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Sampling and Analysis Plan for Post-Remediation Borehole Drilling at Material Disposal Area B, Solid Waste Management Unit 21-015, Technical Area 21

Los Alamos
NATIONAL LABORATORY
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Prepared by the Environmental Programs Directorate

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April 2010

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EXECUTIVE SUMMARY

This sampling and analysis plan (SAP) addresses the installation of boreholes and sampling beneath Material Disposal Area B, an inactive subsurface disposal site, designated as Solid Waste Management Unit 21-015, which may contain both hazardous and radiological chemicals. The site is located in Technical Area 21. This investigation is being conducted under the requirements of the Compliance Order on Consent.

The principal objectives of the soil boring investigation are to

- further define the extent of contamination within the tuff matrix beneath the disposal area and characterize fractures in the Bandelier Tuff if required,
- evaluate the permeability of the tuff unit overlying the Cerro Toledo interval, and
- determine if perched groundwater is present beneath the site.

Locations of the soil borings will be determined using historical information and analytical results from the 2009 direct-push technology soil/waste sampling of the waste trenches and samples taken at locations immediately below and adjacent to the disposal trenches during or following waste excavation. This SAP will be updated or appended as information is received from the postexcavation sampling program and submitted to the New Mexico Environment Department for approval prior to installation and sampling of any of the proposed soil boring locations.

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Acronyms and Abbreviations

bgs	below ground surface
Consent Order	Compliance Order on Consent
DOE	Department of Energy (U.S.)
DP	Delta Prime
DPT	direct-push technology
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
IDW	investigation-derived waste

IRWP	investigation/remediation work plan
LANL	Los Alamos National Laboratory
LANS	Los Alamos National Security
MDA	material disposal area
NMED	New Mexico Environment Department
PCB	polychlorinated biphenyls
PID	photoionization detector
QA/QC	quality assurance/quality control
SAP	sampling and analysis plan
SOP	standard operating procedures
SMO	Sample Management Office
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	technical area
TAL	target analyte list
TBD	to be determined
VOC	volatile organic compound

1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security (LANS), LLC. The Laboratory is located in north-central New Mexico, approximately 60 mi north of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft above sea level.

The Laboratory's Environmental Programs (EP) Directorate is participating in a national effort by the DOE to clean up sites and facilities formerly involved in weapons research and production. The EP Directorate's goal is to ensure that DOE's past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, EP investigates sites potentially contaminated by past Laboratory operations. The site discussed in this work plan is a site where solid wastes had been placed at one time (i.e., it is a solid waste management unit [SWMU]). This sampling and analysis plan (SAP) is being conducted under the requirements of the Compliance Order on Consent (hereafter, the Consent Order), which replaces the corrective action requirements of Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 001585). The New Mexico Environment Department (NMED) is the administrative authority for activities being performed under the Consent Order. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with DOE policy.

Material Disposal Area (MDA) B is an inactive subsurface disposal site, designated SWMU 21-015, which may contain both hazardous and radiological chemicals. The site is located in Technical Area 21 (TA-21), on Delta Prime (DP) Mesa (a mesa separating Los Alamos Canyon and DP Canyon) (Figure 1.0-1). MDA B occupies approximately 6 acres and consists of multiple disposal trenches (Figure 1.0-2). From 1944 until it closed in 1948, MDA B received process wastes from operations within TA-21 at DP East and DP West. The wastes disposed of at MDA B were highly heterogeneous, primarily radioactively contaminated laboratory wastes and debris and limited liquid chemical waste; however, a formal waste inventory was not maintained (LANL 1991, 007529).

Investigation Objectives

The principal objective of the investigation/remediation work plan (IRWP) is to characterize the nature and extent associated with any residual radionuclide, organic chemical, and inorganic chemical contamination exceeding the residential standards at MDA B after the waste is removed. Achieving these objectives requires advancing boreholes into the deeper subsurface at locations to be determined based upon existing information and on results of the confirmation sampling to be conducted following waste removal.

Data about the residual radiological and hazardous chemical concentrations will come from samples to be taken from the native tuff located below the bottom of the excavation. These data will be used to assess the nature and extent of potential residual contamination beneath and surrounding the MDA disposal trenches. This SAP describes the rationale for the proposed scope of work and specifies the investigation and sampling methodologies and protocols that will be used for collecting, analyzing, and evaluating the data required to meet the SAP objectives.

2.0 BACKGROUND

Historical records state that MDA B consisted of several disposal trenches approximately 300 ft long, 15 ft wide, and 12 ft deep, and that MDA B included at least one smaller, shallower trench on the eastern end of the site (LANL 1991, 007529). Waste disposal at MDA B ceased in 1948. Geophysical surveys were conducted to delineate the location and number of disposal trenches at MDA B (Ferguson et al. 1998, 058212; McQuown 1998, 064147; McQuown 1998, 064146; Thavoris 2001, 083862). The results of the surveys were interpreted as several large trenches. One to three of these make up the western portion of the MDA; one large trench makes up the eastern portion (Figure 1.0-2).

From 1944 until 1948, the Laboratory's primary waste-producing operations at TA-21 were located at DP East and DP West. By the fall of 1944, the Laboratory's Chemistry Division had developed several separation techniques to recover plutonium from residues. Solids from incinerator reduction operations were dissolved in nitric and hydrofluorous acids to recover trace amounts of plutonium (Merrill 1990, 011721). During the early 1940s, plutonium recovery was conducted until the maximum concentration for plutonium in solution was 10^{-4} g/L. Once this concentration was reached, the solution was discarded. These processes are described to provide an overview of the materials that were potentially disposed of at MDA B.

MDA B has been investigated numerous times since disposal operations were discontinued. Investigations prior to 2009 focused on surface characterization and potential subsurface releases outside the actual disposal trenches. In August 2009, an investigation program using direct-push technology (DPT) was initiated to characterize the waste materials present in the MDA B waste trenches. The DPT investigation was performed in three phases. The objective of Phases I and II was to collect and characterize core samples of waste and soil from within the disposal trenches. Borings were installed using DPT at 87 locations within and surrounding the suspected waste trenches. Core samples of waste/soil were collected at approximately 5-ft depth intervals in each of the 87 borings and were analyzed for radiological and hazardous organic and inorganic chemicals.

The objective of Phase III was to complete trench boundary probing to improve the knowledge of the extent (or edges) of the waste trenches using the depth-to-tuff (refusal) information. Information gathered during the DPT investigation improved the understanding of the nature and extent of the buried waste trenches at MDA B, and will be utilized to guide development of excavation plans and excavation controls for the remediation.

As a follow up to DPT investigation, nine exploratory trenches were excavated in February 2010 in the vicinity of suspected waste Areas 9 and 10. Information from the DPT investigation combined with observations made during the Area 9 and 10 explorations have confirmed the absence of waste trenches within these two areas.

3.0 SITE CONDITIONS

A detailed description of the site surface and subsurface conditions is provided in Section 3 of the IRWP (LANL 2006, 095499).

4.0 SCOPE OF ACTIVITIES

Based on the results of confirmation sampling and observations during fieldwork, candidate borehole sampling locations will be evaluated and selected. Candidate borehole locations will be determined based on the following criteria.

- Residential cleanup levels were not attained because the depth of the excavation limited the equipment and/or because of safety concerns.
- Areas of heavy staining, severe fracturing, and/or high moisture content exist.
- After excavation of trench contents, residuals containing contamination above residential cleanup levels exist.
- Waste areas of the excavation exist that contain a significantly high hazard.

As excavation activities progress and candidate boring locations are identified, boring locations and depths will be submitted to NMED in an abbreviated work plan for approval. Information provided will include a summary of the excavation activities and analytical results from confirmatory sampling and an explanation of how this information was used to select the number and locations of proposed boreholes. The boring(s) work plan will be approved by NMED prior to its execution. Section IV.C.2.d.iii of the Consent Order recommends the installation of eight borings, with two borings being advanced to the base of the Cerro Toledo interval. The actual number and locations of borings to be installed and sampled will be determined based upon observations made during the excavation activities and the results of the confirmation sampling.

The vertical boreholes will be drilled to characterize the deeper subsurface at MDA B. Information from the boreholes will further define the vertical extent of contamination, provide geotechnical data and fracture characterization, and determine if perched groundwater exists beneath the site. The planned depth of the boreholes will be presented in the updated SAP. Data collected from the boreholes will include field screening, lithology, contaminant characterization, geotechnical testing, fracture characterization, pore gas, perched groundwater, and geophysical logging. Deep boreholes to the base of the Cerro Toledo interval, approximately 380 ft below ground surface (bgs), will be installed only if necessary, and the rationale will be discussed in the updated SAP.

Borehole drilling and sampling will be conducted to further define the extent of potential residual contamination within the tuff matrix beneath the disposal areas. The candidate locations and numbers of the boreholes will be determined based on confirmatory sampling results and observations made during fieldwork.

Cores will be collected continuously from the surface to the total depth (TD) in each borehole. Minimum depth of boreholes will be 25 ft below the bottom of the waste trench. All cores will be visually examined in the field and screened for radiological contamination and volatile organic compounds (VOCs). If levels of contamination are detected during the screening the borehole will be advanced an additional 25 ft or until levels of contamination are no longer detected. Core samples will be collected from directly below the base elevation of the disposal trenches and at the TD of each borehole. At least two other depth intervals (including the sample exhibiting the highest field-screening detection and the sample from the maximum depth in each boring that displays field-screening evidence of contamination) will be selected for sampling, for a minimum of four samples in each borehole. Additional samples may be collected at depths that show field screening or other evidence of contamination, lithologic contacts, fractures, fracture-fill material, surge beds, or other higher-permeability units. In the absence of elevated field-screening results in the boreholes, sample locations will be selected based on physical features.

Samples collected from boreholes will be submitted per the IRWP to the Sample Management Office (SMO) for analysis of VOCs, semivolatile organic compounds (SVOCs), explosive compounds, pH, polychlorinated biphenyls (PCBs), dioxins, furans, nitrates, perchlorate, target analyte list (TAL) metals, total uranium, cyanide, tritium, isotopic uranium, isotopic plutonium, strontium-90, and gamma-emitting radionuclides (Table 4.0-1). Whenever a fracture sample is collected, an additional sample will be collected from the rock matrix adjacent to the fracture sample material to allow a direct comparison to be made between the contaminant concentrations in the fracture fill and the surrounding rock matrix.

If deep borings are required to be installed to the Cerro Toledo, a minimum of three core samples from the tuff units overlying the Cerro Toledo interval and one from within the Cerro Toledo interval will be collected from each borehole for geotechnical analysis to characterize the vadose zone hydrogeology beneath the site. Samples will be analyzed for saturated and unsaturated hydraulic conductivity, matric potential, porosity, chloride-ion concentration, moisture content, and bulk density. Information about the analytical and geotechnical tests planned for the borehole samples are summarized in Table 4.0-1.

Field documentation of the samples collected from fractures will include a detailed physical description of the fracture-fill material and surrounding rock matrix. The volumes of fracture fill and rock matrix material included in the sample (if both media are included in a sample) will be estimated from field measurements and will be recorded on the corresponding sample collection log.

Subsurface pore-gas samples will be collected from the boreholes. In each borehole, one sample will be collected at a depth equivalent to the base of the targeted disposal unit. A second sample will be collected at the TD of the borehole. Subsurface pore-gas samples will be submitted for the analysis of VOCs and tritium. If any volatile contaminants are detected, a second round of samples will be collected approximately 30 days later. The decision about installing pore-gas monitoring wells will be based on the results of this sampling. The boreholes will remain open until the decision to install vapor monitoring wells is made. A long-term vapor monitoring program will be developed, as appropriate.

Groundwater samples will be collected from any interval encountered during drilling that produces sufficient water. Based on current understanding of the site, it is expected that any such interval will be a localized phenomenon and is unlikely to be part of an alluvial or regional groundwater system. The samples will be analyzed for VOCs, SVOCs, explosive compounds, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, tritium, isotopic uranium, isotopic plutonium, strontium-90, and gamma-emitting radionuclides. If groundwater is encountered in sufficient quantity to warrant monitoring, a monitoring well design will be prepared and submitted to NMED for approval. A monitoring well would then be installed in accordance with the approved design, and a long-term groundwater monitoring program would be developed, as appropriate.

To provide additional data for vadose zone characterization, geophysical logging will be performed in competent boreholes.

In addition, a borehole will be drilled in the west laydown area known as A-8a to allow site characterization and possible vapor monitoring. This boring will be advanced to a depth of at least 20 ft below the base of the waste disposal trench at MDA B, and at least 25 ft below the deepest detected contamination, based on field screening or laboratory analyses. A minimum of two core samples will be collected from the borehole; one will be collected at the TD of the borehole, and the other sample interval(s) will be selected based on field screening, presence of fractures, or other observed features. Core samples will be analyzed for VOCs, SVOCs, explosive compounds, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, tritium, isotopic uranium, isotopic plutonium, strontium-90, and gamma-emitting radionuclides. Pore-gas samples will be collected from at least two intervals, including the TD, and will be analyzed for tritium and VOCs. Depending upon the results of the core and pore-gas sample analyses, the borehole may be developed as a vapor-monitoring well. In this case, a vapor-monitoring plan and well design will be developed and submitted to NMED for approval prior to implementation.

5.0 INVESTIGATION METHODS

This section presents the methods to be utilized for borehole installation, sampling, and testing. Where appropriate, Laboratory standard operating procedures (SOPs) for the planned activities are referenced.

5.1 Drilling Methods

Boreholes will be drilled with a drill rig capable of continuous coring and deep borehole production. All drilling activities will follow appropriate Laboratory guidance documents and protocols to ensure that health and safety issues are reviewed and addressed during field operations. Boreholes will be drilled initially using a hollow-stem auger. In the event that boreholes cannot be completed by this method, air-rotary drilling with a split barrel sampler will be used. This will ensure that the desired depth can be achieved and that continuous core can be collected.

5.2 Borehole Soil and Rock Sampling Methods

All boreholes will be cored continuously and logged following the current versions of SOP-5029 and SOP-12.01. Following the current version of SOP-6.26, subsurface tuff samples will be collected from core retained in a split-spoon core barrel and placed into sealed sleeves or core-protect bags to preserve core moisture. The analytical suites for the samples from each borehole are listed in Table 4.0-1.

The primary screening methods to be used are (1) visual examination, (2) radiological screening, and (3) headspace vapor screening for VOCs, in accordance with Section IX.B of the Consent Order.

Radiological screening will target gross alpha, beta, and gamma radiation. Field screening for alpha, beta, and gamma radiation will be conducted within 6 in. of the core material. All instrument background checks, background ranges, and calibration procedures will be documented daily in the field logbooks.

Field screening for VOCs will be accomplished using headspace analysis at 10-ft intervals in each borehole, in accordance with Section IX.B of the Consent Order. Headspace vapor screening of subsurface core for VOCs will be conducted using a photoionization detector (PID) equipped with an 11.7-electron volt lamp as specified in SOP-6.33. The maximum sustained reading and the ambient air temperature will be recorded on the field borehole log for each sample. The PID will be calibrated each day to the manufacturer's standard for instrument operation (all daily calibration results will be documented in the field logbooks).

Quality assurance/quality control (QA/QC) samples will include field duplicate samples to evaluate the reproducibility of the sampling technique and rinsate blanks to evaluate decontamination procedures. These samples and other required QA/QC samples will be collected following the current revision of SOP-5059 and will comply with the collection frequency specified in the Consent Order.

5.3 Geotechnical Analysis Methods

Formation lithology, fracture occurrence, orientation, density, and core recovery (compared to interval drilled) will be established in the field. Lithology and fracture data will be defined following methods described in SOP-5029 and SOP-12.01. During drilling in the Cerro Toledo interval, brass, lexan, or equivalent sleeves will be used to line the core barrel in order to improve recovery and maintain structural integrity of the core and to enhance the accuracy of the geotechnical data.

Analyses for saturated and unsaturated hydraulic conductivity, porosity, bulk density, and moisture content will be performed using analytical methods specified by contract requirements of the Sample Management Office (SMO) (LANL 2000, 071233). One field duplicate will be collected for every 10 geotechnical samples taken, and submitted for the same analyses.

5.4 Geophysical Logging Methods

Geophysical logging will be performed in competent boreholes using methods described in SOP-5030 and SOP-5077, which will provide additional data for characterization of the tuff matrix in the vadose zone.

5.5 Pore-Gas Sampling Methods

Subsurface pore-gas samples will be collected from all boreholes in accordance with the current version of SOP-5074, after allowing for the equilibration of pore gases at the completion of drilling activities. In each borehole, one sample will be collected at the depth of the nearest adjacent disposal unit; the second sample will be collected at the TD. Pore-gas samples will be collected using a straddle packer to isolate discrete depths within the borehole. Each interval will be purged before sampling until measurements of carbon dioxide and oxygen are stable and representative of subsurface conditions. In brief, a purge pump is used to withdraw borehole and formation vapors through the borehole or constructed sampling port. Concentrations of purge indicator gases (carbon dioxide and oxygen) are monitored continuously during this pre-sampling cycle. Once indicator gas concentrations are stable, proper purge is achieved, and formation vapor sampling can proceed. Subsurface pore-gas samples will be collected in SUMMA canisters and submitted for VOC analysis using U.S. Environmental Protection Agency (EPA) Method TO-15. Tritium samples will be collected in silica gel samplers and submitted for tritium analysis using EPA Method 906.0.

Pore-gas QA/QC samples will consist of equipment blanks and field duplicates. These samples will be collected at a frequency of one QA/QC sample for every ten regular samples, as specified in Section IX.B.2.e of the Consent Order. The equipment blank will be collected after sampling and purge decontamination by pulling zero gas (99.9% ultrahigh-purity nitrogen) through the packer sampling apparatus and accumulating a sample of zero gas using SUMMA canisters and silica gel samplers. If the decision is made to install a pore-gas monitoring well, a well design will be developed that outlines target intervals, port types and quantity, and packer configurations. This design will be submitted to NMED for approval prior to implementation.

5.6 Perched Groundwater Sampling Methods

If saturation is encountered as a borehole is being advanced, drilling will be stopped to determine if a sufficient volume of water for sample analyses can be produced from the borehole. In general, a minimum of 0.5 to 1 L of water is required to conduct a partial suite of analyses. If a full suite of analyses cannot be conducted, samples will be analyzed for geochemical parameters and for priority contaminants which will be chosen based on site knowledge and new data produced during the implementation of this work plan. The geochemical analyses will be performed at the Laboratory's on-site geochemical laboratory, and verification may be needed to ensure that sampled water was derived from the formation.

Drilling will be continued in a water-producing borehole until the base of saturation or the perching horizon is reached, to determine the thickness of saturation and the characteristics of the perching horizon. If possible, the perching horizon will not be penetrated. A monitoring well as-built design drawing will be developed and submitted to NMED for approval. Following approval, the well will be installed and developed in accordance with SOP-5032 and SOP-5033 and Section IV.C.2.d.vii of the Consent Order.

An additional borehole will be drilled adjacent to the well using a double-wall-casing advancement drilling method to isolate the known zone of saturation; the borehole will be advanced to the planned TD of the borehole or until another zone of saturation is encountered.

If drilling is halted because of the observation of water, but sufficient water for a representative sample cannot be recovered from the borehole, drilling will be continued. Small volumes of water from discrete intervals will not be composited to make up the minimum volume of water necessary for a sample.

5.7 Borehole Abandonment Methods

Backfilling (abandonment) of investigation boreholes will be conducted according to the requirements of Section X.D of the Consent Order. Backfill materials will be selected and placed specifically to account for observed subsurface conditions such as zones of increased moisture. At the time of abandonment, the abandonment will be thoroughly documented in a field logbook, in accordance with SOP-5034; documentation will include, at a minimum, the types of backfill material used (such as bentonite and/or cement), the volumes (calculated and actual) of backfill material used, intervals of placement, and any additives used to enhance backfilling. No drill cuttings will be placed back in the boreholes at the time of abandonment.

5.8 Equipment Decontamination Methods

Following excavation and transportation activities, project personnel will decontaminate all the equipment that was involved in excavation, drilling, and material-removal activities. Residual material adhering to equipment will be removed using dry decontamination methods, including the use of wire brushes and scrapers (SOP-5061). If equipment cannot be free-released following dry decontamination, a high-pressure sprayer, along with long-handled brushes and rods, will be used to more effectively remove contaminated material from equipment. Pressure-washing of equipment will be performed on a temporary wash pad with a high-density polyethylene liner. Cleaning solutions and wash water will be collected and contained for proper disposal. Decontamination fluids will be sampled to determine final disposition. Air filters on equipment operating in the exclusion zone will be considered contaminated and will be removed and processed for disposal; the filters will be replaced with new clean filters before equipment leaves the site. Equipment will be surveyed and tagged for free release by a radiation control technician before being demobilized.

5.9 Investigation-Derived Waste Management

The investigation/remediation activities described in this SAP will generate a variety of types of investigation-derived waste (IDW) that will be managed in accordance with applicable federal, state, DOE, and Laboratory requirements. Representative samples of the IDW will be collected in a manner compliant with EP Directorate SOPs, EPA methods, and/or the disposal facility's sampling guidelines. Analytes, sample frequencies, sample sizes, sample type (discrete or composite), and the analytical techniques will be prescribed by the waste acceptance criteria for the chosen disposal facilities. Waste-characterization samples, where required, will be submitted through the SMO for analysis at off-site analytical laboratories.

6.0 MONITORING AND SAMPLING PROGRAM

A vadose zone or groundwater monitoring program will be established or integrated into the applicable sitewide program if perched groundwater wells or vadose zone wells are installed during this soil boring investigation.

7.0 SCHEDULE

The schedule for implementation of the work described in this SAP will be provided at the time that the proposed boring locations are submitted to NMED for review and approval.

8.0 LOS ALAMOS NATIONAL LABORATORY'S SOPs

The following is a list of the Laboratory's EP Directorate SOPs that will be followed during execution of this soil-boring installation program.

- SOP-06.09, Spade and Scoop Method for Collection of Soil Sample
- SOP-06.24, Sample Collection from Split-Spoon Samplers and Shelby-Tube Samplers
- SOP-06.26, Core-Barrel Sampling for Subsurface Earth Materials
- SOP-06.33, Headspace Vapor Screening with a Photoionization Detector
- SOP-12.01, Field Logging, Handling, and Documentation of Borehole Materials
- SOP-5029, Drilling Plan Development
- SOP-5030, Contract Geophysical Logging
- SOP-5032, Well Construction
- SOP-5033, Well Development
- SOP-5034, Monitoring Well and Borehole Abandonment
- SOP-5055, General Instructions for Field Investigations
- SOP-5056, Sample Containers and Preservation
- SOP-5057, Handling, Packaging, and Transporting Field Samples
- SOP-5058, Sample Control and Field Documentation
- SOP-5059, Field Quality Control Samples
- SOP-5061, Field Decontamination of Equipment
- SOP-5074, Sampling for Sub-Atmospheric Air
- SOP-5077, Field Sampling of Core and Cuttings for Geological Analysis
- SOP-5181, Notebook and Logbook Documentation for Environmental Directorate Technical and Field Activities
- SOP-015, R3, Down Hole Video Camera and Borehole Logging System Use

9.0 REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

EPA (U.S. Environmental Protection Agency), April 10, 1990. "Module VIII of RCRA Permit No. NM0890010515, issued to Los Alamos National Laboratory, Los Alamos, New Mexico," EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 001585)

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LANL (Los Alamos National Laboratory), May 1991. "TA-21 Operable Unit RFI Work Plan for Environmental Restoration," Vol. II (Chapters 14 to 16), Los Alamos National Laboratory document LA-UR-91-962, Los Alamos, New Mexico. (LANL 1991, 007529)

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McQuown, M.S., August 31, 1998. "Results of Additional Geophysical Surveying TA-21, MDA B, Los Alamos, New Mexico," letter to J. Hopkins (Morrison Knudsen Corporation) from M.S. McQuown (Bay Geophysical Associates), Project No. 98-176P. (McQuown 1998, 064147)

McQuown, M.S., July 24, 1998. "Results of Integrated Geophysical Investigation, Los Alamos National Laboratory TA-21, MDA B," letter to J. Hopkins (Morrison Knudsen Corporation) from M.S. McQuown (Bay Geophysical Associates), Project No. 98-176P. (McQuown 1998, 064146)

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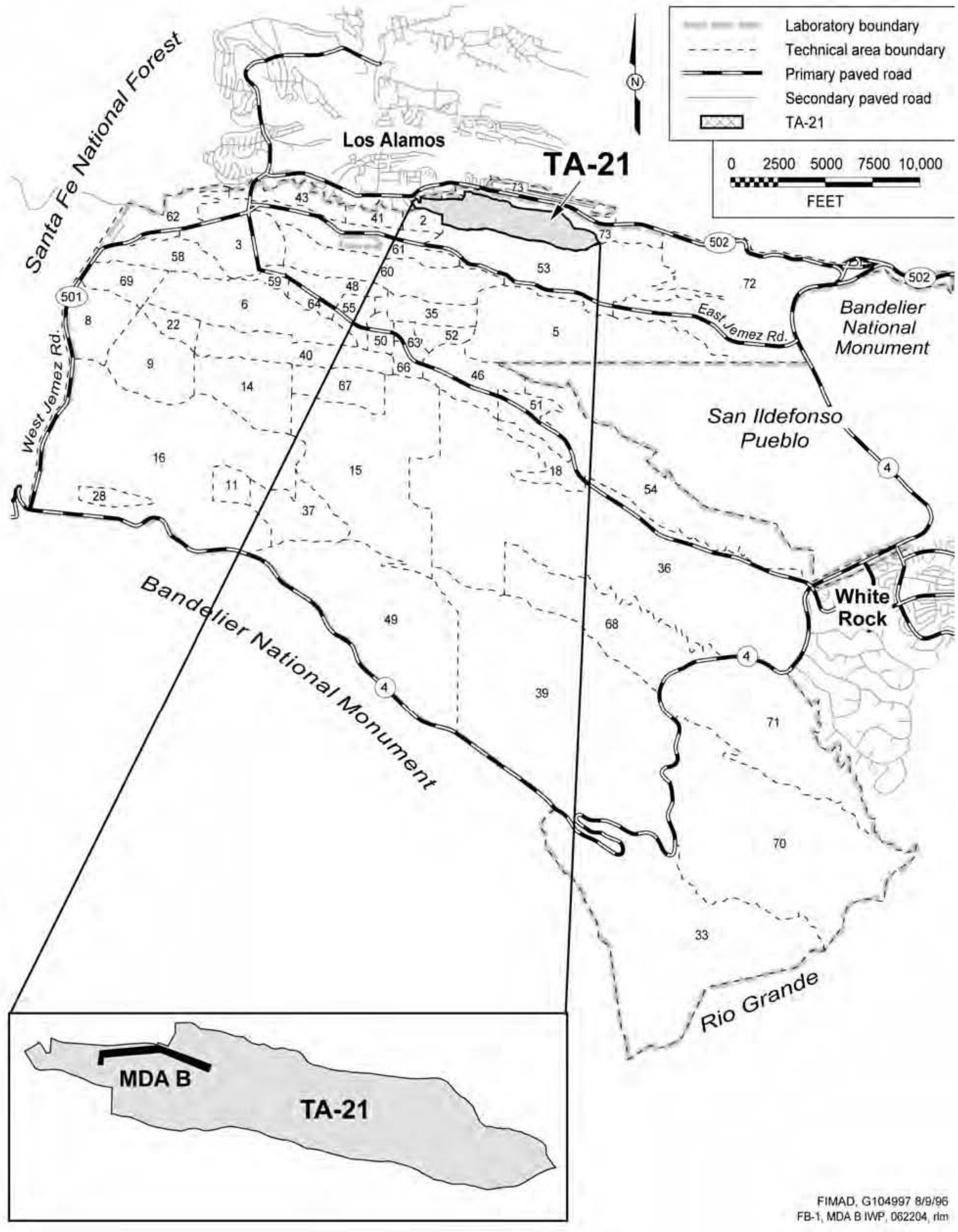

Figure 1.0-1 MDA B and TA-21 location plan

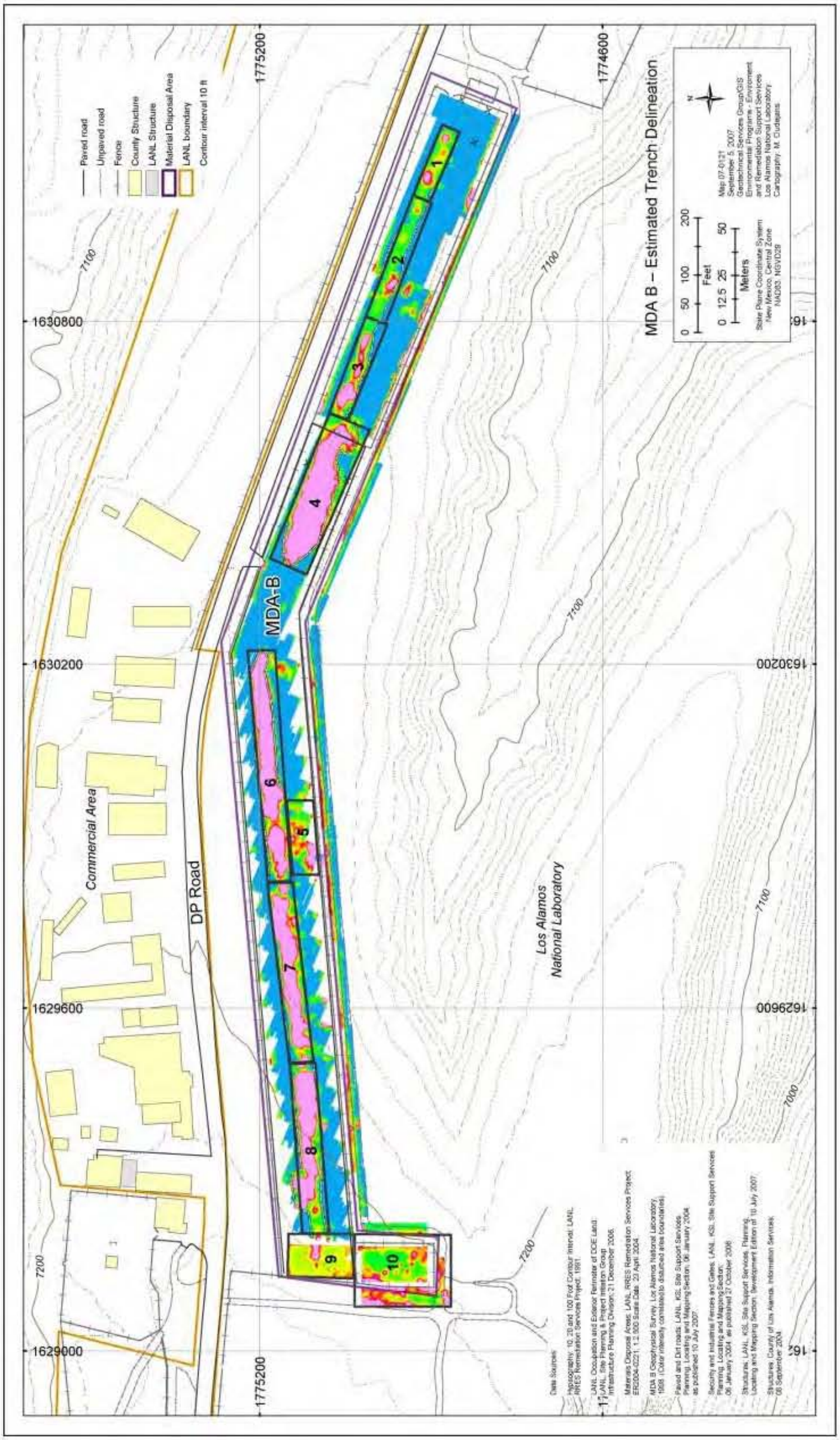

Figure 1.0-2 MDA B site plan

Table 4.0-1
Proposed Borehole Sampling Program

Borehole Number	Sample Type	Number of Samples	Target Intervals/Features	Field-Screening Intervals[a]	Core Intervals[b]	Analytical Suite
Boreholes to be determined (TBD)	Characterization of nature and extent of contamination	TBD	Highest field-screening value Deepest field detection of contamination Immediately below the base of the disposal trenches Total boring depth (base of Cerro Toledo) Fractures and adjacent tuff matrix—paired (as necessary)	Continuous to 25 ft; then every 10 ft to TD	Continuous; discrete samples at minimum of 4 depth intervals or 2 depth intervals (A-8b boreholes)	TAL metals Radionuclides by gamma spectroscopy Tritium Isotopic uranium Isotopic plutonium Strontium-90 VOCs SVOCs Dioxins/furans PCBs Perchlorate Cyanide pH Nitrates Explosive compounds
Boreholes TBD	Geotechnical	Minimum of 4 per borehole	Three from the tuff units above Cerro Toledo interval One from the Cerro Toledo interval Fractures and adjacent tuff matrix – paired (as necessary)	Continuous to 25 ft; then every 10 ft to TD	Continuous; discrete samples at minimum of 4 depth intervals	Saturated and unsaturated hydraulic conductivity Porosity Bulk density Matric potential Chloride-ion concentration Moisture content

Table 4.0-1 (continued)

Borehole Number	Sample Type	Number of Samples	Target Intervals/Features	Field-Screening Intervals[a]	Core Intervals[b]	Analytical Suite
Boreholes TBD	Groundwater	At each occurrence	Perched groundwater	At each occurrence	n/a[c]	TAL metals Radionuclides by gamma spectroscopy Tritium Isotopic uranium Isotopic plutonium Strontium-90 VOCs SVOCs Dioxins/furans PCBs Perchlorate Cyanide pH Nitrates Explosive compounds General chemistry[d]
Boreholes TBD	Pore gas	2 per borehole	Immediately below base of the disposal trenches, total boring depth, biased depths	n/a	n/a	VOCs Tritium Percent moisture

[a] Screening for radiological contamination will be conducted continuously on recovered cores from 0 to 25 ft bgs. Additional field screening will be made of recovered cores at 10-ft intervals at depths greater than 25 ft bgs to TD of each borehole. VOC headspace, x-ray fluorescence, and high explosives screening will be conducted at 10-ft intervals over the entire length of the borehole.

[b] Continuous cores will be collected from each borehole from 0 to 25 ft bgs. Cores will be collected from 10-ft intervals at depths greater than 25 ft.

[c] n/a = Not applicable.

[d] General groundwater chemistry analysis includes anions, alkalinity, total organic carbon, total inorganic carbon, and total dissolved solids.