–1.1]	1.600
Nitroaniline[3-]	0/74	[0.81–1.1]	1.600
Nitroaniline[4-]	0/74	[0.75–1.1]	0.660
Nitrobenzene	0/74	[0.34–0.46]	0.330
Nitrophenol[2-]	0/74	[0.34–0.46]	0.330
Nitrophenol[4-]	0/74	[0.81–1.1]	1.600
Nitroso-di-n-propylamine[N-]	0/74	[0.34–0.46]	0.330
Nitrosodimethylamine[N-]	0/74	[0.34–0.46]	0.330
Nitrosodiphenylamine[N-]	0/74	[0.34–0.46]	0.330
Oxybis(1-chloropropane)[2,2'-]	0/74	[0.34–0.46]	0.330
Pentachlorophenol	0/74	[0.81–1.1]	1.600
Phenanthrene	4/74	[0.34]–2.9	0.330
Phenol	0/74	[0.34–0.46]	0.330
Pyrene	4/74	[0.34]–1.8	0.330
Trichlorobenzene[1,2,4-]	0/74	[0.34–0.46]	0.330
Trichlorophenol[2,4,5-]	0/74	[0.81–1.1]	1.600
Trichlorophenol[2,4,6-]	0/74	[0.34–0.46]	0.330

TABLE 2.2-5
SUMMARY OF ANALYSES TO BE PERFORMED IN THE MDA U INVESTIGATION

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses											
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium + Gravimetric Water Content	Stontium90	Volatile Organic Compounds (Summa)[a]	Semivolatile Organic Compounds[a]	Target Analyte List Metals	PCBs	Actinium-227
Borehole 1																							
1	0–5 ft[b]	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 2																							
1	0–5 ft[b]	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X

a. The Laboratory will be requested to report tentatively identified compounds.
b. This interval will be located in the bed in the sand/gravel layer above the cobbles.

TABLE 2.2-5(continued)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses											
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium + Gravimetric Water Content	Stontium90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs	Actinium-227
Borehole 2																							
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 3																							
1	0–5 ft[b]	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 4																							
1	0–5 ft[b]	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X

b. This interval will be located in the bed in the sand/gravel layer above the cobbles.

TABLE 2.2-5(continued)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses											
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium + Gravimetric Water Content	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs	Actinium-227
Borehole 4																							
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 5																							
1	0–5 ft	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 6																							
1	0–5 ft	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X

TABLE 2.2-5(continued)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses											
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium + Gravimetric Water Content	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs	Actinium-227
Borehole 6																							
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	45–55 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	55–65 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	65–75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
Borehole 7																							
1	0–5 ft	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
6	60 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	70 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X
8	75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	—	X

TABLE 2.2-5(continued)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses											
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium +Gravimetric Water Content	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs	Actinium-227
Borehole 8																							
1	0–5 ft	X	X	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
2	5–15 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	—	X	X	X	X
3	15–25 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
4	25–35 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
5	35–45 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
6	60 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
7	70 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X
8	75 ft	—	—	X	X	X	X	X	X	X	X	X	—	X	X	X	X	X	X	X	X	—	X

TABLE 2.2-5(continued)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses										
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Tritium	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium +Gravimetric Water Content	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs
Surface Soil Samples																						
1	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
2	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
3	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
4	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
5	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
6	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
7	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
8	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
9	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
10	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
11	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
12	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
13	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
14	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
15	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—		—	—	—	X
16	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
17	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
18	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X

TABLE 2.2-5(concluded)

		Field Survey		Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses										
Sample Number	Borehole Length to Sample or Surface Sample Depth	Geodetic Survey	Radiological Survey	Alpha Radiation	Beta/Gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content + Water	Gamma Spectroscopy (Cesium-137)	Gamma Spectroscopy Actinium Daughter Products	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium + Gravimetric Water Content	Stontium90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals	PCBs
Surface Soil Samples																						
19	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
20	—	X	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
21	Duplicate	—	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
22	Duplicate	—	—	X	X	X	—	X	X	X	—	—	X	—	—	X	—	—	—	—	—	X
Cobbles																						
1	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
2	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
3	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
4	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
Paleochannel																						
1	—	X	—	X	X	X	—	X	X	X	X	X	—	X	X	X	X	—	—	—	X	—
2	—	X	—	X	X	X	—	X	X	X	X	X	—	X	X	X	X	—	—	—	X	—

APPENDIX D
SOIL-GAS SAMPLING PROCEDURE FOR OPEN BOREHOLES

SUMMA canisters or resin tubes will be used to collect soil-gas samples from open boreholes. All SUMMA canisters or resin tubes and quality control samples will be filled with 3 L of gas. Samples will be collected using a packer assembly for collection of soil gas.

The gas-sampling procedure is as follows. Procedures 20 through 31 have been taken from LANL-ER-SOP-06.22 (most current version), Canister Sampling for Organics.

1. Remove all drilling tools from the borehole except for hollow-stem augers or casing.
2. Place the packer canister over the borehole.
3. Ensure that the packer membrane is clean and uncontaminated.
4. Attach a low-pressure, filtered air supply hose to the canister.
5. Evert the clean, uncontaminated packer membrane into the borehole to the desired depth.
6. Purge the isolated zone and sample lines.
7. Ensure that all gas-sampling equipment has been calibrated.
8. Assemble gas-sampling equipment on new plastic sheeting at the borehole.
9. Establish the sample line interval depth, and record on the Sample Collection Log.
10. Attach the purge pump to the sample line using new tubing internally lined with Teflon. Between the sample line and the new tubing to the pump there should be a 2-in piece of medical-grade silicone tubing that can be sealed with a clamp after the sample line has been purged. This short piece of tubing will be used to attach the TO-14 canister to the sample line.
11. Record the starting ambient temperature and flow rate on the Sample Collection Log.
12. While purging, the discharge line will be directed through a Brueland Kjaer gas monitor gas chromatograph instrument such as a flame ionization detector (FID) (Foxboro or equivalent) or photoionization detector (PID) (Photovac MicroTIP or equivalent). The screening instrument must be calibrated before its use in this sampling effort. The on-site calibration records must include the vendor of the calibration gas, calibration gas chemical constituent, concentration, vendor lot number, and instrument response concentration.
13. Gas monitor instrument results will be used to ensure proper purging identified by stabilization of screening results of natural soil gas tracers, such as CO_2 and O_2 concentrations.
14. Send the results of the field screens to the laboratory along with the Chain-of-Custody/Request of Analysis (see LANL-ER-SOP-01.04 (most current version), Sample Control and Field Documentation, for instructions on how to fill out the Chain-of-Custody/Request for Analysis form) in order to provide information for dilution before injection of analytical instrument and health and safety purposes for the staff cleaning the canisters.
15. At the completion of purging, turn off the purge pump and simultaneously clamp off the short section of medical-grade silicone tubing. Record volume purged on the Sample Collection Log.
16. Before sampling using air canisters, read the above standard operating procedure (SOP) and consult the analytical vendor providing the canisters. The referenced SOP is consistent with the Environmental Protection Agency's (EPA's) 'The Determination of Volatile Organic Compounds (VOCS) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatograph Analysis, EPA Compendium Method TO-14, May 1988.

17. The analytical contractor will clean and test the sample canister according to EPA's guidance before shipment to the Laboratory.
18. The canister should arrive with a vacuum up to 0.05 mm Hg. The canister will be used to sample in a grab mode. Collect 3 L from each sample interval.
19. The canister train consists of a short Teflon tube from the calibrated flow meter, short tubing to the vacuum gauge, and short tubing to the canister valve. The connection between the vacuum gauge and the canister valve should be a sealing quick-connect, such as Swagelock.
20. The canister train is attached to the well sample port after verification of the correct interval by the field team leader and canister sampling team member. If the sampling team member has not operated a canister, he/she should request from the laboratory a practice canister to practice opening and adjusting the flow rate and closing the canister valve before reaching ambient pressure inside the canister. [Caution: SUMMA canisters will be rejected at the receiving laboratory if they are at ambient pressure. The canister MUST have a slight negative pressure (subatmospheric)].
21. Record the initial canister vacuum reading on the Sample Collection Log.
22. Slowly open the valve and adjust the flow rate not to exceed 500 ml/min. The sample volume should not exceed 3 L.
23. Record the final vacuum reading of the gauge on the Sample Collection Log.
24. Record the ambient temperature.
25. Fill out the SUMMA canister tag with the unique sample number, time, date, final vacuum readings, printed name of sampler, and signature of sampler.
26. Record on the sample tag the field screen values. If over l000 mg/L, duct tape the readings to the two sides of the canister.
27. Complete the Chain-of Custody/Request for Analysis form as required by LANL-ER-SOP-01.04 (most current version), Sample Control and Field Documentation. Complete the rest of the forms required by LANL-ER-SOP-01.04.
28. Pack the canister back into the shipping container in which it was received.
29. Record the waybill number on the Chain-of-Custody/Request for Analysis form and seal the Department of Transportation-approved shipping container.
30. Complete the Sample Collection Log and make the appropriate notations on the Daily Activity Log.
31. Ship the canister to the Sample Management Office on the day of collection.

Types of Analyses to be Conducted in the Field

- Measurements of VOC concentrations will be made using calibrated B and K gas monitor or PID and FID instruments while purging the sample collection line.