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Date: January 23, 2004
Refer to: ER2004-0038

JAN 2004

Ms. Sandra Martin
Permits Management Program
NMED – Hazardous Waste Bureau
2905 Rodeo Park Drive East
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Santa Fe, NM 87505-6303

SUBJECT: RESPONSE TO SECOND NOTICE OF DEFICIENCY FOR THE INVESTIGATION WORK PLAN FOR MATERIAL DISPOSAL AREA C, REVISION 1, DATED DECEMBER 16, 2003, LOS ALAMOS NATIONAL LABORATORY, EPA ID# NM0890010515

Dear Ms. Martin:

On December 23, 2003, Los Alamos National Laboratory (LANL) and the US Department of Energy (DOE) received a second notice of deficiency letter (dated December 16, 2003) for the investigation work plan for MDA C, Revision 1, requiring the Permittees to address the comments and re-submit the document within 30 days of receiving the letter.

We are providing responses to each New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) comment included in attachment to the NMED letter (Enclosure 1). For many of these comments, we disagree with the positions taken by NMED, and our responses provide the basis for our disagreement. Rather than revise the document with these issues outstanding, we believe the best course of action would be to resolve these issues before submitting the next iteration of the work plan. We have, however, updated pages or sections of the document affected by our proposed changes and are submitting them herewith (Enclosure 2). The updated materials are

- the main text of the investigation work plan,
- Figure B-3 and Tables B-11, B-13, B-21, B-23, and B-25, and
- the investigation-derived waste management plan (Appendix F).

When LANL and NMED agree upon the scope of the investigation activities at MDA C and all outstanding issues have been resolved, the report will be reissued as a second revision.

We believe that discussions with your staff concerning the issues we have identified in our comment responses will expedite review and approval of the final MDA C work plan.

Sincerely,

David McInroy, Deputy Project Director
Remediation Services
Los Alamos National Laboratory

Sincerely,

David Gregory, Project Manager,
Department of Energy
Los Alamos Site Office

DM/DG/JH/th

Enclosures: (1) Response to Second NOD for the Investigation Work Plan for MDA C, Revision 1
(2) Updates to the Investigation Work Plan for MDA C, Revision 1

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IM-5, MS A150
S-7, MS F674
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Cy:(w/o enclosure)
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D. Cobrain, NMED-HWB
J. Kieling, NMED-HWB
J. Schoeppner, NMED-GWQB
C. Voorhees, NMED-OB

Response to
Second Notice of Deficiency for the Investigation Work Plan for
Material Disposal Area C, Revision 1, Dated December 16, 2003,
Los Alamos National Laboratory, EPA ID# NM0890010515

INTRODUCTION

To facilitate review of this response, the New Mexico Environment Department's (NMED's) comments are included verbatim. Los Alamos National Laboratory's (LANL's) responses follow each NMED comment.

NMED Comment

1. *The Permittees have misinterpreted NMED's June 17, 1999 position paper titled "Determination of Extent of Contamination." The position paper states, "The vertical and horizontal extent of contamination at a specific site (including off-site migration) is considered adequately determined once concentrations of (1) inorganic constituents (including radionuclides) have been spatially (in three dimensions) delineated relative to background concentrations and (2) organic constituents have been spatially (in three dimensions) delineated relative to practical quantitation limits." The position paper further states that the Permittees* may petition NMED for a variance *from the above-stated requirements on a case-by-case basis. The Permittees have not petitioned NMED regarding MDA C.*

   The position paper does not state that a decreasing trend defines extent of contamination. The Permittees admit in their response to NMED's comments that they expect to detect tritium at both of the proposed sampled depths in the boreholes at MDA C (below the disposal pits and at total depth) and that they expect to see a decreasing trend in the concentration of contaminants. NMED requires the Permittees to advance borings to depths that do not show evidence of contaminants. All improper references to NMED's position paper, including Appendix G, must be removed from the Work Plan. Additionally, the Permittees' incorrect interpretation of the position paper is not acceptable as the justification for not following the investigation requirements included in NMED's November 26, 2002 Order.

LANL Response

1. In response to this comment the Laboratory agrees to remove all references to the NMED position paper with respect to defining extent of contamination. Instead, the work plan will clarify that the extent of contamination must be determined sufficient to make corrective action decisions based on EPA guidance.

   However, given that historically NMED has accepted a decreasing trend in contaminant concentrations as a definition of extent, the Laboratory believes that the approach used is sound and appropriate when characterizing and remediating sites. Historically, NMED guidance has consistently been based on measuring decreasing trends in concentration of contaminants as sufficient to indicate lateral and vertical extent. This guidance has been communicated verbally to the Laboratory in meetings and discussions relative to site investigations and remediations. NMED's guidance over the past six years has shaped the Laboratory's sampling and reporting for Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs) conducted at potentially contaminated sites.

   LANL contends that it is satisfying the criteria stipulated in the position paper by defining extent as decreasing trends relative to background concentrations for inorganic chemicals and practical quantitation limits for organic chemicals. This approach has been accepted by NMED for a number of sites and has been the basis for sampling and analysis plans and reports. Several sites have been

removed from Module VIII of the Laboratory's Hazardous Waste Facility Permit (Module VIII) (EPA 1990, 01585; EPA 1994, 44146) based on this understanding. Recent NMED-approved investigation and cleanup reports based on a demonstration of decreasing trends to define extent include the following:

- SWMU 00-030(g) – RCRA Facility Invesitgation Report for Solid Waste Management Unit 00-030(g), LA-UR-00-5378 (ER IR 70273), approved by NMED on April 29, 2003 (ER ID 76018);
- SWMU 06-003(g) – RFI Report for Potential Release Sites in the Eastern and Western Aggregates at Technical Area 06 (former Operable Unit 1111), LA-UR-98-3710 (ER ID 62227), approved by NMED on March 14, 2000 (ER ID 66381);
- SWMU 21-029 – Phase II RFI Report for Potential Release Site (PRS) 21-029, DP Tank Farm, LA-UR-01-5254 (ER ID 71303), approved by NMED on January 14, 2002 (ER ID 73668);
- SWMU 54-004 – RFI Report for Material Disposal Area H at Technical Area 54, LA-UR-01-1208 (ER ID 70158) and Addendum to the RFI Report for Material Disposal Area H, (Solid Waste Management Unit 54-004) at Technical Area 54, LA-UR-02-3397 (ER ID 73270), approved by NMED on April 11, 2003 (ER ID 76184);
- SWMU 54-007(a) – VCA Completion Report for SWMU 54-007(a), LA-UR-02-5114 (ER ID 79732), approved by NMED on May 5, 2003 (ER ID 76016);
- SWMU 54-007(c)-99 – Voluntary Corrective Action Completion Report for PRS 54-007(c)-99, Revision 1, LA-UR-02-0635 (ER ID 72657), approved by NMED on June 20, 2002 (ER ID 71424); and
- SWMU 73-005-99 – RFI Report for Consolidated PRS 73-005-99, LA-UR-00-1672 (ER ID 66779) approved by NMED on March 28, 2001 (ER ID 69874).

Sites removed from Module VIII based on demonstration of decreasing trends include

- SWMUs 00-016 and 06-003(g) – Hazardous Waste Amendments of 1984 Permit Modification Request, 9 PRSs Proposed for No Further Action, June 2000, LA-UR-00-2265 (ER ID 67472), approved by NMED October 10, 2001 (ER ID 70236) and
- SWMUs 54-007(c)-99 and 73-005 – Los Alamos National Laboratory Permit Modification Request, September 2002 (ER ID 73668), approved by NMED August 8, 2003 (ER ID 79282).

Moreover, the Laboratory's approach is consistent with the US Environmental Protection Agency's (EPA's) guidance for defining extent of contamination under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and corrective action under RCRA. EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988, 59107, p. 3-13) states that one of the primary objectives of site investigations is "to characterize the nature and extent of contamination such that informed decisions can be made as to the level of risk presented by the site and the appropriate type(s) of remedial response." In most cases, and specifically at Material Disposal Area (MDA) C, neither of these decisions requires defining the extent of contamination to background levels. EPA offers similar guidance with respect to RCRA corrective actions. In the EPA's May 1, 1996, Advance Notice of Proposed Rulemaking for RCRA Corrective Action (61 FR 19444), EPA states, "in delineating the extent of contamination it may not be necessary to delineate to background concentrations in all cases. In some cases, information

adequate to support cleanup decisions can be obtained through delineation to risk based concentrations or other investigation endpoints."

NMED Comment

2. *The requirements listed in NMED's Order dated November 26, 2002 are the minimum requirements for investigation of MDA C. Based on the data and information in the Historical Investigation Report and other data provided by the Permittees, NMED may require additional work at MDA C in order to adequately determine the nature and extent of contamination at the site. NMED is not required to provide rationale or the technical bases for imposing additional requirements, including specifications for collecting QA/QC samples, for the investigation.*

LANL Response

2. LANL has and continues to follow RCRA guidance in all site investigations implemented in accordance with Module VIII (EPA 1990, 01585; EPA 1994, 44146). Data quality objectives (DQOs) were identified in the RFI Work Plan for Operable Unit 1147, LA-UR-92-0969 (LANL 1992, 07672) that the EPA approved on April 6, 1993 (ER ID 27044). The Phase I RCRA Facility Investigation (RFI) was implemented in accordance with that work plan. The DQO process for identifying investigation requirements is also included in LANL's Installation Work Plan (ER ID 62060), which was approved by NMED on June 10, 1999 (ER ID 63518). The Phase I RFI data for MDA C were reviewed and presented in the Historical Investigation Report (HIR) and were the basis for identifying additional sampling required to complete the definition of the nature and extent of contamination.

   The comment states that the requirements in the November 26, 2002, Order are minimum requirements for investigation of MDA C and that NMED may require additional work following its review of the information in the HIR and other data provided by LANL. However, in NMED's November 26, 2002, response to LANL's comments on the May 1, 2002, draft Order, including those comments related to MDA C (Comments No. R403 through R411), NMED states that existing documents submitted by LANL were reviewed and the investigations described in those documents were found to be insufficient to characterize nature and extent of contamination. NMED then indicated that the investigation described in the Order must be implemented to characterize nature and extent. However, NMED acknowledged in its response to LANL's comments to the draft Order that LANL may have conducted investigations that had not been previously reported to NMED and that these investigations may be used to satisfy Order requirements.

   In the case of MDA C, the only document submitted to NMED before issuance of the Order was the approved RFI Work Plan for Operable Unit (OU) 1147 (LANL 1992, 07672). Based on NMED's response to LANL's comments on the draft Order, the requirements in the Order are those that NMED contends are necessary to characterize nature and extent of contamination at MDA C based solely on the historical information provided in the approved RFI work plan. The proposed investigation work plan for MDA C was developed after review of additional data not previously provided to NMED. This information demonstrates that some investigation requirements thought not to have been addressed have now been satisfied. The comment also does not take into account guidance provided to LANL during a meeting with NMED on October 16, 2003, to discuss NMED's disapproval of the first MDA C investigation work plan. During this meeting, NMED indicated that LANL could propose fewer investigation requirements than stipulated in the Order provided the modifications could be justified based on a review of data from previous investigations.

LANL disagrees with NMED's position that it has the authority to require additional work at MDA C without providing a "rationale or the technical bases." It is a well-established legal and regulatory principle that the regulator must provide a supportable technical justification to require the permittees to perform additional work.

NMED Comment

3. *The Data Interpretation and Identification of Investigation Objectives Section (2.7.3.2), which is part of the Summary of Historical Investigations, is unnecessarily lengthy. The section includes six pages of data interpretation and evaluation and a description of the current knowledge of the nature and extent of contamination at MDA C. A previous Section (2.7.3) lists the Phase I RFI Results in five short bulleted items. These items should be expanded to include the pertinent information from Section 2.7.3.2 and references to relevant figures and data tables. A short paragraph stating the interpretations and conclusions that the Permittees have made based on the previous investigations conducted at MDA C may be included at the end of the bulleted items. The Data Interpretation Section (2.7.3.2) should be deleted. Additionally, the Investigation Objectives are identified and listed in Section 1.2 of the Work Plan and they do not need to be described here.*

LANL Response

3. The information presented in Section 2.7.3.2 of the revised MDA C work plan was originally presented in Section B-4 of the HIR of the July 2003 work plan (Revision 0). During an October 16, 2003, meeting between NMED, the University of California (UC), and the US Department of Energy (DOE) to discuss the disapproval of Revision 0, the parties agreed that this information would be moved to Section 2 of the revised work plan. The issue of interpretation of Phase I RFI data was specifically discussed at this meeting because NMED originally indicated in its comments that the HIR should present only the Phase I RFI results and should not include any data interpretation or conclusions. UC and DOE responded that interpretation of the Phase I RFI was an essential part of the work plan because it forms the basis for the proposed technical approach and, therefore, the justification for varying from the investigation requirements specified in the November 26, 2002, Order. NMED indicated that Phase I RFI data presented in the HIR could be used to justify alternate investigation approaches, but the reference to data being used to support a justification needed to be very specific. The discussion of data presented in Section 2.7.3.2 is LANL's response to meeting that request. Interpretation of data in Section 2 ("Background") is also consistent with Section XI.B of the Order, which states, "In general, interpretation of data acquired during previous investigations shall be presented only in the background sections of work plans."

   NMED, UC, and DOE all agree that the objective of the investigation of MDA C is to determine the nature and extent of contamination at the site. NMED believes this objective can be met by implementing the November 26, 2002, Order requirements, which did not consider previous investigation results (see response to Comment 2). Phase I RFI results have refined the conceptual site model of MDA C such that the additional data needed to complete determination of nature and extent is now significantly less than specified in the Order. To complete the determination of nature and extent, existing data must be interpreted to identify the remaining investigation requirements. The level of detail presented Section 2.7.3.2 is commensurate with this purpose, and this section provides the rationale and technical bases for the investigation approach proposed by UC and DOE in the work plan to address the remaining investigation requirements. For these reasons, Section 2.7.3.2 will not be removed from the work plan.

NMED Comment

4. *The Permittees do not intend to field screen samples during the investigation at MDA C and state that the concentrations of contaminants in the subsurface at MDA C are sufficiently low that field screening is ineffective for the purpose of identifying samples for laboratory analysis. NMED requires field screening in order to help guide the investigation, enable the Permittees to determine the extent of contamination at the site, and to minimize the need for additional investigation and field work at the site in the future. NMED notes that the Permittees will be continuously coring the boreholes and that samples will be readily available for field screening.*

   The Work Plan contains conflicting statements regarding radionuclide screening that will be performed during the investigation of MDA C. NMED requires clarification of the methods, purpose, and use of the radionuclide screening that will be employed. The Air Rotary subsection of Section 5.1.1 (Drilling Protocol) states, "If radiological contamination is detected using field screening methods at the proposed TD, the boring will be advanced until contamination is no longer detected." Section 5.1.2 (Collection of Tuff Samples) states, "Samples will be collected from intervals where contamination is suspected because field screening results are elevated and/or visual inspection identifies fractures or staining." These statements appear to contradict the Screening of Core Samples subsection of Section 2.7.3.1 (Field Screening Results) that states, "there was no significant difference in field screening results for samples having radionuclides within and above local BVs."

   NMED requires information regarding the lamp that was used in the photoionization detector (PID) used in previous field investigations at MDA C, because there were no detects of VOCs in the field during those investigations. The Permittees must consider using a PID with a sufficiently sensitive lamp, flame ionization detector (FID), field gas chromatograph (GC), or another instrument to field screen core samples for VOCs.

   The Permittees claim in their response to NMED's comments that, "Field screening for tritium will not be performed, as there are no field screening methods capable of detecting tritium and locations of tritium samples are not dependent on field screening results." NMED disagrees that there are no field screening methods capable of detecting tritium. It is NMED's understanding that there are at least two types of instruments that can field-detect tritium in soil/tuff. The electret chamber can be used to scan a core to determine gross beta levels, and a liquid scintillation counter can be used to determine a more definitive tritium concentration. The Permittees must consider methods for field screening core samples for tritium.

LANL Response

4. In the first paragraph of the comment, NMED states that field screening is required "to help guide the investigation, enable the Permittees to determine the extent of contamination at the site, and to minimize the need for additional investigation and field work at the site in the future." LANL's response to Comments 16(b), 16(c), and 25 in Attachment 1 to NMED's September 4, 2003, letter disapproving the first MDA C work plan (Revision 0) explained that field screening would not generate useful data. In addition, Section 4.2.3 of Revision 1 to the work plan explains why the field screening methods specified in the NMED Order will not reliably detect the levels and types of contamination found at MDA C. LANL notes that NMED's assertion that field screening will enable the Permittees to "determine the extent of contamination" is inconsistent with Comment 1, in which NMED states that extent of contamination must be defined by comparison to practical quantitation limits. The detection limits of field screening methods are much higher than practical quantitation limits for laboratory analytical methods and could not be used to satisfy this condition for determining extent of contamination.

In the second paragraph of the comment, NMED identifies an apparent contradiction between statements in Sections 5.1.1 and 5.1.2 and Section 2.7.3.1 of the revised MDA C work plan concerning field screening for radionuclides, which was provided to NMED for informational purpose only. LANL does not believe these sections are contradictory. Sections 5.1.1 and 5.1.2 state that boreholes would be advanced or samples collected if field screening identifies radioactive contamination. The data presented in Section 2.7.3.1 show that field screening was not capable of detecting the levels of radioactivity present in tuff at MDA C. As noted in Section 4.2.3 of the work plan, all samples will be field screened for health and safety purposes. If this screening shows the presence of contamination, it would indicate higher levels of radioactivity than have previously been detected at MDA C. If such levels were detected, LANL would collect a sample and/or continue to advance a borehole, as specified in Sections 5.1.1 and 5.1.2.

The third paragraph of the comment requests information on the lamp used in the photoionization detector (PID) used during the Phase I RFI at MDA C. Requirements for PID lamps are specified in site-specific health and safety plans (SSHASPs). The SSHASP for the Phase I RFI at MDA C (LANL 1995, 56538) specified that an 11.7 eV lamp would be used for field screening for volatile organic compounds (VOCs). Field screening logs from the 1995 drilling and sampling program recorded H Nu System PID results obtained during coring activities at each borehole. All readings were non-detects. The ionization potential of organic chemicals detected at MDA C, as discussed in the HIR, ranges between 8.93 to 11.32 ppm. The lamp has a high enough energy to detect VOCs that are chemicals of concern at MDA C. A PID will be used for health and safety monitoring of the breathing zone during the MDA C field work.

As described in Section 4.2.3 of the revised MDA C work plan, VOCs are present in pore gas in the tuff. Headspace and direct field screening of the core is not appropriate since only a small volume of pore gas remains in the core once at the surface. Therefore, to characterize vapor-phase contaminant extent, relatively large volumes of pore gas are sampled from isolated zones using straddle packers, sampling membranes, or traditional vapor well constructions. As described in the work plan, the extent of the VOC plume will be determined by collecting two rounds of pore-gas samples from each new and existing borehole. During sampling, pore gas will first be screened for carbon dioxide, oxygen, methane, TCA, TCE, and PCE using a landfill gas monitor and a Bruel and Kjear Multigas Analyzer. These instruments confirm purge and/or zone isolation as well as provide real-time data of the known primary contaminants at the site down to parts per million(ppm) level concentrations. SUMMA canisters will be used to collect pore-gas samples to be analyzed by an off-site laboratory. LANL used pore gas, rather than core samples, to determine the nature and extent of a subsurface VOC plume at MDA H (Addendum to the RFI Report for Material Disposal Area H [Solid Waste Management Unit 54-004] at Technical Area 54, LA-UR-02-3397 [LANL 2002, 73270]), which was approved by NMED on April 11, 2003 (ER ID 76184). This approved approach for delineating the plume at MDA H did not employ the field screening for VOCs specified in the Order.

LANL does not agree that alternative screening methods can be used to field-detect tritium in tuff at MDA C, as stated in the fourth paragraph of the comment. Field detection of tritium cannot be accomplished using standard radiation screening instruments because of the very low energy of the beta particles emitted from tritium decay. The NMED comment mentions electret chambers and liquid scintillation counters as possible field screening methods. LANL previously employed ionization chambers for field screening of tritium during an Interim Action at SWMU 21-024(i). Ionization chambers were not capable of detecting tritium in the field even though the maximum concentration of tritium detected in sludge removed during this action was approximately 200,000 pCi/g.

Electret (ionization) chambers are not sufficiently sensitive to field-detect the levels of tritium expected in tuff at MDA C. For example, Rad Elec, Inc., a manufacturer of the electret chamber, reports a limit of

detection of 6300 dpm/cm^2 for surface tritium measurements based on a one-hour detection period. This detection limit is equal to a tritium flux of 2800 pCi/cm^2-hr. This flux would have to result from diffusion of tritiated water from the core sample into the electret chamber. Diffusion of tritiated water would occur occur until the humidity in the chamber equilibrated with that in the tuff. Based on the reported chamber volume of 210 mL, the mass of tritiated water that could diffuse into the chamber would be very small. The 210 mL chamber would contain approximately 0.004 g of water when saturated. The tritium concentration in this water would need to be approximately 40,000,000 pCi/mL to be detectable. The highest detected value at MDA C was 650,000 pCi/mL, as reported in the Phase I RFI data. In addition, the electret chamber is designed to be used on a flat surface, which is difficult with core samples. LANL notes that these devices are primarily used for health and safety monitoring where action levels are orders of magnitude higher than levels of contamination found at MDA C.

Liquid scintillation counting is a laboratory radioanalytical method, not a field screening method. Although this method can be performed in the field, it must be performed in a field laboratory and would not produce "real-time" results.

NMED Comment

5. ***Table 2.2-1, Summary of Wastes Disposed of at MDA H Shafts, page 9***

NMED requires clarification regarding the proposed analysis of samples for dioxins and furans. In the Permittees' response to comments, Comment 13a states, "LANL modified the scope of work to call for analysis of dioxins and furans in the samples collected nearest the base elevation of each disposal pit." However, the Work Plan states in Section 4.2.4 (Analytical Suites), "tuff samples collected directly beneath the Chemical Pit will be analyzed for dioxins and furans...tuff samples from other locations will not be analyzed for dioxins or furans"). Additionally, neither Table 3 nor Figures 11 through 24 indicate that dioxins and furans will be included as analytes for the borings.

LANL Response

5. Section 4.2.4, Table 3, and Figures 11 through 24 of the work plan will be modified to indicate that dioxins and furans will be added to the analytical suite for the first tuff sample collected beneath a pit or shaft in boreholes A through J, the only boreholes passing beneath the disposal units.

NMED Comment

6. *The fifth paragraph of Section 2.7.2 (Phase I RFI Field Investigations) indicates that the results of the geophysical surveys were not entirely conclusive in determining the locations of the pits. The paragraph states, "Sufficient anomalies were detected in the areas of Pits 1 through 5 to infer general pit boundaries; however, the anomalies extend over the reported width of the pits making it difficult to distinguish the boundaries between the pits. No clear anomalies were observed to indicate the boundaries of Pit 6 or the Chemical Pit." NMED believes that the locations of the disposal pits and shafts must be accurately determined in order to ensure that the site can be sufficiently and safely investigated. If the locations of the pits have not been determined, as is indicated by this statement, then the Permittees must develop a plan to make such determinations prior to conducting work under the Investigation Work Plan, as stated in NMED's disapproval letter dated November 19, 2003. This plan, if needed, shall be included as an appendix to the Work Plan.*

NMED requires clarification of the statement in Historical Investigation Report, Section B-2.1.2 (Geophysical Survey Results), subsection "2002 Geophysical Survey" that notes that the anomalies

from the survey extend to a greater distance than the reported pit boundaries and that these differences will be taken into consideration when locating new boreholes during this investigation.

LANL Response

6. The locations of the disposal units have been established as accurately as possible using LANL engineering drawings and geophisical surveys. These locations could not be confirmed by geophysical surverys with sufficient accuracy to implement the drilling program specified in the Order without a reasonable probability of drilling into the buried waste inventory. As a result, LANL has proposed an investigation approach that will meet the objective of determining nature and extent within the constraints posed by uncertainties in exact disposal unit location.

   The boundaries of the Chemical Pit and Pit 6 (Figure B-5) shown on the LANL engineering drawings could not be adequately confirmed by geophysical methods because of interference from the subsurface infrastructure and inadequate contrasts in the physical properties between the pit and surrounding materials. Specifically, buried utilities are present at the suspected location of the Chemical Pit. The geophysical response from the utility corridor is much greater than the measured response from the two disposal pits. The presence of the pipe would easily mask any anomalies caused by pit materials. The boundary of Pit 6 is not discernible because the contrasts are insufficient. Either the physical character of the pit materials is similar to the surrounding materials or subsequent excavation or fill activities have obscured the former pit boundaries.

   The geophysical surveys were performed using the latest technologies and have been successfully applied to achieve similar objectives in previous surveys at LANL. In addition, the MDA C surveys achieved complete coverage and very high resolution. EM31 data were acquired at less than 2-ft intervals along lines spaced approximately 10 ft apart, resulting in 43,806 measurement points in a total line 9 miles long. EM61 data were acquired at less than 1-ft intervals along lines spaced approximately 10 ft apart, resulting in 105,738 measurement points in a total line 15 miles long. GPR data were acquired continuously (less than 1-in. intervals) along a total line length of almost one mile.

   Although geophysical techniques are valuable tools to help where wastes are buried, they have inherent limitations. Geophysical techniques are indirect techniques that respond to bulk physical properties of subsurface materials. These techniques alone generally do not provide definitive or unique solutions to problems. To obtain unique solutions, the geophysical results must be integrated with information from direct techniques such as excavations or test borings. In the case of MDA C, the latter are constrained by safety concerns associated with intrusion into buried wastes.

   Since the distances between Pits 1 and 3, 3 and 2, and 2 and 4 are minimal, and the geophysical data are insufficient to confirm the pit boundaries, for purposes of investigation, the work plan approaches these pits as one disposal unit with multiple cells (Figure B-5). Section B-2.1.2 will be clarified to explain that the geophysical results cannot be used to delineate and confirm boundaries between Pits 1 through 4 with sufficient accuracy to install boreholes between the pits.

NMED Comment

7. *The Permittees claim in their response to NMED's comments that advancing one deep boring (Borehole M) at MDA C will be sufficient to determine the vertical extent of the VOC plume at the site. The Permittees state, "The results of previous investigations of the VOC plume at MDA L, which is far more extensive than that at MDA C, indicate that the vertical extent of VOC migration is controlled by stratigraphic features (i.e., permeable units that allow rapid communication with the atmosphere) and,*

thus, does not vary widely across the site." NMED considers all sites on an individual basis and will not accept preliminary conclusions from one site to be used at a different site.

LANL Response

7. All text comparing the VOC plume at MDA C with the plume in the MDA L subsurface will be removed from the document.

   To determine the vertical extent of the VOC plume at MDA C, the Permittees will sample pore gas from all proposed boreholes and all existing boreholes (50-09100 and 50-10131) as specified in the NMED Order. These boreholes will be sampled immediately after drilling activities are completed and again after one month. The depths to be sampled in these boreholes are presented in Section 4.2.2 of the MDA C work plan.

   Pore-gas data for VOCs from the first and second phase of VOC sampling in the new and existing boreholes will be used to determine the vertical extent of VOC pore-gas contamination. Should the results of sampling indicate that the VOC contamination extends below the total depth of a new borehole, the borehole may be lengthened, and deeper pore-gas samples may be collected as necessary to define the vertical extent of the contamination sufficient for corrective action decisions (see response to Comment 1). However, because of the VOC transport mechanism, boreholes cannot be advanced until no VOCs are detected. The VOCs are a vapor-phase plume, and the transport mechanism is diffusion. Therefore, VOCs will diffuse to the bottom of a borehole. If a borehole is advanced further, then VOCs will continue to diffuse down the borehole, and the borehole will act as a conduit for transporting contaminants further below the ground surface.

   The data collected during the two rounds of pore-gas VOC sampling will be used to define a vapor-monitoring plan for VOCs in the MDA C Investigation Report.

NMED Comment

8. *The Permittees have proposed advancing angled boreholes to investigate below Pit 6. They claim that extending the boreholes to greater depths would not generate useful information because the boreholes would extend beyond the boundaries of the disposal pit. The Permittees should be aware that if angled boreholes are advanced and contaminants are present in the bottom interval, then NMED will require further investigation and advancement of additional boreholes to determine the extent of contamination. The Permittees must include the advancement of additional borings in the Work Plan.*

LANL Response

8. Consistent with past LANL practice (e.g., at MDA H), and as specified in the approved work plan for OU 1147, if a review of analytical data shows that the nature and extent of contamination has not been defined in the subsurface at MDA C, then either the boreholes will be extended or additional boreholes will be drilled. LANL will propose a modification to the work plan and meet with NMED to reach concurrence on the additional work. This approach is used in the work plan for completing the determination of extent of contamination for Pit 6 and the Chemical Pit (i.e., boreholes are drilled beneath previous Phase I RFI boreholes when extent was not defined).

NMED Comment

9. *The Investigation Derived Waste (IDW) plan (Appendix F) is lacks details regarding management of the wastes that will be generated during the investigation at MDA C. Basic elements of an IDW plan, such as the types of wastes that are anticipated to be generated and the sampling, characterization and disposal of these wastes, are not described. NMED requires the Permittees to include details regarding the characterization, management, containerization, and anticipated volume generation of wastes during the investigation of MDA C in the IDW plan.*

LANL Response

9. Detailed requirements for managing waste at LANL, including IDW, are specified in various Laboratory Implementation Requirements (LIRs) and standard operating procedures (SOPs). These requirements are generally not unique to a site and, therefore, LANL believes it is more appropriate to present these requirements in documents such as LIRs and SOPs, rather than in site-specific documents such as an IDW plan. References to applicable SOPs, which incorporate applicable LIRs, are provided in the IDW plan. The anticipated volume of waste is unique to a site investigation and additional details on waste type and volumes are provided in the revised IDW plan for MDA C (Appendix F).

NMED Comment

10. *NMED requires clarification regarding how nuclear safety requirements would affect the type of drilling to be conducted. For example, Section 5.1.1 (Drilling Protocol) states, "Vertical boreholes will be drilled using the hollow-stem auger method and angled boreholes will be drilled using either the hollow-stem auger or air-rotary method depending on nuclear safety requirements."*

LANL Response

10. Clarification is provided in the following revised first paragraph for Section 5.1.1 of the MDA C work plan that the requirements address worker safety, not nuclear safety:

    "Vertical and angled boreholes will be drilled using either the hollow-stem or air-rotary method depending on worker safety requirements. To address worker safety requirements for this investigation, the potential for worker exposure to subsurface contaminants from borehole cuttings and/or core will need to be reviewed in the site specific health and safety plan and the documented safety analysis. Although the hollow-stem auger drilling method is preferred when investigating vapor phase contamination, the air-rotary drilling method provides for engineered controls (ie., cyclone-velocity dissapator and HEPA filter) to manage downhole material at the surface, thereby reducing and/or eliminating exposure pathways. The drilling methods to be used at MDA C are described in the following paragraphs."

NMED Comment

11. *The Permittees claim in Table 4 that "Previous sampling of the two existing vapor wells at MDA C has shown that results do not change appreciably over time" and that "resampling of the existing wells is not necessary." NMED disagrees with these statements. According to the data provided in Table D-4, some vapor-phase contaminants are increasing over time (for example, TCE at 260 feet in borehole 50-09100 increased from 680 ppbv in August 2001 to 7000 ppbv in January 2003); some vapor-phase contaminants are decreasing over time (for example, TCE at 90 feet in borehole 50-09100 decreased from 9400 ppbv in August 2000 to 3300 ppbv in January 2003); and some contaminants appear as*

detections for the first time in 2003 (for example, chloroform at 315 feet in borehole 50-09100 is noted as a detection only in January 2003 at 190 ppbv).

The only data provided from borehole 50-10131 below a depth of 150 feet is from sampling conducted in January 2003. Section D-3.3 (VOCs in Pore-Gas Samples) states that Table D-4 presents a summary of all of the detected VOCs from all sampling in both boreholes. Therefore, NMED assumes that these constituents were not detected prior to January 2003. The Permittees' claim that results do not change appreciably over time is not valid. NMED continues to insist that boreholes 50-09100 and 50-10131 must be monitored for pore-gas VOCs and tritium at the same frequency as the newly installed boreholes in order to accurately track the trends of the contaminant plumes at MDA C.

LANL Response

11. LANL will sample vapor from boreholes 50-09100 and 50-10131 for VOCs and tritium at the same frequency as the proposed new boreholes, consistent with the requirements of the Order, until a monitoring plan is accepted as part of the investigation report for MDA C. LANL contends that the results from previous monitoring of boreholes 50-09100 and 50-10131 are generally consistent over time, with some differences that are expected given the low VOC concentrations. Because LANL has agreed to perform the sampling, the interpretation of these results will not be offered as justification for varying from the requirements of the Order. The following changes have been made to the text of the work plan:

Page 74, Table 4, Item 16:

Item 16 will be deleted.

Section 4.2.2, Subsurface Vapor Sampling, first paragraph:

To establish the extent of VOC contamination in tuff, VOC pore-gas data will be collected immediately after drilling activities are completed for each new and existing borehole at MDA C.

Section 4.2.2, Subsurface Vapor Sampling, fourth paragraph:

All ten ports in boreholes 50-01900 and 50-10131 were sampled for VOCs in January 2003. The VOC concentrations measured in this sampling were consistent with results from sampling performed in 2000 through 2002, indicating minimal variability in VOC pore-gas concentrations over time. An additional two rounds of pore-gas sampling will be conducted at boreholes 50-01900 and 50-10131 after drilling activities are completed and again after one month. Data will be collected from all ten ports in each borehole. Port depths for borehole 50-01900 are 20, 50, 90, 103, 120, 160, 200, 233, 260, and 315 ft bgs. Port depths for borehole 50-10131 are 25, 50, 75, 100, 125, 150, 175, 200, 225, and 250 ft bgs. Pore gas data for VOCs from the first and second phase of VOC sampling in the new and existing boreholes will be used to determine the extent of VOC pore-gas contamination and the need for additional boreholes instrumented for monitoring of VOCs in pore gas.

Section 5.1.3, Collection of Pore-Gas Samples, first paragraph:

Subsurface pore-gas samples will be collected from boreholes A through K and N, and boreholes 50-09100 and 50-10131 following LANL-ER-SOP-6.31, Rev 1.

NMED Comment

12. *Section 5.2.2 (Collection of Pore-Gas Samples) states, "The subsurface vapor sample at TD will be collected only if the conditions for purge-gas stabilization according to LANL-ER-SOP-6.31 are met." LANL's SOP does not provide any directions or procedures to follow if stabilization conditions are not attained. When collecting pore-gas samples, the sample interval must be purged until the proper sampling conditions are achieved.*

LANL Response

12. The following text has been added to the SOP, and the SOP is in the process of being re-issued:

    If CO_2 and O_2 measurements do not stabilize or are equal to the atmospheric value then do not take a sample. Function check CO_2/O_2 sensor, perform leak check of sampling system, confirm straddle packer seal and sample line integrity down to packer as applicable, and reverse purge well port with zero gas as applicable. If the problem persists, then no sample will be collected.

NMED Comment

13. *NMED sent a letter to the Permittees dated November 19, 2003 regarding the Department's concerns with the schedule in Section 7.0.*

LANL Response

13. When the first MDA C Investigation Work Plan was submitted in July 2003 (Revision 0), activities conducted by the Risk Reduction and Environmental Stewardship (RRES) project at LANL were not subject to 10 CFR 830. Subsequently, the DOE Site Office made the decision that RRES work was subject to 10 CFR 830, thus requiring additional safety-basis requirements during the investigation.

    Under 10 CFR 830, DOE required that LANL prepare a hazard categorization for each RRES radiological site. The DOE Site Office approved the categorization of 11 nuclear hazard category 2 and 3 sites on November 26, 2003. Work activities at these sites are now subject to compliance with 10 CFR 830, Subpart B, which requires a DSA before work commences. Specific work activities, such as drilling at MDA C, will be documented as addenda to a new programmatic DSA for surveillance and maintenance that is currently in progress and scheduled for submittal to DOE in April 2004. The DSA for MDA C drilling is in progress and is scheduled to be submitted to DOE in May 2004. Review and approval of the MDA C DSA is expected to take approximately 30 days.

NMED Comment

14. *The "frequency of detects" tables (Tables B-10, B-12, B-14, B-20, B-22, B-24) are unnecessary. The Permittees shall delete these tables.*

LANL Response

14. LANL contends that the frequency of detection tables provide useful information for the public and will not delete them from the report.

NMED Comment

15. *NMED has reviewed the surface sampling data and Figure B-3 and has determined that the extent of surface radionuclide contamination in the southeast portion of the site has not been defined. Am-241, Pu-238, and Pu-239 were detected in sample locations 50-08346, 50-08396, and 50-08446 on the far eastern boundary of MDA C. NMED is concerned that contamination may be present outside the site boundary. The Permittees shall propose additional surface sampling for radionuclides east of the sample locations mentioned above.*

LANL Response

15. This response is provided for informational purposes only. A total of 203 soil samples were collected from the 0 to 6 in. interval at nodes of the 60- by 60-ft grid and screened for gross alpha, beta, and gamma radiation using hand-held field instruments. Based on the radiation screening results, a total of 68 surface samples were submitted to an off-site contract laboratory for analysis of gamma-emitting radionuclides by gamma spectroscopy, strontium-90, americium-241, total and isotopic uranium, and isotopic plutonium. Based on a review of the data, the extent of contamination has been defined within the SWMU boundary. Samples from locations 50-08346, 50-08396, 50-08446, and 50-08494, which are outside the boundary of the SWMU, were part of these 68 samples. The samples from these locations, collected east of the MDA C boundary, showed elevated levels of americium-241 and plutonium isotopes slightly above fallout values but below screening action levels (SALs). This area has been cleared by the Laboratory's Health Physics Operations Group for unrestricted work. To define the extent of contamination, the work plan has been updated to propose the collection of six surface soil samples east of the MDA C fenceline.

NMED Comment

16. *The data and information provided in the Work Plan and the Historical Investigation Report are not adequate to support the Permittees' proposed alternative scope of work as described in Section 4.0 (Scope of Activities) and Table 4 (Summary of Proposed Alternatives to NMED Order Specifications and Justifications for Alternative). NMED has accepted some of the Permittees' proposed alternatives to the scope of work. However, the justifications provided for Items 1, 2, 5, 8, 10, 13, and 16 in Table 4 are not acceptable. The Permittees must clarify and provide adequate justification for not doing work required by NMED for the investigation of MDA C.*

    The scope of work for the proposed investigation is not extensive enough to define the lateral and vertical extent of the VOC or tritium plumes in the subsurface tuff. The Permittees have proposed one additional boring in Revision 1 to the Work Plan; however, additional borings are necessary for adequate characterization of the site. Plans must be included to extend boreholes to greater depths if field screening indicates the presence of contaminants at the bottom interval of any borehole. Additionally, field screening must be conducted in order to accomplish these objectives. NMED provided specific comments on the need to expand the scope of work of the investigation in the September 4, 2003 Comments on the MDA C Investigation Work Plan. NMED's position has not changed. Refer to General Comment # 1 in this Attachment for NMED's comments on the position paper on determination of extent of contamination. Refer to General Comment # 4 for NMED's comments on field screening for contaminants. Refer to General Comment # 11 for NMED's comments on sampling of the existing vapor wells.

LANL Response

16. Item 1: LANL is using a phased approach for determining the nature and extent of contamination that requires drilling fewer boreholes than specified in the November 26, 2002, NMED Order. Table 5 in the work plan provides a comparison of the number and locations of the boreholes specified in the Order and the number and locations of boreholes previously installed during the Phase I RFI and proposed in the work plan. A reference to Table 5 will be added to the justification summary in Table 4. As described in LANL's response to Comment 3, LANL's investigation approach is based on review of data collected during the Phase I RFI and reported in the HIR. This approach also determines nature and extent of contamination according to decreasing trends, an approach previously approved by NMED at other LANL SWMUs (see Response to Comment 1). In addition, LANL has determined that boreholes should not be installed at some locations specified in the Order, particularly those associated with Pits 1 through 4 (see response to Comment 6).

    Item 2: LANL has developed a technical approach for determining the vertical extent of contamination at MDA C. As noted in Item 1 above and in LANL's response to Comment 1, this approach does not rely on characterization to background or non-detect levels.

    Item 5: LANL's proposed approach for determining the extent of vapor-phase contamination is based on sampling all new and existing boreholes (see response to Comment 7). The justification summary in Table 4 will be revised to provide clarification. Item 5 also addresses requirements for determining whether a perched aquifer is present below MDA C. Given the size of MDA C relative to perched aquifers and the fact that borehole M will be installed at a location of high expected infiltration, one deep borehole is sufficient to determine whether a perched aquifer is present.

    Item 8: LANL provided extensive justification in Section 4.2.3 of the work plan to demonstrate why the field screening specified in the Order would not generate useful information at MDA C. Additional justification is provided in LANL's response to Comment 4.

    Item 10: As described in LANL's response to Comment 4, samples will be screened for purposes of health and safety monitoring for radionuclides and VOCs. If this monitoring provides evidence of contamination, such samples would be submitted for laboratory analysis. Table 4 will be clarified to explain that "field screening" refers to health and safety screening, not to the field screening specified in the Order. Also, these samples will not be submitted for analysis of the suite presented in the Order; rather the alternate suite proposed in Item 9 of Table 4 will be analyzed.

    Item 13: See response to Item 10 above.

    Item 16: All existing and proposed boreholes will be sampled (see response to Comment 11). Item 16 will be deleted from Table 4.

NMED Comment

17. *The rationale provided by the Permittees in Table 5 (Comparison of Borehole Locations Specified in November 26, 2002 NMED Order and Existing and Proposed Boreholes) for not proposing to drill boreholes in many of the locations required by NMED is not adequate or appropriate. Insufficient drilling space is an acceptable justification for not advancing boring in certain locations (for example, along the north side of Pit 6). Lack of drilling space is not acceptable justification if the exact locations of the pits have not been determined (refer to General Comment #6). Previously drilled boreholes that contain contaminants in the bottom interval are not appropriate or sufficient for use in determining the extent of contamination. In addition, advancing fewer angled boreholes along pits with the intent of*

extending sample coverage beneath the pits, instead of advancing a greater number of vertical boreholes along the pits, may not achieve the objective of determining the extent of contamination (refer to General Comment #8). The Permittees must propose additional borings to adequately investigate the site.

LANL Response

17. See response to Comment 6 for information on the drilling space between Pits 1 through 4. Review of HIR data was used to determine if additional boreholes were required to supplement data in previously drilled boreholes where extent was not defined (see response to Comment 2). Angled boreholes are proposed to be drilled under disposal units since the area under the disposal units is the most likely to see releases from the disposal units versus areas adjacent to the disposal units. Section 4.2.1 of the work plan provides the rationale for installing each of the proposed new boreholes.

NMED Comment

18. *Section XI.B.11 of the Order contains a list of tables for inclusion in Investigation Work Plans. Item number 1 is "summaries of regulatory criteria, background, and applicable cleanup levels". The Permittees shall include such information in the Work Plan. The information may be included on the tables of analytical data or as separate tables.*

LANL Response

18. The required data tables are presented in the HIR; the radionuclide data are presented for informational purposes only. These tables consist of all inorganic chemicals and radionuclides detected above background/fallout values and all detected organic chemicals (Tables B-11, B-13, and B-15 for surface soil and fill and Tables B-21, B-23, and B-25 for subsurface tuff). The tables for inorganic chemicals and radionuclides already include associated background and fallout values (there are no background values for organic chemicals) but do not include regulatory criteria or cleanup levels. LANL notes that the phrase "regulatory criteria" is not specifically defined in the November 26, 2002, Order, but that Section XI.C.8 of the Order, which addresses regulatory criteria for investigation reports, includes risk-based screening levels and risk-based cleanup goals. Therefore, LANL has revised the above data tables for inorganic chemicals and organic chemicals to include NMED's soil screening levels or, if these levels do not exist, EPA Region VI soil screening levels. Tables for radionuclides have been revised to include SALs for radionuclides. Because cleanup levels are established only after it has been determined that cleanup is necessary, no "applicable cleanup levels" for MDA C are provided in this work plan.

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November 2003
(Updated January 2004)
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Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50, Revision 1

CD included with this document

Los Alamos
NATIONAL LABORATORY
Los Alamos NM 87545

Disclaimer

This document contains data on radioactive materials, including source, special nuclear, and by-product material. The management of these materials is regulated under the Atomic Energy Act and is specifically excluded from regulation under the Resource Conservation and Recovery Act and the New Mexico Hazardous Waste Act. These data are provided to the New Mexico Environment Department for informational purposes only.

Prepared by
Risk Reduction and Environmental Stewardship–Remediation Services

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Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50, Revision 1

November 2003

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EXECUTIVE SUMMARY

This investigation work plan presents recommendations for investigation activities required to complete the Resource Conservation and Recovery Act facility investigation (RFI) of Material Disposal Area (MDA) C, Solid Waste Management Unit (SWMU) 50-009, at Technical Area (TA-) 50 at Los Alamos National Laboratory (the Laboratory). The work plan also includes a description of sampling activities and analytical results for historical investigations at MDA C.

The objectives of the investigation activities are designed to complete the determination of the nature and extent of contamination identified during past investigations, including the Phase I RFI fieldwork conducted at MDA C, and to collect additional information on the hydrogeologic properties and other physical characteristics of the vadose zone beneath MDA C. In addition, the objectives of the work plan are to determine the nature and extent of hazardous waste constituent and/or radionuclide releases to the environment identified during the Phase I RFI. Nature and extent will be determined sufficient to support corrective action decisions for MDA C.

Evaluation of environmental data generated during the Phase I RFI consisted of comparisons of site data with background values (BVs) and/or fallout values (FVs) in environmental media, evaluation of correlations among environmental measurements, and spatial plots of contaminant concentrations in surface and subsurface environmental media. The following contaminant releases were identified at MDA C.

- Americium-241, plutonium-238, and plutonium-239, -240 were elevated with respect to FVs in surface soil on the northeastern and eastern edges of MDA C.
- Limited evidence indicates that Aroclor-1260 and bis(2-ethylhexyl)phthalate may be elevated locally in the surface soil and the fill above Pit 6.
- Numerous metals were detected above BVs in subsurface tuff in one or more samples primarily in borehole 50-09109 beneath Pit 6.
- Numerous radionuclides were detected in the subsurface tuff. With the exception of strontium-90 and tritium, these detections occurred primarily below Pit 6.
- Volatile organic compounds (VOCs) were detected in pore-gas samples collected from two monitoring boreholes (50-09100 and 50-10131).
- VOC surface-flux data indicate airborne releases of trichloroethylene (TCE) and tetrachloroethene (PCE) near the former Chemical Pit, in a location on the southern edge of Pit 5, and in the western regions of Pits 1 through 4.
- Near-surface tritium pore-gas concentrations indicate releases to the atmosphere from locations north of Pit 6 and in the vicinity of the northern portion of Shaft Group 3.

The Phase I RFI data were evaluated to determine if additional data is required to complete the characterization of the nature and extent of contamination. Additional data are required to determine the following:

1. the extent of metals, cyanide and radionuclide contamination in tuff beneath Pit 6;
2. the concentrations and spatial extent of VOCs in the vapor phase in subsurface tuff;
3. the concentrations and spatial extent of tritium in the vapor phase in subsurface tuff;
4. the nature and extent of potential releases of metals, cyanide and radionuclides to tuff beneath Pits 1–5, Shaft Groups 1 and 2, and the strontium-90 disposal shaft;

5. the extent of radionuclide contamination in surface soil on the eastern boundary of MDA C;
6. the presence of perchlorate, nitrate, dioxin, and furan contamination in tuff;
7. the presence of perched groundwater beneath MDA C; and
8. information on hydrogeologic properties and fracture characteristics to support contaminant transport modeling of the vadose zone at MDA C.

Ten vertical and four angled boreholes are proposed to be drilled adjacent to or under the disposal units, and samples will be collected to supplement the Phase I RFI data to determine the nature and extent of contamination, determine whether perched groundwater is present, and collect hydrogeologic property data. A gamma spectroscopy survey will be performed to determine the extent of radionuclide contamination in surface soil on the eastern boundary of MDA C. Based on the results of the survey, six surface soil samples will be collected for fixed laboratory analysis.

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1.0 INTRODUCTION

1.1 General Site Information

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the Department of Energy (DOE) and managed by the University of California (UC). The Laboratory is located in north-central New Mexico approximately 60 miles northeast of Albuquerque and 20 miles northwest of Santa Fe. The Laboratory covers 40 square miles 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 between 6200 ft and 7800 ft.

The Laboratory's Risk Reduction and Environmental Stewardship–Remediation Services (RRES-RS) project, formerly the Environmental Restoration (ER) Project, is participating in a national effort by the DOE to clean up sites and facilities formerly involved in weapons research and production. The goal of RRES-RS is to ensure that past operations under the DOE do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, RRES-RS is currently investigating sites potentially contaminated by past Laboratory operations. The sites under investigation are either solid waste management units (SWMUs) or areas of concern (AOCs).

The SWMU addressed in this investigation work plan (SWMU 50-009) contains both hazardous and radioactive components.[1] Depending on the type of contaminant(s) and the history of a site, the New Mexico Environment Department (NMED) or the DOE has administrative authority over work performed by the RRES-RS Program at that site. NMED has authority under the State of New Mexico Hazardous Waste Act (NMHWA) over cleanup of sites with hazardous waste or certain hazardous constituents, including the hazardous waste portion of mixed waste (i.e., waste contaminated with both radioactive and hazardous constituents). The DOE has authority over cleanup of sites with radioactive contamination. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." DOE is also the administrative authority for sites not under NMED's NMHWA authority.

NMED enforces the Hazardous and Solid Waste Amendments (HSWA) Module of the Laboratory's Hazardous Waste Facility Permit, hereafter referred to as Module VIII. Module VIII specifies conditions and requirements for investigation and cleanup activities at the Laboratory, which are performed by RRES-RS. The Environmental Protection Agency (EPA) issued Module VIII on May 23, 1990, and revised it on May 19, 1994 (EPA 1990, 1585; EPA 1994, 44146). NMED is currently revising the Hazardous Waste Facility Permit.

In accordance with Module VIII, the nature and extent of releases of hazardous waste or hazardous constituents are determined through the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) process. Under RRES-RS, the Laboratory also implements the RFI process for those sites under the administrative authority of DOE.

Material Disposal Area (MDA) C (SWMU 50-009) is located in the east-central portion of the Laboratory on a mesa at the head of Ten Site Canyon (Figure 1). MDA C is an 11.8-acre fenced, radiologically controlled area containing seven subsurface disposal pits and 108 shafts of various dimensions. It is located near the west end of Mesita del Buey, a mesa located primarily between Mortandad and Pajarito

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[1] This document contains data on radioactive wastes, including source, special nuclear, and byproduct material. The management of these materials is regulated under the Atomic Energy Act and is specifically excluded from regulation under the Resource Conservation and Recovery Act and the New Mexico Hazardous Waste Act. These data are provided to the New Mexico Environment Department for informational purposes only.

Canyons. Technical Area (TA-) 55 (the plutonium-processing facility); TA-42 (former incinerator site within the boundaries of TA-55); TA-50 (the Radioactive Liquid Waste Treatment Facility [RLWTF]), TA-52 (office and laboratory facilities); TA-62 (maintenance shop and office trailers); and TA-35 (formerly used for radionuclide research, currently the center for laser technology, optics, and nuclear safeguards) are also located on Mesita del Buey. Figures 1 and 2 show the location of MDA C and other TAs on Mesita del Buey. Figure 3 shows the locations of the pits and shafts as well as other site surface features and topographical contours.

MDA C consists of seven pits, with depths ranging from 12 to 25 ft below the original ground surface, and 108 shafts with depths ranging from 10 to 25 ft below the original ground surface, i.e., before a cover was placed over the site in 1984. The pits and shafts are constructed in the Tshirege Member of the Bandelier Tuff, a consolidated tuff unit with relatively numerous fractures. The regional aquifer is estimated to be approximately 1300 ft deep based on data from other wells at the Laboratory and the predictions of the hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599). The topography of MDA C is relatively flat, although the slope steepens to the north and where the northeast corner of MDA C abuts the south wall of Ten Site Canyon.

Historically, MDA C was used for the disposal of solids and liquids including uncontaminated classified wastes, hazardous chemicals, and radionuclides. Los Alamos Scientific Laboratory Engineering Drawings ENG-R-1264 (LASL 1970, 76047) and ENG-R-4459 (LASL 1974, 38446) were used to locate the pits and shafts. Two geophysical surveys verified the general location and horizontal dimensions of the disposal pits (AGS 2001, 73710; AGS 2002, 73711) and the depth of cover thickness, although the pit boundaries inferred from the geophysical investigation did not exactly match those shown on the engineering drawings. The depth of cover materials across MDA C was investigated using ground-penetrating radar (GPR) in 2001 (AGS 2001, 73710). The cover thickness over Pits 1–6 ranges from approximately 2.5 ft to about 8 ft. However, the cover thickness over Shaft Groups 2 and 3, the western ends of Pits 1–4, and the Chemical Pit was estimated to be less than 1 ft. The current thickness of cover materials at MDA C is illustrated in Figure 4. The depth of the shafts and pits was documented in the approved work plan for operable unit (OU) 1147 (LANL 1992, 07672) and based on historical documents, but elevation data were not documented. Subsequent additions of cover material have increased the elevation across the site. The elevation of the shafts and pits at the time of excavation was estimated from the tuff/soil interface logged in the 1995 Phase I RFI borehole logs.

This work plan presents the results of historical investigations (including the Phase I RFI) of MDA C, SWMU 50-009, at TA-50 and presents recommendations for additional activities required to complete the investigation of MDA C. It includes site background, site conditions, scope of activities to complete the investigation, investigation methods, and the anticipated schedule for completing the field activities. Appendix A includes a list of acronyms, defines terms used in this report, and presents a table with metric-to-US customary conversions. Appendix B describes the historical investigations, including Phase I RFI activities and analytical results for MDA C. Appendix C contains the borehole logs from Phase I RFI drilling activities. Appendix D describes statistical analyses to support data interpretation. Appendix E, on a CD on the inside back cover of this report, provides the Phase I RFI data. Appendix F describes the management of investigation-derived wastes.

1.2 Investigation Objectives

The objectives of the WP for MDA C are to

- present the current knowledge of the nature and extent of hazardous waste constituents and/or radionuclide releases to the environment based on existing data, including those collected during the Phase I RFI;

- establish the rationale for additional data collection and analysis, including justifications for deviating from the scope of work presented in the November 26, 2002, Order issued by NMED to DOE and UC; and
- identify appropriate methods and protocols for collecting, analyzing, and evaluating data to finalize the characterization of MDA C.

RRES-RS conducted Phase I RFI fieldwork at MDA C from 1993 to 2003. The results of these investigations are summarized in a Historical Investigation Report (HIR) in Appendix B. Based on an evaluation of existing environmental data collected at MDA C, several data requirements were identified that must be addressed to define the nature and extent of contamination in the environment sufficient to support corrective action decisions and to evaluate risks to potential human and ecological receptors. These requirements are described in Section 2 of this work plan.

2.0 BACKGROUND

2.1 Operational History

MDA C is a decommissioned material disposal area established to replace MDA B at TA-21 as a disposal area for Laboratory-derived waste. MDA C operated from May 1948 to April 1974 but received waste only intermittently from 1968 until it was decommissioned in 1974. Wastes disposed of at MDA C included liquids, solids, and gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory, including uncontaminated classified materials, metals, hazardous materials, and radionuclides. Historical reports (Rogers 1977, 0216) indicate it was common practice for chemicals to be burned in the chemical disposal pit at MDA C. A chronology of the major events pertinent to MDA C is presented in Table 2-9, p. 2-49 of the approved RFI Work Plan for OU 1147 (LANL 1992, 07672).

At MDA C, 7 pits and 108 shafts were excavated into the overlying soil and unit 3 of the Tshirege Member of the Bandelier Tuff (Figure 3). The pits and shafts were unlined except for 10 shafts in Shaft Group 3 that were lined with concrete. After each pit or shaft was filled with waste, it was backfilled to ground level with crushed tuff. Once the disposal shafts were filled, they were sealed with concrete. The dimensions and operational dates of the pits and shafts are listed in Table 1.

2.2 Land Use

MDA C is located in an industrial area currently used for Laboratory waste management. The Laboratory does not anticipate that the land use at TA-50 and surrounding TAs will change in the future. Public access to the site is restricted by fencing, locked gates, and restricted access to Pajarito Road. Under present-day conditions, only Laboratory employees or contractors may enter the site for management operations (such as emplacing erosion controls) or collecting environmental samples.

2.3 Relationship to Other SWMUs and AOCs

The only SWMU and/or AOC within close proximity that potentially could have affected MDA C is SWMU 50-006(c). SWMU 50-006(c) refers to surface soil contamination from radioactive contaminants (primarily isotopes of plutonium and americium) deposited by historical stack emissions from operations at TA-50. Based on Phase I RFI data for MDA C and adjacent SWMUs at TA-50 and TA-35, the only areas within close proximity that could potentially have been affected by MDA C is Ten Site Canyon, which is considered an AOC (Figure 5). Eroded surface soils from MDA C, in addition to soils and

contaminant releases from other SWMUs and/or AOCs at TA-50 and other TAs, have been deposited in the canyon bottom and stream banks (Nyhan et al. 1978, 5702).

2.4 Contaminant Transport Mechanisms and Potential Receptors

The inventory of wastes disposed of at MDA C includes radionuclides, metals, and organic chemicals. The relevant release and transport processes associated with these wastes are a function of chemical-specific properties, the physical form and/or container associated with a waste, and the nature of the transport process. The transport of tritium and VOCs, for example, occurs primarily in the gas phase and by diffusion or advection in air. Relatively water-soluble contaminants, primarily certain metals and radionuclides, are susceptible to release and transport via infiltration of water through the interred wastes. These contaminants can also be associated with a higher likelihood of transport via root uptake of grasses, shrubs, and trees. Strontium-90 is a good example of such a contaminant. Contaminants with relatively low water solubility, including organic chemicals such as Aroclors, are likely to be released from subsurface wastes only by some physical disturbance such as excavation by burrowing animals. The primary potential release and transport mechanisms for contaminants in subsurface wastes at MDA C include the following.

- *Volatilization, diffusion, and dispersion in air.* Gas or vapor-phase contaminants diffuse from waste and mix with air in the shafts or pits, then diffuse through the air-filled pores in the subsurface rock. Migration of gas- or vapor-phase contaminants from tuff into ambient air may occur by diffusion or by advection driven by barometric pressure changes.
- *Dissolution and advective transport in water.* Rain or melting snow on the surface moves down through the shafts and pits, dissolves contaminants, and slowly transports dissolved contaminants through the subsurface rock. Transport in tuff may be facilitated by the presence of fractures, particularly when fractures have coatings with low conductivity or when sufficient liquid saturates the matrix adjacent to the fracture where flow is occurring.
- *Biotic perturbation and translocation of contaminants in subsurface wastes.* Plants grow into the waste and incorporate contaminants into their surface biomass; contaminants are deposited onto the soil surface as biomass decays. Burrowing animals excavate contaminated wastes and release them onto the soil surface as burrow spoils. Surface contamination may then be transported back into the subsurface by burrow collapse or dissolution in surface water infiltrating the soil or be transported away from the site by suspension in air or surface water runoff.

In addition to the processes described above, which were discussed in the context of buried wastes, contaminants may also have impacted environmental media at MDA C from releases that occurred during its operation. Dissolution of contaminants in infiltrating water, for example, may have been more prevalent during site operations when pits and shafts were open for disposals. Currently, two release mechanisms are inactive at MDA C but may have contributed to existing contamination in environmental media:

- *Operational releases.* Contaminants may have been released to surface soil during the period when wastes were actively disposed at MDA C. Fires in the disposal pits at MDA C have been recorded (LANL 1992, 07672) and may have released contamination to surface soils and air.
- *Erosion prior to installation of existing cover.* The emplacement of a cover over MDA C in 1984 may have been instigated by erosion of the native cover prior to that time. Waste materials were reportedly exposed on the ground surface in the area of Pit 5 prior to the installation of the crushed tuff and fill cover in 1984 (LANL 1992, 07672).

Phase I RFI data collection activities occurred over the past ten years at MDA C. Site conditions have been relatively constant over this period, such that potential temporal changes in the concentrations of

contaminants in environmental media are expected to be negligible. One exception may be the presence of locally elevated rates of water infiltration caused by surface depressions related to subsidence within MDA C. Subsidence has been observed above Pit 6 in a location coincident with a surface runoff channel. The subsidence has been repaired.

Receptors potentially exposed to contamination from MDA C include site workers at MDA C and TA-50 and biota at the site. Potentially, site workers may be exposed to contaminants via inadvertent soil ingestion, inhalation of suspended soil (dust), dermal absorption from soil on the skin, and external irradiation. Inhalation of gas-phase contaminants such as tritium and/or volatile organic compounds (VOCs) emanating from the site into the atmosphere is also a possible source of exposure. Ecological receptors may be exposed via these pathways as well as via root uptake and the food web; in addition, these receptors may be exposed to higher concentrations of vapor-phase contaminants in subsurface burrows.

It is possible for plant roots and burrowing animals to penetrate the existing cover and come in contact with subsurface contamination. Site inspections have revealed that rodent and ant burrow spoils contain crushed tuff material that differs from surface soils. Grasses, trees, and shrubs are also present, or have historically been present across MDA C. Results of recent sampling of burrow spoils and small ponderosa pines within MDA C (Appendix B) will be reported in the MDA C Investigation Report.

A perched aquifer was not encountered nor is suspected beneath Mesita del Buey at MDA C (LANL 1998, 59599). No perched water was observed in 316 ft of drilling in the deepest borehole (borehole 50-09100, Appendix C). No perched water was observed in 700 ft of drilling in the nearby borehole SHB-1 or in borehole R-14 (Figure 6). Therefore, the potential for exposure of receptors through a water-mediated pathway is unlikely. Data from other wells at the Laboratory and predictions of the hydrogeologic conceptual model for the Pajarito Plateau place the regional aquifer at a depth of 1300 ft below MDA C (LANL 1998, 59599). Because of the depth to the aquifer and the low moisture content (1%–10% gravimetric moisture content) of the vadose zone, it is unlikely that contamination at MDA C could reach the regional aquifer in the near future. However, contaminants from MDA C have the potential to reach groundwater, and this pathway will be investigated and evaluated in the MDA C Investigation Report for present-day risk.

2.5 MDA C Waste Inventory

Waste disposal records for MDA C are contained in a series of disposal logbooks (LANL 2003, 76035). Radioactive waste disposal records provided sufficient detail to determine the location, type, and volume of waste disposed and to estimate the number of curies present in specific pits and shafts (Appendix B). However, little data exist on the volume of hazardous constituents disposed of at MDA C. The description of waste items disposed of at MDA C is based on information provided in Section 2.3 of the approved RFI work plan for OU 1147 (pp. 2-51 to 2-57, LANL 1992, 07672) and is summarized in Appendix B of this work plan.

2.6 Historical Releases

Results of historical investigations indicate contaminants have been released to environmental media as a direct consequence of disposal activities. Between 1976 and 1983, analysis of soil and vegetation samples from MDA C "confirmed the presence of pCi/g levels of radionuclides in localized areas" (Section 2.3.2.2.1, LANL 1992, 07672). Wastes in some pits (especially in Pit 5 on the north side of MDA C) were exposed at the ground surface as a result of natural degradation or erosion of the shallow soil covers. Additionally, anecdotal information related in the approved RFI work plan for OU 1147 states,

"chemical wastes were responsible for many fires at Areas B and C." It is possible that fires served as a vehicle of contaminant transport from open pits and/or shafts to the surrounding surface soil.

In 1984, additional crushed tuff was placed over contaminated soil on the surface of MDA C. Historical documents report that approximately 1.5 ft of crushed tuff, followed by between 0.5 to 3 ft of topsoil, was placed over existing cover material (LANL 1992, 07672). The 2001 geophysical survey of MDA C (Appendix B) indicates the existing cover thickness across the site ranges from a minimum of 0.0 ft to 8.8 ft with a mean value of 3.4 ft (Figure 4). The only portion of MDA C where additional cover was not placed was the northeast corner of the site where no pits or shafts are located. The isotopic plutonium and americium-241 concentrations detected in surface soils in the northeast portion of the site measured during Phase I RFI resulted in part from windborne deposition of contamination released during waste disposal activities and from deposition of historical stack emissions from operations at TA-50.

2.7 Summary of Historical Investigations

2.7.1 Pre-RFI Field Investigations

Sampling and analysis activities to ascertain the presence and scale of potential environmental contamination at MDA C began following the decommissioning of the facility in 1974. Radiation surveys of site soils and vegetation using field instrumentation were conducted from 1976 through 1984 (p. 2-57, LANL 1992, 07672). Following the placement of crushed tuff and cover material over MDA C in 1984, additional field surveys were conducted and supplemented with off-site contract laboratory analyses of radionuclides in soils and vegetation (p. 2-59, LANL 1992, 07672) in 1985 and 1986. These investigations and the associated findings are described in the HIR (Section B-1 of Appendix B) and in the approved RFI work plan for OU 1147 (LANL 1992, 07672).

2.7.2 Phase I RFI Field Investigations

Phase I RFI activities included sampling of surface soil, subsurface tuff, and pore gas. Surface sampling activities conducted in 1993 included a radiation survey conducted on a 60- by 60-ft grid and the collection of 203 0–6-in. surface samples of soil or tuff. All surface samples were field-screened for radioactivity. One hundred twenty-two samples were submitted to a mobile analytical laboratory for analysis of polychlorinated biphenyls (PCBs). Sixty-eight surface samples were analyzed at an off-site contract laboratory for target analyte list (TAL) metals, radionuclides, and semivolatile organic compounds (SVOCs). Fifty-nine of these samples were also analyzed for PCBs and nine surface samples were analyzed for VOCs. Phase I surface RFI results are reviewed and interpreted in Section 2.7.3 of this work plan; the data are summarized in Appendix B and included on a data CD (Appendix E) attached to the inside back cover of this report.

A total of 390 subsurface samples were collected in 1995 and 1996 from two vertical and nine angled boreholes drilled to depths ranging from 77 to 316 ft below ground surface (bgs). The subsurface samples were field-screened at approximately 5-ft intervals for radioactivity, high explosives (HE) and VOCs and submitted to a mobile radiological analysis laboratory. Samples were collected at approximately 20-ft intervals and submitted for off-site contract laboratory analysis for TAL metals and cyanide, radionuclides, and SVOCs. With the exception of samples from boreholes 50-09100 and 50-09102, 24 subsurface samples were also analyzed for VOCs and PCBs/pesticides.

In 1996, 15 additional samples were collected from curated borehole cores, in response to a request from EPA (Neleigh 1995, 55112). These samples were submitted to an off-site contract laboratory for analysis of inorganic chemicals (excluding cyanide and mercury since the holding times had lapsed) and

radionuclides (except tritium). However, based on the core collection dates and the actual dates the samples were analyzed, more than half of the curated core samples missed the 180-day holding time for inorganic chemicals. The inorganic chemical data from these samples is provided only for the purpose of comparison. Because the holding times for PCBs, VOCs, SVOCs, and tritium had been exceeded, curated core samples were not analyzed for these analytes. Phase I RFI subsurface results are reviewed in Section 2.7.3 and presented in Appendix B (Section B-2.0).

Ten of the 11 boreholes were backfilled and abandoned after the 1995 fieldwork. One vertical borehole (50-09100) was capped after the 1995 fieldwork and subsequently completed in 2000 as a vapor monitoring well with ten sampling ports. A second vertical borehole (50-10131) was drilled as a vapor monitoring well in 2001. Pore-gas samples of VOCs were collected quarterly from selected ports in these boreholes in 2000, 2001, 2002, and 2003. Surface-flux measurements of VOCs were conducted in 2000 at 101 locations. Near-surface tritium soil gas concentrations were measured at 15 locations at MDA C in February 2003. Phase I RFI pore-gas and surface-flux results are reviewed in Section 2.7.3 and in Appendix B.

Terrain conductivity (EM31), high-sensitivity metal detector (EM61), and GPR data were gathered during two geophysical surveys at MDA C conducted in 2001 and 2002 (Appendix B, Section B-2.1.1) to confirm the general location of the disposal units, confirm that Pits 1 through 5 do not extend east or south past the MDA C fence line and to map the thickness of cover materials across the site. Sufficient anomalies were detected in the area of Pits 1 through 5 to infer general pit boundaries; however, the anomalies extend over the reported width of the pits making it difficult to distinguish the boundaries between the pits. No clear anomalies were observed to indicate the boundaries of Pit 6 or the Chemical Pit. Cover thickness over the site was determined.

In January 2003, ant mounds and animal burrows were field-screened for radionuclides (gross alpha and gross beta) to select sample locations. Samples of conifer needles from 16 trees and soil from small-mammal burrow spoils and ant mounds (29) were collected in February 2003 and submitted for analysis of gross alpha, beta and gamma radiation. The purpose of this sampling was to determine if plants or animals were transporting contaminants from buried wastes to the ground surface. Results of the February 2003 biota sampling will be presented in the MDA C Investigation Report.

2.7.3 Phase I RFI Results

Conclusions regarding the nature and extent of contamination at MDA C based on the results of Phase I RFI activities are as follows.

1. Releases of radionuclides to historical surface soils were largely covered with crushed tuff in 1984. Elevated concentrations of americium-241 and isotopic plutonium in surface soils in the northeast area of MDA C are likely related to releases from MDA C prior to placement of crushed tuff on the surface of the site in 1984. The extent of current surface radionuclide contamination is defined sufficient to support corrective action decisions.

2. Lead and silver were the only metals detected at concentrations above their respective BVs in surface soil and fill. Statistical analyses in Appendix D indicate that the range of values is almost identical to background. There are sporadic detects of SVOCs and Aroclor-1254 and Aroclor-1260, but no defined pattern and no evidence for a widespread release of organic chemicals from MDA C were found. The extent of current surface inorganic and organic chemical contamination is defined sufficient to support corrective action decisions.

3. Concentrations of specific metals (including barium, copper, and lead) and radionuclides (strontium-90 and americium-241) in tuff beneath disposal pits indicate that contamination has

migrated from disposal pits into underlying rock. The extent of subsurface contamination has not been defined sufficient to support corrective action decisions.

4. Tritium and VOC contamination (primarily trichloroethylene [TCE], tetrachloroethene [PCE], and 1,1,1-trichloroethane [TCA]) exists in subsurface pore gas; however, the vertical and horizontal extent of this contamination has not been defined sufficient to support corrective action decisions.
5. Surface flux of VOCs and near-surface tritium soil-gas concentrations indicate localized areas where releases to the atmosphere are occurring.

A detailed review of the Phase I RFI data is presented in Section B-3 of Appendix B. Phase I RFI data are presented in Appendix E (on a CD attached to the inside back cover of this report).

2.7.3.1 Field Screening Results

Screening of Core Samples

Information presented in Section B.2 of the HIR is summarized and interpreted in this section to describe the effectiveness of field screening during the Phase I RFI and its applicability during future investigation activities.

Subsurface samples collected during the Phase I RFI were screened in the field for HE using a spot-test kit, alpha and beta/gamma radioactivity using field survey meters, and VOCs using a photoionization detector (PID). Field screening results for HE, radionuclides and VOCs indicate that concentrations of contaminants in the subsurface at MDA C are sufficiently low such that field screening is ineffective for the purpose of identifying samples for laboratory analysis.

During the Phase I RFI, 332 subsurface core samples were screened in the field for HE using a spot test procedure. No HE was detected in any of these samples.

During the Phase I RFI, 333 subsurface core samples were screened in the field for alpha and beta/gamma radioactivity, and 67 of these samples were submitted for laboratory analysis of radionuclides. Results of the screening analyses are summarized in Table B-18. Forty-three of these 67 samples had detected activities of radionuclides other than tritium within the range of local BVs. The remaining 24 samples had detected activities of radionuclides other than tritium above local BVs. As shown in the Phase I field screening results summarized below, there was no significant difference in field screening results for samples having radionuclides within and above local BVs.

Phase I RFI Field Screening Results	43 Samples Within Background	24 Samples Above Background
Alpha counts per minute		
Range	0–3	0–2
Median	1	1
Average	0.8	0.7
Beta/Gamma counts per minute		
Range	120–220	140–210
Median	180	165
Average	177	170

During the Phase I RFI, 333 subsurface core samples were screened in the field for VOCs by surveying the surface of each core sample with a PID having an 11.7 eV lamp. No VOCs were detected by the PID in any of the samples. Although VOC data were reported for tuff samples, these data are of little value because tuff does not effectively adsorb VOCs and is, therefore, a poor sample matrix for VOCs. VOCs in the subsurface exist primarily in the gas phase because of the low absorptive capacity of the tuff and cannot be detected by a PID in the field. Results of RFIs conducted at other MDAs since 1995 have shown that it is necessary to sample pore gas instead of tuff to determine the nature and extent of VOCs in subsurface tuff.

2.7.3.2 Data Interpretation and Identification of Investigation Scope

Information presented in Sections B-1.0, B-2.0, and B-3.0 of the HIR is summarized and interpreted in this section to describe the current understanding of the nature and extent of environmental contamination at MDA C. Based on this interpretation, data requirements related to the nature and extent of environmental contamination at MDA C are identified.

Interpretation of Phase I RFI Surface Soil and Fill Data

Metals: Lead and silver were the only metals detected at concentrations above their respective BVs in the surface soil and fill. Silver was detected above the BV of 1.0 mg/kg in two of the 68 samples. Lead, detected above its BV at a frequency of about 13%, has the highest concentrations along the southeast portion of the site. The maximum lead concentration (30 mg/kg) was detected in a sample collected from a location west of Shaft Group 3 and Pits 1 and 2 and south of Pit 6 and the Chemical Pit and is only slightly above the BV (22.3 mg/kg). A box plot of the site surface soil and background soil data for lead (Figure D-15) show that the range of concentrations in the two data sets is almost identical. These findings indicate that the slightly higher site concentrations of lead are most likely related to characteristics of the fill material, natural variability, and the proximity of MDA C to roadways and parking areas. Present-day concentrations of metals in surface soil at MDA C do not indicate that a release of metals from MDA C has occurred to the surface.

Radionuclides: Americium-241, plutonium-238, plutonium-239, -240, thorium-232, tritium, and uranium-238 were detected above their respective BVs in at least one surface sample. The highest concentrations of americium-241, plutonium-238, and plutonium-239, -240 were detected in surface samples collected in the northeast corner of MDA C and along the eastern edge of MDA C. Cover materials placed over the surface of MDA C in 1984 did not extend to this area of the site (Figure B-6). These findings indicate that the elevated concentrations of americium-241 and isotopic plutonium in surface soils are related to releases during historical MDA C site operations and/or from the deposition of historical airborne emissions from operations at TA-50. Concentrations of americium-241, plutonium-238 and plutonium-239, -240 are comparable to results from surface samples collected near the northeast corner of MDA C during the 1993 RFI of atmospheric releases [SWMU 50-006(c), pp. 24–29, LANL 1995, 49925]. The nature and extent of americium-241 and isotopic plutonium in surface soils in the northeast corner of MDA C and along the eastern edge of MDA C has not been defined. Uranium-238 was detected above the BV in only one of 68 surface samples (2.45 pCi/g), which is slightly higher than its BV (2.29 pCi/g). Thorium-232 was detected above its BV (2.33 pCi/g) in 15 of 68 samples, with the maximum concentrations approximately twice the BV. Spatial patterns do not indicate any release of these isotopes to surface soils at MDA C.

Organic Chemicals: There is no consistent spatial pattern among the detected concentrations of organic chemicals in surface soil and fill at MDA C. Acenaphthene and pentachlorophenol were detected only once in two different samples collected on the south side of MDA C. Bis(2-ethylhexyl)phthalate was

detected in two fill samples in the northwest part of MDA C. Like bis(2-ethylhexyl)phthalate, Aroclor-1260 was detected in four of the 43 samples collected in the northwest portion of MDA C, while Aroclor-1254 was detected in two samples from the southeastern portion of the site and in a single sample at the highest concentration, collected from a central location adjacent to Pit 2. Results of mobile laboratory analysis for PCBs showed four detections of Aroclor-1260, all above Pit 6 in the northwest corner of the site and no detections of Aroclor-1254. The detection of Aroclor-1260 in eight samples (four fixed laboratory and four mobile laboratory) and bis(2-ethylhexyl)phthalate in two samples in the same general location may indicate a localized release from Pit 6 to surface soil during historic site operations. The nature and extent of organic chemicals present in surface soils at MDA C is defined sufficient to support corrective action decisions.

Nature and Extent of Surface Soil and Fill Contamination

An evaluation of the metal, radionuclide, and organic chemical Phase I RFI data for surface soil and fill at MDA C does not reveal any data needs related to the nature and extent of contamination within the MDA C boundary. A release of radionuclides, including americium-241, plutonium-238, and plutonium-239, -240, was identified in the northeast region of MDA C. This release is most likely associated with historical site operations and/or with the deposition of airborne emissions from historic operations at TA-50 rather than more recent transport of contamination from wastes buried in the disposal units. A release of Aroclor-1260 and bis(2-ethylhexyl)phthalate may have occurred in the area of Pit 6 during operation of the site. The detected concentrations of these chemicals are bounded by other soil and fill samples where they were not detected; therefore, the spatial extent of potential surface releases from MDA C has been established by the Phase I RFI data sufficient to support corrective action decisions. Additional surface sampling is proposed along the eastern boundary of MDA C to define the extent of radionuclide contamination.

Interpretation of Phase I RFI Subsurface Tuff Data

Metals: A number of metals were detected above their respective BVs in Phase I RFI tuff samples collected at MDA C. Aluminum, beryllium, calcium, chromium, cobalt, magnesium, and nickel were detected above BV in only a single sample. Antimony, arsenic, barium, copper, cyanide, lead, selenium, and thallium were detected in two or more samples above their BVs. Of these metals, cyanide and lead were detected above BVs with the greatest frequency. The greatest depth that metals were detected in the subsurface at MDA C was 83.4 ft bgs in the bottom sample from borehole 50-09106. Metals were detected above BVs in the samples collected from the bottom of two boreholes, vertical borehole 50-09104 adjacent to the southern boundary of Pit 1 and borehole 50-09106, which was angled beneath the north end of Shaft Group 3 and the west end of Pit 4. Plots of the analytical results for metals detected in two or more samples above their BVs are presented in Figures D-10 to D-17.

Phase I RFI boreholes from which samples were collected adjacent to or beneath Pit 5 include 50-09100 and 50-09102, both located north of the pit. Cyanide was detected at a concentration of 0.53 mg/kg in a sample collected from a depth of 43.5 ft bgs in borehole 50-09100; however, there is no BV for cyanide. Cyanide was not detected in any subsequent samples from borehole 50-09100. No other metals were detected above BVs in either borehole (Table 2).

Phase I RFI boreholes from which samples were collected adjacent to Pits 1 through 4 and Shaft Groups 1 through 3 include 50-09103, -09104, -09105 and -09106. Cyanide was detected in the bottom sample from borehole 50-09104 (sample ID 0550-95-0099) at a concentration of 0.26 mg/kg and in samples collected from four of the five previous depth intervals (Table 2). In addition, arsenic, beryllium, copper and thallium were detected in single samples from borehole 50-09104, and lead was detected above

background in two consecutive samples from the sample borehole. Thallium was detected in the bottom sample from borehole 50-09106 (sample ID 0550-95-0071) at a concentration of 1.2 mg/kg, and lead was the only other metal detected in this borehole at a concentration of 51.1 mg/kg (BV of 11.2 mg/kg). Lead was the only metal detected in borehole 50-09103, and arsenic was the only metal detected in borehole 50-09105; no metals were detected in subsequent samples collected from either borehole. Collectively, the data for boreholes 50-09103, 50-09104, 50-09105, and 50-09106 indicate releases of metals to tuff have occurred from several of the pits and shafts located in the eastern portion of MDA C; however, the nature and extent of these releases have not been determined, except for the area adjacent to and beneath the northeast area of Pit 5 (Table 2, Table B-16, and Appendix D).

Phase I RFI boreholes from which samples were collected beneath or adjacent to Pit 6 include 50-09101, 50-09107, 50-09108, 50-09109, and 50-09110. With the exception of beryllium, the seven inorganic chemicals listed above detected above BVs were all detected in the same sample, (sample ID 0550-96-0112) collected at a depth of 47 ft bgs in borehole 50-09109 beneath Pit 6. Concentrations of barium, copper, lead, selenium, and thallium were also elevated above BVs in this particular sample. The subsurface sample with the next greatest number of metals detected above BVs (sample ID 0550-95-0231) was also collected from borehole 50-09109 at a depth of 25 ft bgs. Antimony, barium, copper, and lead were detected above BVs in this shallower sample. Of the inorganic chemicals detected above BVs in two or more samples, the highest concentrations of antimony, copper, and thallium were detected in borehole 50-09109 beneath the southwest portion of Pit 6 and the northwest corner of the Chemical Pit.

The highest concentrations of barium, cyanide, and lead were detected in boreholes 50-09107, 50-09101, and 50-09110 adjacent to and beneath Pit 6, respectively. None of these concentrations were detected in the deepest sample from a borehole, and all of the maximum concentrations detected (with the exception of calcium and selenium) were within a factor of 10 of the BV. Detected concentrations of calcium and selenium exceeded BVs by more than a factor of 30 in the sample collected at 47 ft bgs in borehole 50-09109 (sample ID 0550-96-0112). Collectively, the data for boreholes 50-09101, 50-09107, 50-09108, 50-09109, and 50-09110 indicate that releases of metals to tuff below Pit 6 and the Chemical Pit have occurred; however, the nature and extent of these releases has not been determined (Table 2, Table B-16, and Appendix D).

Radionuclides: Radionuclides detected at concentrations above BV, or detected in tuff when there is no tuff BV, include tritium, americium-241, plutonium-238, plutonium-239, uranium-235 and uranium-238, and various fission or activation products including strontium-90, cobalt-60, cesium-134 and cesium-137, europium-152, and sodium-22. The maximum depth of detected radionuclides (other than tritium) was 84.8 ft bgs (Table 2). Radionuclides were detected in samples collected from the bottom of six of the eleven Phase I RFI boreholes. Borehole plots of radionuclides in the subsurface are provided in Appendix D.

Phase I RFI boreholes from which samples were collected beneath or adjacent to Pit 6 include 50-09101, 50-09107, 50-09108, 50-09109, and 50-09110. Americium-241 was detected in the sample collected from the bottom of borehole 50-09101 at a concentration of 0.011 pCi/g at 81 ft bgs (sample ID 0550-95-0309) and in samples from two previous nonconsecutive depth intervals (Table 2). Amercium-241 was also detected in the sample collected from the bottom of borehole 50-09107 at a concentration of 0.032 pCi/g at 78.5 ft bgs (sample ID 0550-95-0191) and in samples from three previous depth intervals (Table 2). Sodium-22 was detected in the sample collected from the bottom of borehole 50-09109 at a concentration of 0.056 pCi/g at 81 ft bgs (sample ID 0550-95-0241). Additional radionuclides detected below Pit 6 include cesium-134, strontium-90, and plutonium-238 in borehole 50-09108; strontium-90, uranium-235, and uranium-238 in borehole 50-09109; and strontium-90 in borehole 50-09109. Collectively, the data for

boreholes 50-09101, 50-09107, 50-09108, 50-09109, and 50-09110 indicate that releases of radionuclides to tuff below Pit 6 have occurred; however the nature and extent of these releases has not been determined (Table 2, Table B-18, and Appendix D).

Phase I RFI boreholes from which samples were collected adjacent to or beneath Pit 5 include 50-09100 and 50-09102 both located north of the pit. Amercium-241 was detected at 0.027 pCi/g, uranium-235 was detected at a concentration of 0.21 pCi/g at a depth of 33.7 ft bgs, and plutonium-239 was detected at a concentration of 0.014 pCi/g at a depth of 43.5 ft bgs in borehole 50-09100; no radionuclides were detected in any subsequent samples from borehole 50-09100. No radionuclides were detected above BVs in borehole 50-09102 (with the exception of tritium; Table 2).

Phase I RFI boreholes from which samples were collected adjacent to Pits 1 through 4 include Shaft Groups 1 through 3 include 50-09103, -09104, -09105 and -09106. Strontium-90 was detected in the sample collected from the bottom of borehole 50-09103 at a concentration of 0.599 pCi/g at 82.6 ft bgs beneath the southeast corners of Pits 2 and 3 (sample ID 0550-95-0129) and in the sample collected from the bottom of borehole 50-09106 at a concentration of 0.767 pCi/g at 83 ft bgs beneath Pit 4 and the north end of Shaft Group 3 (sample ID 0550-95-0071). Plutonium-238 was detected at a concentration of 0.014 pCi/g at 85 ft bgs in borehole 50-09105 beneath Shaft Group 3 and the west end of Pit 3. Plutonium-239 was detected at a concentration of 0.080 pCi/g in the sample collected from the bottom of borehole 50-09105 at 84.5 ft bgs. Americium-241, uranium-235, and various fission or activation products were detected sporadically and at low concentrations in boreholes 50-09103, 50-09104, and 50-09105. The frequent rate of detection of strontium-90 at depth (it was present in four boreholes and below 65 ft in three of the boreholes) may be associated with its greater solubility compared with elements such as americium, uranium, and plutonium.

Collectively, the data for boreholes 50-09103, 50-09104, 50-09105, and 50-09106 showed sporadic detections of radionuclide at low concentrations in tuff adjacent to and beneath several pits and shafts located in the eastern portion of MDA C; however the nature and extent has not been determined, except for the area adjacent to and beneath the northeast area of Pit 5 (Table 2, Table B-18, and Appendix D). Additional sampling is required to determine whether a decreasing trend exists.

Tritium migrates in tuff in the form of water vapor; therefore, its occurrence in the tuff is not necessarily correlated with infiltration of water but is related to diffusion and advection in a gaseous state. Tritium was detected in almost every tuff sample collected at MDA C; borehole profiles for tritium concentrations in tuff are provided in Figure D-18 in Appendix D. Some of the highest tritium concentrations in tuff pore moisture were measured in borehole 50-09107, the same borehole where americium-241 was detected in the bottom borehole sample and three previous sample intervals. However, tritium concentrations were also relatively high in samples collected beneath Pits 4 (borehole 50-09106) and 5 (borehole 50-09102). The tritium tuff data indicate a release of tritium in the subsurface, with concentrations higher in the northern portions of the site below Pits 4, 5, and 6, although subsurface tritium data are lacking from the central portions of Pits 1 through 5. By contrast, near-surface tritium pore-gas concentrations indicate relatively low concentrations directly above Pits 5 and 6.

Organic Chemicals: The tuff data for SVOCs do not show evidence of a release from the disposal units and are not consistent with the metals and radionuclide data. Bis(2-ethylhexyl)phthalate was the only SVOC detected in tuff samples, and the range of detection limits encompassed the detected concentrations. Thus, the detected concentrations were very close to the limits of detection. PCBs and pesticides were not detected in any tuff samples. Although VOC data were reported for tuff samples, these data are of little value because tuff does not effectively adsorb VOCs and is, therefore, a poor sample matrix for VOCs. VOCs in the subsurface exist primarily in the gas phase because of the low absorptive capacity of the tuff. Also, the low moisture content of the tuff, coupled with the low solubilities

of chlorinated hydrocarbons such as PCE and TCE, results in only negligible quantities of VOCs in pore moisture. The distribution of VOCs in pore gas is discussed below (see section entitled "Interpretation of Subsurface Pore-Gas Data" below).

Nature and Extent of Subsurface Contamination

Tuff data for metals (including cyanide), and for radionuclides, indicate that releases to subsurface tuff have occurred below Pit 6 because these contaminants are present at concentrations exceeding BVs and/or fallout values (FVs).

Available data from angled boreholes beneath Pits 3, 4, and 5, and Shaft Group 3 do not provide evidence of infiltration-related releases of metals or radionuclides. However, relatively few tuff samples were collected from beneath these disposal units. No tuff samples were collected from beneath Pits 1 and 3, beneath Shaft Groups 1 and 2, or beneath the strontium-90 disposal shaft. The number and locations of tuff samples are not adequate to support any conclusions regarding the nature and extent of contamination beneath Pits 1 through 5, Shaft Groups 1 and 2, and the strontium-90 disposal shaft.

Tritium pore-gas data in tuff indicate a release of tritium in the subsurface, with higher concentrations measured in the northern portions of the site below Pits 4, 5, and 6. Near-surface tritium pore-gas data indicate that a release of tritium to the atmosphere is occurring in the western regions of Pits 1 through 4, in an area west of Shaft Group 3 and north of Pit 6. One or more shafts on the northern end of Shaft Group 3 may be the source of the high concentration of tritium in pore gas measured in a location west of these shafts, but the Phase I RFI samples are inadequate to confirm this hypothesis.

In addition to the analytical suites applied to the Phase I RFI tuff samples, additional suites may be appropriate given the nature of the wastes disposed at MDA C. Nitrates and perchlorate, which are very soluble and susceptible to migration with infiltrating surface water, were not analyzed in Phase I RFI tuff samples. Nitrates are associated with fertilizers and are also a common breakdown product of most nitrogen-containing organic materials. Perchlorate-containing chemicals have been widely used as oxidizers in a variety of chemical processes, and perchloric acid is a common strong acid used in laboratories. Because of their mobility and potential occurrence in disposed waste at MDA C, analysis of nitrates and perchlorate in tuff samples is appropriate. Therefore, nitrates and perchlorates will be added to analytical suite for subsurface tuff samples to be collected in accordance with this work plan. Dioxins and furans were not reportedly disposed of at MDA C. Historic records indicate that chemicals were burned in the Chemical Pit, however, and may have formed dioxins and furans. Therefore, dioxins and furans will be added to the analytical suite for subsurface tuff samples to be collected beneath Pit 6 and the Chemical Pit in accordance with this work plan.

Information on the hydrogeologic properties and other physical characteristics of the vadose zone at MDA C is generally lacking and is, therefore, needed for evaluating potential future migration of contaminants from MDA C. Information on the moisture content of tuff was collected from the Phase I RFI samples but only to a depth of approximately 316 ft bgs. Other relevant hydrogeologic information, as well as information on the water content of tuff at greater depths in the vadose zone, must be inferred from data obtained elsewhere at the Laboratory. Hydrogeologic properties such as saturated and unsaturated hydraulic conductivity, porosity, bulk density, chloride-ion concentration, and matric potential are also important parameters for evaluating the migration of liquid- and vapor-phase contaminants in the vadose zone. Such evaluations usually performed using numerical models to simulate field conditions provide support for conclusions regarding the nature and extent of contamination. It also helps in estimating possible future migration of contaminants from the waste disposal units.

The hydrogeologic properties described above pertain primarily to the rock matrices of the geologic strata at MDA C. Some strata, specifically units of the Tshirege Member of the Bandelier Tuff, also contain fractures that can act as conduits for the migration of liquid- and vapor-phase contaminants in the vadose zone. Information from fractured rock that can be used to evaluate the potential role of fractures in contaminant migration includes fracture density, fracture apertures, the strike and dip of fractures, and the presence and characteristics of fracture coating and fill. Where fractures are encountered during coring of boreholes, a comparison of chemical concentration data from tuff immediately adjacent to a fracture and tuff further from the fracture can also provide valuable information on the role of fractures in contaminant transport at MDA C.

Evaluation of Subsurface Pore-Gas and VOC Surface Flux Data

TCE, PCE, and TCA were the most frequently detected VOCs in pore-gas samples collected in 2000 and 2001 from borehole 50-09100 (north of Pit 5) and borehole 50-10131 (adjacent to the Chemical Pit). Data analysis has focused on TCE and PCE because these VOCs were detected at higher concentrations than TCA. TCE concentrations ranging from 10.0 to 15.0 parts per million by volume (ppmv) were measured between 10 to 250 ft bgs in borehole 50-09100, and the concentrations do not decline in samples collected at the bottom of this borehole at 316 ft bgs (Figure D-29). PCE concentrations decreased with depth in borehole 50-09100 (Figure D-28). In borehole 50-10131, maximum TCE concentrations were approximately 5 to 10 times lower (between 1.0 and 2.0 ppmv) than at borehole 50-09100 (Figure D-26). PCE concentrations ranged from 1.0 to 2.0 ppmv at depths above 100 ft bgs in borehole 50-10131 and declined to 0.5 ppmv at the bottom of the borehole at 250 ft bgs (Figure D-25).

In January 2003, pore-gas samples were simultaneously collected in each of the 10 sampling ports in boreholes 50-09100 and 50-10131. Prior to January 2003, sampling of individual ports was sporadic, and the effect of temporal variability on VOC pore-gas concentrations was not known. However, the results from the 2003 sampling were consistent with the previous TCE and PCE data. The highest pore-gas concentrations of TCE in borehole 50-09100 are at 200 to 250 ft bgs, and concentrations of TCE decreased slightly in the two deeper sample intervals. By contrast, the highest concentrations of TCE and PCE in borehole 50-10131 are at 50 ft bgs.

In June and July 2000, 105 EMFLUX® samplers were placed across the surface of MDA C to estimate the surface flux of VOCs. PCE, followed by TCE, was the most frequently detected VOC, with measured fluxes ranging up to approximately 200 and 60 ng/m^2–min, respectively. PCE flux was highest in the area of the Chemical Pit and at a location on the southern edge of Pit 5 (Figure B-8). There were also frequent measurements of PCE at fluxes of approximately 10 to 30 ng/m^2–min between Pits 1 and 3 and in the western regions of Pits 2 and 4.

In February 2003, near-surface pore-gas tritium samples, collected at a depth of 2.5 ft bgs in silica gel columns, were obtained at 15 locations across MDA C. The highest measured tritium concentrations were north of Pit 6 (2500 pCi/mL), and in an area west of the northern portion of Shaft Group 3 where no subsurface disposal units exist. Tritium pore-gas samples from directly above Pit 6, including a location just south of the high concentration north of Pit 6, do not show such high concentrations. The elevated concentration of tritium west of Shaft Group 3 may be related to a release from these shafts; moreover, concentrations of tritium in pore-gas from borehole 50-09106 near this location are also relatively high. Relatively high tritium pore-gas concentrations were measured on the western areas of Pits 2 and 3 as well. A tritium source at the northern portion of Shaft Group 3 could possibly explain these measurements. Near-surface pore-gas tritium concentrations are shown in Figure D-31.

Nature and Extent of Subsurface Pore Gas Contamination and VOC Surface Flux

With only two vertical boreholes, data are inadequate to define the lateral extent of vapor phase VOCs in subsurface tuff. Based on VOC surface-flux measurements and the pore-gas data from 50-09100 and 50-10131, TCE and PCE are the most prevalent VOCs in the subsurface at MDA C. Surface flux measurements indicate the highest near-surface VOC measurements are in the vicinity of the chemical disposal pit. In fact, VOC concentrations were greatest at shallower intervals at this location (borehole 50-10131) than in borehole 50-09100. The nature and extent of VOCs in the vapor phase has not been determined and will be addressed during the implementation of this work plan.

Phase I RFI data for tritium in subsurface tuff samples indicate a release occurred in the subsurface at MDA C. The highest tritium concentrations were observed in tuff samples from angled boreholes beneath Pit 6, the same area where elevated metals concentrations in tuff were measured. Only a limited number of tritium samples have been collected in tuff samples beneath disposal units, other than beneath Pit 6. A comparison of tritium data from subsurface tuff samples and near-surface pore-gas samples shows a poor correlation of these data. RRES-RS now collects pore-gas samples for tritium, rather than tuff samples, because the pore-gas samples provide a more accurate indication of tritium concentrations in the subsurface. For these reasons, the spatial extent of tritium in the subsurface will be determined during the implementation of this work plan.

3.0 SITE CONDITIONS

This section discusses aspects of the environmental setting at MDA C that are important in assessing the potential impacts posed by contaminated surface and subsurface media, including

- semiarid climate with low precipitation and a high evapotranspiration rate, which limits the amount of moisture percolating into the disposal units and thus limits the amount of moisture available to leach radionuclides or hazardous waste constituents;
- thick, relatively dry unsaturated zone, which greatly restricts or prevents downward migration of contaminants in the liquid phase through the vadose zone to the regional aquifer; and
- canyon-mesa terrain, which affects atmospheric conditions and ecological habitats.

3.1 Surface Conditions

MDA C is located on Mesita del Buey, a 140- to 220-ft-high, finger-shaped mesa that trends southeast (Figure 5). The elevation of Mesita del Buey ranges from 7210 to 7280 ft. The topography at MDA C slopes gently from west to northeast, gradually getting steeper across the northeastern quadrant of the site toward Ten Site Canyon. At MDA C, Mesita del Buey is approximately 2000 ft wide and is bounded by Mortandad Canyon (800 ft to the north) and Two Mile Canyon (750 ft to the south [Figure 2]).

The surface vegetation at MDA C consists of a native grama grass mixture. The vegetation was initially established after the 1984 addition of fill and topsoil. This cover was placed over the tops of the pits and shafts used for disposal at MDA C.

Localized surface subsidence on the north boundary of Pit 6 was observed in 2002. The subsidence may have promoted infiltration of storm water into Pit 6 since it resulted in a hole along an asphalt drainage that carries runoff into Ten Site Canyon. The subsidence has since been mitigated.

3.1.1 Soils

The soils of Mesita del Buey are derived from the weathering of the Tshirege Member tuffs (phenocrysts and phenocryst fragments, devitrified glass, and minor lithic fragments) and from wind-blown sources. Soils on the flanks of the mesa are developed on Tshirege Member tuffs and colluvium with additions from wind-blown and water-transported sources. Native soils have been disturbed by waste management operations over much of the surface of Mesita del Buey, but when present native soils are generally thickest near the center of the mesa and thinner toward the edges.

In general, soils can be considered thin and poorly developed on the mesa surface; they tend to be sandy in texture near the surface and more clay-like beneath the surface. More highly developed soil profiles exist on the north-facing slopes; they tend to be richer in organic matter. Soil profiles on the south-facing slopes tend to be poorly developed. Soil-forming processes have been identified along fractures in the upper part of the mesa, and the translocation of clay minerals from surface soils into fractures has been described at Mesita del Buey. A discussion of the soils in the Los Alamos area can be found in Section 2.5.1.3 of the approved installation work plan (LANL 1998, 62060).

The original soils in the vicinity of MDA C were poorly developed, as is typical of soils derived from Bandelier Tuff and formed under semiarid climate conditions. In general, undisturbed soils on the mesa tops are comprised of the Carjo loam, the Hackroy loam, and the Seaby loam. At MDA C, natural or undisturbed surface soil cover is limited as a result of disposal unit and cover construction. The present-day surface of MDA C is predominantly fill (crushed tuff) and imported topsoil.

Canyon bottoms near MDA C (Cañada del Buey, Two Mile Canyon, Pajarito Canyon, Mortandad Canyon, and Ten Site Canyon) are covered with colluvium and alluvium that has eroded from the tuff and soils on the mesa top and canyon walls. The canyon rims and slopes are composed of soils from the Hackroy-Rock outcrop complex; canyon bottoms are composed of the Tocal, a very fine, sandy loam. Since disposal activities began at MDA C, Ten Site Canyon has experienced a period of accretion, and eroded soils from MDA C, as well as other SWMUs at TA-50, have been deposited on the canyon bottom and stream banks. The canyons are being investigated under separate work plans.

3.1.2 Surface Water

There are no streams on Mesita del Buey; water flows only as storm water and snowmelt runoff on the mesa and in small drainages off the mesa to the northwest and the south. Runoff consists primarily of sheet flow from MDA C into Ten Site Canyon (Figure 5). Sheet erosion appears to be occurring around the east and northeast portions of the site. The RLWTF at TA-50 (SWMU 50-016) discharges treated effluent to NPDES-permitted Outfall 051 in Mortandad Canyon [SWMU 50-006(d), Figure 5]. At the Laboratory, surface water runoff and sediment transport are among the potential migration pathways by which contaminants might be transported to off-site receptors. Surface water may also transport subsurface contaminants exposed by soil erosion. 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.

RRES-RS conducted a surface water assessment at MDA C in 2002 following the mitigation of the surface subsidence, which occurred along the northern boundary of MDA C. MDA C received an erosion matrix score of 8.8, indicating low erosion potential. The calculated score includes 8.8 for site setting, an erosion matrix runoff score of 0.0, and a run-on score of 0.0.

3.2 Subsurface Conditions

3.2.1 Stratigraphy

The former ER Project (now RRES-RS) drilled, cored, and sampled eleven boreholes at MDA C during the Phase I RFI to characterize potential contaminant releases and transport in the subsurface. Borehole logs from the site provide detail on the stratigraphy below the ground surface to a depth of approximately 316 ft (borehole 50-09100) and are included in Appendix C. The locations and depths of regional boreholes used to infer the stratigraphy beneath MDA C are shown in Figure 6. Figure 6 also shows east-west cross-sections beneath and in the vicinity of MDA C. The stratigraphy beneath MDA C includes Bandelier Tuff, Cerros del Rio lavas, Puye Formation, Totavi Lentil Deposits, Santa Fe Group, and Santa Fe age basalts (Figures 6 and 7). Descriptions of stratigraphic units beneath MDA C follow.

Bandelier Tuff

In regard to Bandelier Tuff, the term *welding* is used to distinguish between tuffs that are uncompacted and porous (nonwelded) from tuffs that are more compacted and dense (welded). In the field, the degree of welding in tuff is quantified by the degree of flattening of pumice fragments (a higher degree of flattening and elongation equals a higher degree of welding). Petrographically, welded tuffs show adhesion (welding) of grains, while nonwelded tuffs do not. The term *devitrified* is applied to tuffs whose volcanic glass has crystallized. Figure 7 shows the generalized stratigraphy of the Bandelier Tuff.

Tshirege Member

The Tshirege Member of the Bandelier Tuff is a compound cooling unit that resulted from several successive ash-flow deposits separated by periods of inactivity, which allowed for partial cooling of each unit. Properties related to water flow and contaminant migration (e.g., density, porosity, degree of welding, fracture content, and mineralogy) vary both vertically and laterally as a result of localized emplacement temperature, thickness, gas content, and composition.

Tshirege Member Unit 3 (Qbt 3)

Unit 3 of the Tshirege Member of the Bandelier Tuff is poorly welded and nonindurated to slightly indurated. It forms the cliffs of the Pajarito Plateau. Its thickness, as intersected by borehole 50-09100 in the region of MDA C, is 66.5 ft (20 m).

Tshirege Member Unit 2 (Qbt 2)

Unit 2 of the Tshirege Member of the Bandelier Tuff is a competent, resistant unit that forms cliffs where it is exposed on the sides of the mesa. The rock is described as a moderately welded ash-flow tuff composed of crystal-rich, devitrified pumice fragments in a matrix of ash, shards, and phenocrysts (primarily potassium feldspar and quartz). Its thickness in borehole 50-09100 is 78 ft (24 m); the unit thins to the east across Mesita del Buey.

Unit 2 is extensively fractured as a consequence of contraction during post-depositional cooling. The cooling-joint fractures are visible on the mesa edges and on the walls of the pits. In general, the fractures dissipate at the bottom of unit 2. On average, fractures in unit 2 are nearly vertical. Mean spacing between fractures ranges between 1.9 ft and 2.6 ft (0.6 m and 0.8 m), and fracture width ranges between less than 0.03 in and 0.51 in (1 mm and 13 mm), with a median width of 0.12 in (3 mm). The fractures are typically filled with clays to a depth of about 9.9 ft (3 m); smectites are the dominant clay minerals present.

Smectites are known for their tendency to swell when water is present and for their ability to strongly bind certain elements, both of which have implications for the transport of radionuclides and inorganic chemicals in fractures. Opal and calcite can occur throughout the fractured length, usually in the presence of tree and plant roots (live and decomposed); the presence of both the minerals and the roots indicates some moisture at depth in fractures.

At the base of unit 2 is a series of thin (less than 3.9-in.-thick [10-cm-thick]), discontinuous, crystal-rich, fine- to coarse-grained surge deposits. Bedding structures are often observed in these deposits. The surge beds mark the base of unit 2.

Tshirege Member Unit 1v (Qbt 1v)

Tshirege Member unit 1v is a vapor-phase-altered cooling unit underlying unit 2. This unit forms sloping outcrops, which contrast with the near-vertical cliffs of unit 2. Unit 1v is further subdivided into units 1vu and 1vc.

Unit 1vu. Unit 1vu is the uppermost portion of unit 1v where u signifies upper. It is devitrified and consists of vapor-phase-altered ash-fall and ash-flow tuff. Unit 1vu is unconsolidated at its base and becomes moderately welded nearer the overlying unit 2. Only the more prominent cooling fractures originating in unit 2 continue into the more welded upper section of unit 1vu but die out in the less-consolidated lower section. More typically, fractures in unit 2 do not extend into unit 1vu. The measured unit thickness in borehole 50-09100 is 73 ft (23 m).

Unit 1vc. Beneath unit 1vu is unit 1vc, where c stands for colonnade, named for the columnar jointing visible in cliffs formed from this unit. Unit 1vc is a poorly welded, devitrified ash-flow tuff at its base and top, becoming more welded in its interior. The measured unit thickness in borehole 50-09100 is 10 ft (3 m).

Tshirege Member Unit 1g (Qbt 1g)

The basal contact of unit 1vc is marked by a rapid change (within 0.7 ft [0.2 m] vertical) from devitrified (crystallized) matrix in unit 1vc to vitric (glassy) matrix in the underlying unit 1g. Vitric pumices in unit 1g stand out in relief on weathered outcrops, while devitrified pumices above this interval are weathered out. In outcrop, this devitrification interval forms a prominent erosional recess termed the *vapor-phase notch*. There is no depositional break associated with the vapor-phase notch; the abrupt transition indicates that this feature is the base of the devitrification that occurred in the hot interior of the cooling ash-flow sheet after emplacement.

Unit 1g is a vitric, pumiceous, nonwelded ash-flow tuff underlying the devitrified unit 1vc. Few fractures are observed in the visible outcrops of this unit, and weathered cliff faces have a distinctive Swiss-cheese appearance because of the softness of the tuff. The uppermost 5 ft to 20 ft (1.5 m to 6.1 m) of unit 1g are iron-stained and slightly welded. This portion of unit 1g is resistant to erosion, helping to preserve the vapor-phase notch in outcrop. A distinctive pumice-poor surge deposit forms the base of unit 1g. Its thickness measured at borehole 50-09100 is 80 ft (24 m); it thins to 49 ft (15 m) to the east beneath MDA C.

Tsankawi Pumice Bed

The Tsankawi Pumice Bed is the basal air-fall deposit of the Tshirege Member of the Bandelier Tuff. It is a thin bed of gravel-sized vitric pumice. The unit thickness in borehole 50-09100 is about 2–3 ft (0.6–1 m).

Cerro Toledo Interval (Qct)

The Cerro Toledo interval consists of thin beds of tuffaceous sandstones, paleosols, siltstones, ash, and pumice falls; the Cerro Toledo interval separates the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval also includes localized gravel- and cobble-rich fluvial deposits predominantly derived from intermediate composition lavas eroded from the Jemez Mountains west of the Pajarito Plateau. The interval is about 20 ft (6.1 m) thick.

Otowi Member (Qbo)

The Otowi Member tuffs are about 100 ft (30 m) thick in the northwestern portion of Mesita del Buey and become thinner towards the east. The tuffs are a massive, nonwelded, pumice-rich, and mostly vitric ash flow. The pumices are fully inflated, supporting tubular structures that have not collapsed as a result of welding. The matrix is an unsorted mix of glass shards, phenocrysts, perlite clasts, and minute broken pumice fragments.

The Guaje Pumice Bed is the basal air-fall deposit of the Otowi Member of the Bandelier Tuff. The thickness of the unit has been measured as 10 ft (3 m) in the northwestern reaches of Mesita del Buey and as 12 ft (3.7 m) in Pajarito Canyon south of MDA G. The pumice bed is nonwelded and brittle. Pumice tubes are partially filled with silica cement.

Cerros del Rio Basalts (Tb4)

Few data exist to describe the Cerros del Rio lavas directly beneath MDA C; however, dacitic lavas were penetrated to the west (SHB-1) and to the east (R-14). Cerros del Rio basalts were observed to the east in R-15. In R-14, the dacitic lavas are approximately 150 ft (46 m) thick, extending from 620 to 768 ft below ground surface (bgs). Local borehole cores at MDA L show that the basalts consist of both angular rubble and dense, fractured masses, with zones of moderately to very porous lavas.

Puye Formation (Tpf, Tpp) and Older Fanglomerate

The Puye Formation is a conglomerate deposit derived primarily from volcanic rocks to the west, with varying lithologies including stream channel and overbank deposits, ash and pumice beds, debris flows and lahar deposits. Well tests on the Pajarito Plateau confirm the unit is very heterogeneous with both high and low permeability zones present (Nylander et al. 2003, 76059). The formation is poorly lithified and as such is unlikely to sustain open fractures.

The Puye Formation was encountered to the west (SHB-1) above the Cerros del Rio lavas and to the east (R-14) both above and below the lavas. Two types of Puye rocks were noted at R-14 (Figure 7): an upper layer of fanglomerate rock (Tpf), which may be relatively low in permeability, and a lower layer of pumicious sands and gravels (Tpp), higher in permeability. The water table is found near the bottom of the fanglomerate member beneath MDA C at a depth of 1300 ft.

Totavi Lentil Deposits (Tpt)

The Totavi Lentil is an ancestral Rio Grande deposit composed of coarse gravels and sands with abundant quartzite. The deposit has been alternatively conceptualized as a series of distinct north-south trending ribbons and a continuous thin sheet at the base of the Puye Formation. Like the overlying Puye Formation it has both high permeability and low permeability zones (Nylander et al. 2003, 76059). It was

not penetrated by wells near MDA C but may exist at the base of the Puye Formation predicated on evidence from PM-5, about 1 mile to the east (Figure 6).

Santa Fe Group (Tsf, Tf, and Ts) and Santa Fe-Age Basalts (Tb1 and Tb2)

The Santa Fe Group is an alluvial-fan deposit comprised of medium to fine sands and clays. Numerous north-south trending faults are present in the Santa Fe Group. Santa Fe Group rocks are deep below MDA C (1500 ft bgs at PM-5, which is approximately 1 mile east of MDA C) and were not penetrated by R-14 (Figure 6). Most water supply wells on the eastern edge of the Pajarito Plateau and elsewhere in the basin are completed in these rocks. The Santa Fe Group units are characterized with the lowest permeability compared to the other units in the regional aquifer (Nylander et al. 2003, 76059).

Basaltic lava flows occurred during the time the Santa Fe Group was deposited; these basalts are of substantial thickness at PM-5 and may exist within the Santa Fe Group rocks beneath MDA C.

3.2.2 Hydrology

The proposed hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599) is presented in Figure 8. The model predicts infiltration of water into the subsurface and subsequent transport of water, vapor, and solutes through the upper regions of the vadose zone are heavily influenced by surface conditions such as topography, surface water flow, and microclimate. According to model predictions, movement through deeper layers, including the regional aquifer, is influenced only weakly by surface conditions and is influenced more by hydraulic characteristics of aquifer rocks, regional groundwater flow patterns, and stresses induced by water supply production. The following sections provide an overview of infiltration rates and groundwater occurrence in the vicinity of MDA C.

Infiltration

Surface and near-surface conditions (topography, precipitation, surface runoff) control the infiltration of water into the subsurface and the transport of contaminants in the shallow subsurface. In this respect, the climate behavior of mesas and canyons forming the plateau differ from one another (LANL 1998, 59599). Mesas are generally dry, both on the surface and within the rock that forms the mesa. Canyons range from wet to relatively dry; the wettest canyons contain continuous streams and perennial groundwater in the canyon-bottom alluvium. Dry canyons have only occasional stream flow and may lack alluvial groundwater.

The amount of mesa top recharge along the western portion of the Laboratory where MDA C is located is uncertain. Higher rainfall, increased vegetative cover, and increased welding and jointing of the tuff might lead to different recharge rates than those observed in better-studied portions of the Laboratory such as TA-54 (LANL 1997, 63131). Mesa top recharge can be locally significant under disturbed surface conditions. Such local differences occur when the soil is disturbed, when the vegetation is removed, or when more water is artificially added to the hydrologic system by features such as blacktop, lagoons, or effluent disposal. Fractures within mesas do not enhance the movement of dissolved contaminants unless saturated conditions develop. Contaminants in the vapor phase generally migrate in a diffusive manner through mesas (Stauffer et al. 2002, 69794; LANL 1997, 63131).

Mesita del Buey is one of the drier mesas found at the Laboratory on the Pajarito Plateau. Infiltration into the mesa appears to be very low, possibly only 0.04 in./yr ([1 mm/yr] LANL 1997, 63131) and occurs during snowmelts or intense summer thunderstorms, which lead to slightly higher moisture contents within the uppermost few meters of the mesa surface. During dry periods, evapotranspiration removes moisture

from the surface of the mesa; permeable zones such as fractures and surge beds act as conduits for air and aid in the drying of the mesa.

Groundwater

Groundwater beneath the Laboratory occurs in the regional aquifer (at depths ranging from 1200 to 600 ft bgs) and in perched aquifers (Nylander et al. 2003, 76059). With the exception of TA-16, perched aquifers have been detected only in wells beneath the relatively wet canyons (i.e., Los Alamos Canyon). They exist as two types: (1) shallow alluvial aquifers that occur in some wet canyons (generally at depths less than 100 ft), and (2) deeper "intermediate" perched aquifers that occur in zones separated from both alluvial and regional aquifers by unsaturated rock. To date, data obtained indicate that dry mesas such as Mesita del Buey show no evidence of perched aquifers (Nylander et al. 2003, 76059). However, alluvial and intermediate perched aquifers in adjacent canyons may cause increased moisture contents within the vadose zone at the margins of the mesa.

Perched Intermediate Waters

Observations of perched intermediate water are rare on the Pajarito Plateau. Perched waters are thought to form mainly at horizons where medium properties change dramatically, such as at paleosol horizons containing clay or caliche. It is not known whether perched water bodies are isolated or connected and to what degree they may influence travel times and pathways for contaminants in the vadose zone. Although perched intermediate waters have been observed in some locations elsewhere on the plateau, none have been observed in the regional wells (R-22, R-21, R-20, and R-16) or in R-14, the well closest to MDA C ([Figure 6] LANL 1998, 59599).

Perched intermediate groundwater was not encountered nor is suspected beneath Mesita del Buey at MDA C (LANL 1998, 59599). No perched water was observed in 316 ft of drilling in the deepest borehole drilled to date (borehole 50-09100, Appendix C), although core collected at the depth interval from 71.5 ft to 73.5 ft was described in the borehole log as "wet" (Appendix C). No perched water was observed in 700 ft of drilling in the nearby borehole SHB-1 or in borehole R-14 (Figure 6).

Perched intermediate zones of saturation have been delineated beneath Mortandad Canyon. At borehole MCOBT-4.4, a perched zone was identified in the Puye Formation above Cerros del Rio basalts. The spatial location of perched zones (disconnected, associated with different units) potentially indicates a lack of a continuous perched zone beneath the canyon. However, geochemical data indicate that continuity must have existed at some time in the past and might persist in Mortandad Canyon at present (Longmire 2003, 76050). In addition, when regional aquifer Test Well (TW)-8 was drilled in 1960, the units between the alluvium and the regional aquifer were unsaturated, although possible perched zones were encountered during borehole advancement (Baltz et al. 1963, 8402).

Regional Aquifer

The regional aquifer of the Pajarito Plateau is the only aquifer capable of large-scale municipal water supply (Purtymun 1984, 6513). The regional aquifer extends throughout the Española Basin (an area roughly 6000 km^2) and reaches its maximum thickness beneath the Pajarito Plateau (over 9800 ft [3000 m] thick; Cordell 1979, 76049).

Depths to the regional aquifer range between about 1200 ft (366 m) along the western edge of the plateau (1296 ft bgs at R-25, 950 ft at R-19) and about 600 ft (183 m) to the east. Beneath MDA C, the

water table elevation is approximately 5884 ft (at R-14) or approximately 1300 ft bgs. Figure 9 depicts water table elevations in the regional aquifer across the Pajarito Plateau.

Spatial variations in water table gradients are caused by a combination of aquifer heterogeneity and the influence of pumping. The horizontal component of the background hydraulic gradient beneath MDA C is approximately 0.02, although gradients locally are steeper (0.03) from pumping at Pajarito Mesa (PM-) 5. At this time, information about the hydrogeological conditions in the vicinity of PM-5 is insufficient to conclusively predict the impact of PM-5 pumping in the deep units on the hydraulic heads and gradients in the shallow aquifer units (Puye Formation and Totavi Lentil). Pore-water velocity is predicted to be approximately 40 ft/yr (12 m/yr) according to a calculation of Darcy's Law that estimates groundwater velocity in the regional aquifer. This velocity assumes hydraulic conductivity of 0.7 ft/day ([0.2 m/day], see Table 5, EPA 1992, 15344), a gradient of 0.03, and a porosity typical of sedimentary rocks (0.2, Freeze and Cherry 1979, 64057). At this velocity, travel time in the regional aquifer between MDA C and PM-5 or R-14 would be approximately 100 yr.

Estimates of groundwater transport velocity will be evaluated more accurately using the existing aquifer model (Nylander et al. 2003, 76059), which takes into account the three-dimensionality of the groundwater flow paths, spatial distribution of recharge along the canyons, time-variation of PM-5 pumping rates, medium heterogeneity, etc. To date, such small-scale model analysis for PM-5 has not been performed.

Vadose Zone

The region beneath the ground surface and above the regional aquifer is called the vadose (unsaturated) zone. This discussion focuses on the vadose zone beneath the mesa at MDA C. The source of moisture in the vadose zone is precipitation, most of which is removed as runoff, evaporation, and transpiration (LANL 1997, 63131). The subsurface movement of the remaining moisture (often referred to as recharge) is predominantly vertical in direction and is influenced by properties and conditions of the vadose zone. Characteristics of infiltration in the vadose zone are described above (see "Perched Intermediate Waters").

The geologic property of the Bandelier Tuff that most influences fluid flow in the unsaturated zone is the degree of welding. Welded tuffs tend to have less matrix porosity and more fractures than nonwelded tuffs. Fractures in welded tuff may include relatively close-spaced cooling joints as well as tectonic fractures. Although welded tuffs also have fractures, they are generally less abundant than in welded tuffs.

Several competing effects determine moisture content and fluid flux in welded, devitrified tuff. While water moves slowly through the unsaturated tuff matrix, it can move relatively rapidly through fractures if nearly saturated conditions exist (LANL 1997, 63131). The saturation levels measured at MDA C are relatively low ([1%–10% gravimetric moisture content] Appendix B). At these saturation levels, most of the fractures beneath the site are expected to be completely dry, and the water will exist in the tuff matrix only. Only in situations when substantial infiltration occurs from the ground surface will the fractures become wet and conduct water. However, modeling studies predict that when fractures disappear at contacts between stratigraphic subunits, when fracture fills are encountered, or when coatings are interrupted, fracture moisture is absorbed into the tuff matrix (Soll and Birdsell 1998, 70011).

4.0 SCOPE OF ACTIVITIES

This section identifies the specific activities that will be performed during the field investigation of MDA C. These proposed activities differ from those identified in Section IV.C.3.c of the Order issued by NMED to DOE and UC on November 26, 2002, because this work plan considers the requirements of the Order as well as information developed during the Phase I RFI Investigation. Because the proposed scope of work differs from that in the Order, this section also provides a justification for the alternate approach.

Although the scope of activities proposed in this work plan differs from that in the Order, the data obtained from this investigation, combined with the data previously collected in the Phase I RFI, satisfy the investigation objectives identified in the Order, namely determining the nature and extent of contamination and migration pathways to receptors.

4.1 MDA C Investigation Activities

The field investigation of MDA C will be comprised of the following activities. The methods used to conduct each of these activities are identified and discussed in Section 5.

- Ten angled and four vertical boreholes will be installed at the locations shown in Figure 10. Boreholes will be advanced at the angles and to the depths and lengths specified in Table 3.
- Continuous core samples will be collected from each borehole. Core will be visually inspected, field screened for alpha and beta/gamma radioactivity, and geologically logged. Borehole logs will be prepared for each borehole.
- Tuff samples will be collected at approximately 20-ft intervals for laboratory analysis for the parameters shown in Table 3. Collection of samples for laboratory analysis will begin once the borehole is advanced beneath the associated disposal unit. Preliminary sample locations are shown on the cross sections presented in Figures 12 though 24.
- Subsurface vapor samples will be collected from boreholes A through L and N at the approximate depths of 40 to 50 ft bgs and 140 to 150 ft bgs and at 30, 60, 90, 120 and 150 ft bgs in borehole K.
- Subsurface vapor samples will be collected from borehole M at the approximate depths of 100 ft, 200 ft, 300 ft, abandonment of auger drilling (approximately 400 ft), and total depth (800 ft).
- Subsurface vapor samples will be analyzed for VOCs and tritium.
- Groundwater samples will be collected if perched water is encountered.
- Surface soil samples will be collected on the eastern boundary of MDA C for laboratory analysis for the parameters specified in Section 5.3.

4.2 Justification for Alternative Scope of Work

The proposed alternate work scopes are summarized in Table 4, along with a brief justification for the alternate approach. The following subsections provide additional details related to the justifications for alternate approaches referenced in Table 4.

4.2.1 Number, Locations, and Depth of Boreholes

The NMED Order prescribes borehole locations that apply to each pit and shaft group at MDA C. This prescriptive approach does not consider the data that were collected during the Phase I RFI. In addition,

this prescriptive approach does not consider access limitations and other constraints, such as safety requirements associated with drilling activities at MDA C. The borehole locations proposed in this work plan are based on an evaluation of the Phase I RFI data and other relevant information. This evaluation was directed toward defining the current knowledge of nature and extent (see section 2.7.3.2) and identifying specific data requirements that need to be met to satisfy the objectives of the investigation. These objectives are to determine the nature and extent of contamination sufficient to support corrective action decisions and to characterize migration pathways to receptors to assess the potential present-day and future risk posed by the site. This evaluation of data is presented in Section 2 and yielded the following three data requirements:

1. the nature and extent of contamination in subsurface tuff, including
   - extent of metal and radionuclide contamination in tuff beneath Pit 6,
   - concentrations and spatial extent of VOCs in the vapor phase in subsurface tuff,
   - concentrations and spatial extent of tritium in the vapor phase in subsurface tuff,
   - nature and extent of releases of metals, cyanide, and radionuclides to tuff beneath Pits 1–5, Shaft Groups 1 and 2, and the strontium-90 disposal shaft, and
   - extent of perchlorate, nitrate, dioxin, and furan contamination in tuff beneath MDA C;
2. the potential presence of perched groundwater beneath MDA C; and
3. information on hydrogeologic properties and fracture characteristics of the vadose zone to support contaminant transport modeling in the vadose zone.

These data requirements were considered, along with access constraints and other limitations, to identify the borehole locations and specifications shown in Figure 10 and Table 3, respectively. A comparison of the borehole specifications contained in the NMED Order for each pit and shaft group with the boreholes installed during the Phase I RFI and proposed in this work plan is presented in Table 5. The rationale for installation of each borehole is presented below.

Boreholes A and B: Two angled boreholes (boreholes A and B; Figures 11 and 12) will be advanced beneath Pit 6. Borehole A also will be advanced beneath the Chemical Pit. The boreholes will be advanced from the south side of Pit 6 with a northward strike. Drilling from the south side of Pit 6 is proposed because a review of engineering drawings for Pit 6 and the results of geophysical surveys indicate that its northern boundary is only 10 ft from the fence line. There are numerous subsurface utilities near the fence line and beneath the pavement at TA-50 across the fence, which would compromise the safety of drilling a borehole from the north side of Pit 6.

Boreholes A and B will be advanced at a 45-degree angle from a position 40 ft from the southern boundary of the Chemical Pit (borehole A) and Pit 6 (borehole B). This distance from the disposal units will afford a margin of safety to avoid drilling into the waste, as it is expected that the maximum depth of the disposal units is 25 to 30 ft bgs, and the boreholes should pass below the southern edge of the pits at a depth of 40 ft bgs.

The location and strike of borehole A will allow for collecting tuff samples in the vicinity of (and beneath) Phase I RFI boreholes 50-09109 and 50-09110, where previous tuff samples have indicated metals and radionuclide contamination (other than tritium) at a depth of 57 and 81 ft, respectively. Additional tuff samples in this area will support an evaluation of the extent of contamination beneath the western end of Pit 6. Additionally, borehole logs from 50-09109 and 50-09110 describe the presence of fractures at several depths (Appendix C). The presence of both fractures and contamination in previous tuff samples

makes this an ideal location for evaluating whether contamination in tuff is associated predominantly with fractures, the tuff matrix, or both.

Borehole B is situated for completion beneath the area of surface subsidence where water may have infiltrated Pit 6. Measurements of the moisture content in tuff in this borehole, and analytical data for contamination in tuff will support an evaluation of whether the subsidence of Pit 6 has resulted in the migration of contaminants.

Borehole C: Tuff samples obtained from this angled borehole will provide information on the presence of contaminants beneath the western portion of Pit 5 (Figure 10). No boreholes are presently located in this area to provide information on potential releases.

Borehole D: To date, VOC pore-gas samples have been collected only from boreholes 50-09100 and 50-10131, although EMFLUX® VOC flux data (Figure B-8) indicate that VOCs in the vapor phase may be present in subsurface tuff at other locations at MDA C. The largest VOC flux in an area other than the Chemical Pit occurs on the south edge of Pit 5. Borehole D (Figures 10 and 14) is located such that it will be completed below Pit 5 in the area where the high VOC flux was measured previously. The location of borehole A also serves the purpose of evaluating VOC concentrations beneath the Chemical Pit (where EMFLUX® VOC flux was greatest) to supplement VOC data available from Borehole 50-10131.

Borehole E: The angled borehole extending beneath Shaft Group 1 will provide information on the presence of contaminants beneath this disposal unit (Figure 10). No boreholes are presently located to provide information on potential releases in this area. The orientation of the borehole along the axis of the shafts will maximize the probability of encountering contamination associated with these shafts (Figure 15).

Borehole F: The angled borehole beneath the central areas of Pits 2 and 4 will provide information on the presence of contaminants beneath these disposal units (Figure 10). No boreholes are presently located to provide information on potential releases in this area (Figure 16).

Borehole G: The angled borehole extending beneath the northeast portions of Pits 2 and 4 will provide information on the contaminants beneath these disposal units (Figure 10). With the exception of some samples beneath Pit 2 from the base of borehole 50-09103, no boreholes are presently located in this area to provide information on potential releases. In the event that the floors of Pits 2 and 4 have a slope consistent with surface topography, these boreholes will be sited on the downgradient side of the pits (Figure 17).

Borehole H: The angled borehole that extends beneath the strontium-90 shaft is intended primarily to establish whether a release of strontium-90 has occurred at this location (Figure 10). Strontium-90 is relatively water-soluble and thus is potentially mobilized with infiltrating water. The location of the borehole was sited to the northwest of the strontium-90 shaft to evaluate potential releases of contaminants beneath the southern portion of Shaft Group 3 (Figure 18). Advancing an angled borehole from a position south of the strontium-90 shaft was not feasible because Pajarito Road and its associated utility corridor are located in this area.

Borehole I: The angled borehole extending beneath the eastern portions of Pits 1 and 3 was sited to provide information on the presence of contaminants beneath these disposal units (Figure 10). No boreholes are presently located in this area to provide information on potential releases (Figure 19). Angled boreholes cannot be advanced from the south at this location because Pajarito Road and utilities are located in this area.

Borehole J: The angled borehole extending beneath the eastern portion of Shaft Group 2 was sited to provide information on the presence of contaminants beneath this disposal unit (Figure 10). No boreholes are presently located to provide information on potential releases in this area. The location of Shaft Group 3 prohibits situating a borehole that extends beneath the western region of Shaft Group 2 (Figure 20). Angled boreholes cannot be advanced from the area south of Shaft Group 2 because Pajarito Road and utilities are located in this area.

Borehole K: The vertical borehole located immediately west of the northern end of Shaft Group 3 was sited to determine whether tritium pore-gas concentrations indicate a release near this location and to provide information on the presence of contaminants adjacent to these disposal units (Figure 10). No vertical boreholes are presently located in this area to provide information on potential releases. Borehole K will be drilled to a depth of 150 ft bgs (Figure 21).

Borehole L: Borehole L is a vertical borehole located to provide information on the presence of contaminants potentially released from Pit 1 (Figure 10). Although an angled borehole extending beneath Pit 1 is preferable to evaluate potential releases of these contaminants from a disposal unit, angled boreholes can be advanced only from the east of Pit 1 because of the presence of other disposal units to the north and west of Pajarito Road and utilities to the south (Figure 22).

Borehole M: A single, vertical borehole will be drilled to a depth of approximately 800 ft in the area north of Pit 5 near the head of Ten Site Canyon (Figures 10 and 23) to determine whether perched groundwater is present below MDA C. The location of the vertical borehole adjacent to the head of Ten Site Canyon will provide the best chance of encountering perched groundwater in the vicinity of MDA C. The borehole is near a storm water runoff channel that is cut into the tuff north of MDA C and that directs storm water collected from parking areas and roadways serving TA-50 into Ten Site Canyon. Therefore, local infiltration rates should be much higher in this area than in other locations near MDA C.

Borehole M provides an opportunity to collect geotechnical data to support transport modeling by characterizing site-specific hydrogeologic properties at MDA C. These properties include saturated and unsaturated hydraulic conductivity, chloride-ion concentration, porosity, bulk density, matrix potential (i.e., suction), and moisture content. A detailed profile of moisture content will ensure an adequate data set to calibrate a neutron probe for moisture logging. Collecting a profile of matrix potential in combination with the moisture content will provide data on the likely direction of moisture movement in the subsurface. Estimates of saturated and unsaturated hydraulic conductivity also support modeling of liquid migration in the vadose zone. Tuff samples for chloride-ion concentration support evaluation of the rates of water infiltration and evaporation.

Borehole N: Vertical borehole N will be drilled to a depth of 150 ft bgs adjacent to the southwest corner of Pit 1, immediately southeast of the strontium-90 shaft (Figure 10). Data from this borehole is intended to establish whether a release of strontium-90 has occurred from the strontium-90 shaft. Strontium-90 is relatively water-soluble and thus is potentially mobilized with infiltrating water. Data from borehole N will also help establish the spatial extent of metals, cyanide, and radionuclide contamination in tuff beneath Pit 1, and from Shaft Group 3. No vertical boreholes are presently located in this area to provide information on potential releases (Figure 24).

Tuff samples will be collected at least every 20 ft in the ten angled boreholes beginning beneath the target disposal unit. Vertical boreholes K, L, and N will be sampled at least every 20 ft beginning at the same depth as the nearest disposal unit. The frequency of sample collection along the boreholes for submittal to an analytical laboratory is one sample per 20 ft, whereas Section IV.C.3.a.iv of the November 26, 2002, NMED Order states, "A minimum of two samples per 100 feet of drilling depth shall be selected from each boring for laboratory analysis."

Samples will be collected from intervals where visual inspection indicates contamination and/or fractures are present. The maximum depth at which Phase I radionuclides were detected beneath Pit 6 was 80 ft bgs. The proposed borehole depths of 140 to 150 ft (approximately twice the vertical depth of the Phase I RFI boreholes) will be sufficient to establish the vertical extent of contamination beneath Pit 6 with respect to concentrations relative to background or a decreasing concentration gradient. This approach exceeds the requirements in Section IV.C.3.c.iii, item 6, of the NMED Order for boreholes to extend 25 ft below the depth of contamination detected in previous investigations.

Establishing the "extent" of a liquid-borne release of metals or radionuclides from a disposal unit is difficult because contaminants can migrate with water infiltrating below a pit or shaft via fractures in the tuff rather than in the tuff matrix. Under fracture flow conditions, detection of residual contamination in tuff is largely uncertain and establishing the vertical and horizontal extent of such contamination is inherently subjective, even with respect to concentrations relative to background or a decreasing concentration gradient. The sample locations, depths, and sampling design (paired samples of fracture fill and surrounding intact tuff) of proposed Boreholes A and B were specified to supplement existing tuff data beneath Pit 6 and determine whether contamination may have migrated via fractures. The depths for collection of samples beneath the other disposal units is consistent with this approach.

Field documentation of samples collected from fractures will include a detailed physical description of the fracture fill material and rock matrix sampled. The volumes of fracture fill and rock matrix material included in the sample will be estimated from field measurements. An additional sample will be collected from the rock matrix adjacent to the fracture sample material to allow for comparison. The fractures and matrix samples are paired and will be assigned unique identifiers.

4.2.2 Subsurface Vapor Sampling

To establish the extent of VOC contamination in tuff, VOC pore-gas data will be collected immediately after drilling activities are completed for each new and existing borehole at MDA C. For boreholes A through L and N, the first sample will be collected at a depth of approximately 40 to 50 ft bgs, corresponding to a depth of 10 to 30 ft beneath a disposal unit, depending upon the depth of the pit or shafts, where VOC concentrations associated with release from a disposal unit should be evident. The second VOC pore-gas sample will be collected from the bottom (total depth [TD]) of each borehole at 140 to 150 ft bgs to measure VOC concentrations at depth.

Five VOC pore-gas samples will be collected at borehole M immediately after drilling activities are completed to establish the VOC concentration profile with depth at this location. Three samples will be collected at 100, 200, and 300 ft bgs; a fourth sample will be collected at the depth where auger drilling is abandoned in favor of air-rotary drilling methods at an anticipated depth of 400 ft bgs; and a fifth sample will be collected at TD of the borehole following extensive purging of borehole air. Previous experience in drilling boreholes has shown that auger drilling is of limited use in the geologically unstable materials below this approximate depth; thus, the remaining depth of the borehole will be drilled by air-rotary methods (see Section 5).

A second round of VOC pore-gas sampling at the same depths will be conducted approximately one month after drilling activities are completed. The purpose of the second round of sampling is to confirm the VOC pore-gas data findings for samples collected immediately after drilling. It is possible that the initial VOC pore-gas measurements may be affected by drilling activities; therefore, VOC measurements collected after subsurface pore-gas conditions have stabilized may be more representative of actual conditions. The schedule for VOC pore-gas sampling is discussed in Section 7 of this work plan.

All ten ports in boreholes 50-09100 and 50-10131 were sampled for VOCs in January 2003. The VOC concentrations measured in this sampling were consistent with results from sampling performed in 2000 through 2002, indicating minimal variability in VOC pore-gas concentrations over time. An additional two rounds of pore-gas sampling will be conducted at boreholes 50-01900 and 50-10131 after drilling activities are completed and again after one month. Data will be collected from all ten ports in each borehole. The port depths for borehole 50-01900 are 20, 50, 90, 103, 120, 160, 200, 233, 260, and 315 ft bgs. Port depths for borehole 50-10131 are 25, 50, 75, 100, 125, 150, 175, 200, 225, and 250 ft bgs. Pore-gas data for VOCs from the first and second phase of VOC sampling in the new and existing boreholes will be used to determine the extent of VOC pore-gas contamination and the need for additional boreholes instrumented for monitoring VOCs in pore gas.

To establish the extent of tritium vapor contamination in tuff, tritium pore-gas data will be collected immediately upon completion of drilling activities for each new borehole at MDA C. For boreholes A through J, L and N, two samples will be collected. The first sample will be collected at a depth of approximately 40 to 50 ft bgs. This corresponds to a depth of 10 to 30 ft beneath a disposal unit, depending on the depth of the pit or shafts, where tritium concentrations associated with release from a disposal unit should be evident. The second tritium pore-gas sample will be collected from the bottom 140 to 150 ft bgs (TD) of each borehole to measure tritium concentrations at depth. For borehole K, five tritium samples will be collected every 30 ft bgs.

Five tritium pore-gas samples will be collected immediately drilling activities are completed at borehole M (the 800-ft vertical borehole) to establish the profile of tritium concentrations with depth at this location. A second round of tritium pore-gas samples will be collected approximately one month following the completion of drilling activities for all boreholes. Tritium pore-gas samples will be collected in silica gel samplers for analysis by an off-site contract laboratory.

With respect to boreholes A through L and N, based on the Phase I RFI results, sampling VOCs and tritium at both the sampled depths (40 to 50 ft bgs and 140 to 150 ft bgs) should produce a decreasing trend allowing extent of contamination to be defined sufficient to support corrective action decisions.

4.2.3 Surface Soil Sampling

Phase I RFI surface soil data indicate the extent of radionuclide contamination has not been defined along the eastern border of MDA C.

Concentrations of americium-241 and isotopic plutonium were detected above BV/FV in a total of 11 samples northeast and east of the MDA C boundary. Americium-241 was detected in 9 samples, plutonium-238 was detected in 5 samples, and plutonium-239 was detected in all 11 samples. The highest concentration of each radionuclide from these samples are 1.017 pCi/g americium-241 at location 50-08138; 0.068 pCi/g plutonuim-238 at location 50-08494; and 10.687 pCi/g plutonium-239 at location 50-08086. A summary of radionuclides detected above BV/FV in surface soil at MDA C is provided in Table B-12, and bubble plot maps are of radionuclide detects are provided in Figures D-3, D-4, and D-5.

A gamma spectroscopy survey will be performed to determine the extent of radionuclide contamination in surface soil along the eastern boundary of MDA C. Based on the results of the survey, six surface soil samples will be collected for fixed laboratory analysis as specified in Section 5.3.

4.2.4 Field Screening

Section IV.C.3.c.iv, Paragraph 2, of the NMED Order specifies that core samples collected at MDA C be screened using the methods described in Section IX.B of the Order. Section IX.B.2.d of the Order

specifies that all core samples be screened by: (1) visual examination; (2) headspace vapor screening for VOCs; and (3) metals screening using x-ray fluorescence (XRF). Additional screening for release-specific characteristics, such as pH and HE, shall be conducted where appropriate. Section IV.C.3.c.iv of the Order indicates that screening results for the samples collected at MDA C shall be used to identify samples to be submitted for laboratory analysis.

Results of Phase I RFI at MDA C indicate that the screening methods specified in the Order, other than visual examination, would be ineffective and would generate no useful information for the purpose of identifying samples to submit for laboratory analysis. The limitations of field screening methods for various classes of analytes are discussed below.

VOCs

The headspace vapor screening procedure given in Section IX.B.2.d of the Order calls for the sample to be sealed in a bag or other container and equilibrated with the ambient air inside the container. The concentration of VOCs in the headspace gas is then measured using a PID. The results of previous investigations at MDA C indicate that this procedure is not appropriate for the core samples to be collected at MDA C.

The above procedure is designed to identify samples having elevated concentrations of VOCs in the solid matrix. This procedure is designed to cause VOCs associated with the solid phase to volatilize into the headspace, where they can be detected using a PID. At MDA C, VOCs are present in subsurface tuff samples in the pore gas and are not associated with the solid matrix. If this screening procedure was applied to samples from MDA C, vapor-phase VOCs would diffuse from the sample pore space into the container headspace and decrease the concentration as the VOCs are diluted into the headspace gas. Based on the results of past subsurface pore-gas monitoring at MDA C, the concentration of VOCs in the headspace gas would be too low to detect using a PID. Past pore gas monitoring has shown maximum concentrations of most VOCs to be less than 1 ppmv, with several VOCs having maximum concentrations in the low ppmv range. The concentration after dilution into the headspace should be less than 1 ppmv, which is the detection limit of many PIDs.

Alternate VOC screening approaches, such as direct surveys of the surface of the core using a PID would also be ineffective. During Phase I RFI, 333 subsurface core samples were screened in the field by direct survey with a PID. No VOCs were detected in any of these samples.

Metals

During Phase I RFI, 82 subsurface tuff samples were submitted for laboratory analysis of metals. Fourteen metals were detected at concentrations above BVs. Only three of these metals (barium, calcium, and lead) were present at concentrations that would have been detectable using XRF. For the other metals detectable using XRF, maximum concentrations were generally less than half the respective XRF detection limit.

HE

During the Phase I RFI, 332 subsurface core samples were screened in the field for HE using a spot-test procedure. No HE was detected in any of these samples.

Radioactivity

The MDA C work plan specifies radiation screening of all samples. This screening is primarily for health and safety purposes rather than for identifying samples for laboratory analysis. The results of the Phase I RFI show that field radiation screening was not effective in identifying samples to submit for laboratory analysis.

During the Phase I RFI, 333 subsurface core samples were screened in the field for alpha and beta/gamma radioactivity, and 67 of these were submitted for laboratory analysis of radionuclides. Forty-three of these 67 samples had detected activities of radionuclides other than tritium within the range of BVs. The remaining 24 samples had detected activities of radionuclides other than tritium above BVs. Table 6 summarizes the results of the field screening for the samples having radionuclide activities within the background range and above background. As shown in Table 6, there was no significant difference in field screening results for samples having radionuclides within and above background values. Therefore, field screening for radionuclides is not useful for determining which samples should be submitted for laboratory analysis. Additionally, field screening methods for tritium suitable for the levels of tritium present at MDA C are not available.

4.2.5 Analytical Suites

Subsurface tuff samples will not be submitted for analysis of all analytes specified in the NMED Order. Specific analyses that will not be performed on any VOC, SVOC, pH, HE, and PCB samples. VOCs will not be analyzed in tuff samples because such analyses are not appropriate. As explained in Section 2.7.3 of this work plan, VOCs are primarily present in the subsurface as vapors and are not associated with the solid matrix. As a result, the most accurate method of sampling for VOCs is pore-gas sampling. Pore-gas sampling will be used to determine the extent of subsurface VOC contamination at MDA C.

Subsurface core samples collected during the Phase I RFI were submitted for analysis of SVOCs and PCBs. The results of this sampling indicate that the nature and extent of SVOC and PCB contamination is established at MDA C (Section 2.7.3) and no additional sampling for SVOCs or PCBs is required.

Analysis of tuff samples for pH is not appropriate considering the low moisture content of the tuff and will not be performed.

Subsurface tuff samples will not be analyzed for HE based on the low potential for HE to be present at MDA C. Descriptions of waste sent to MDA C (Appendix B) indicate that the only potential sources of HE-containing wastes were wastes associated with the demolition of Bayo Canyon, which was the location of historic firing sites, and trinitrotoluene (TNT) element samples identified in the waste inventory for Shaft Group 3. Additional details on the wastes associated with Bayo Canyon demolition are contained in the associated RFI work plan and reports and historical reference documents that indicate HE is not present in the wastes sent to MDA C from Bayo Canyon.

When the firing sites in Bayo Canyon were active, residuals and debris from the firing sites were disposed of to a disposal pit, SWMU 10-005. During decontamination and decommissioning of this disposal site in 1957, the wastes in SWMU 10-005 were excavated and burned, and the ash was subsequently disposed of at MDA C (p. 3-63, LANL 1992, 07668). Any HE present in the residuals would have been destroyed by burning. Subsurface samples were collected at the site of SWMU 10-005 during the RFI of this site and were analyzed for HE. No HE was detected in these samples (p. 102, LANL 1996, 54332). The only other wastes from Bayo Canyon identified as potentially having been sent to MDA C was ash from a burn pit used to burn combustible wastes (SWMU 10-006; pp. 4-1–4-3, LANL 1992, 07668.). As at SWMU 10-005, the ash is unlikely to have contained appreciable amounts of HE. The final cleanup of the Bayo

Canyon firing sites in 1963 is described in an historical report (LASL 1963, 04771). All remaining firing site debris was removed at this time and no HE was found in this debris (p. 6, LASL 1963, 04771).

TNT is listed in three disposal logbook entries for Shaft Group 3. The origin of this waste is Wing 9 of the Chemical and Metallurgy Building, where significant quantities of HE would not be present for safety reasons. The waste description for some of the TNT refers to "TNT SS center elements," "TNT element samples," or "TNT mounts." There is also accompanying fission product or U with the TNT. The units of disposal are gallon cans, so only a small quantity was disposed of. The results of Phase I RFI SVOC analyses did not identify detectable amounts of 2,4-dinitrotoluene or 2,6-dinitrotoluene, which are associated with TNT, in any tuff samples. Additionally, 233 phase I RFI borehole samples were screened for HE and there were no detects, including those core samples in boreholes 50-09105 and 50-09106 that passed beneath Shaft Group 3.

A review of waste inventory records (see Appendix B) does not indicate the presence dioxins or furans in the disposed wastes. However, dioxin and furans can be generated by the combustion of organic material containing, or in the presence of, chlorine atoms. Therefore, the first tuff sample collected directly beneath the Chemical Pit (borehole A) will be analyzed for dioxins and furans because of the reported practice of burning chemicals disposed in the Chemical Pit (Rogers 1977, 0216). Additionally, the first tuff sample collected beneath a pit or shaft in boreholes B through J will also have dioxins and furans added to the analyte suite. Tuff samples from vertical boreholes K through M will not be analyzed for dioxins or furans.

5.0 INVESTIGATION METHODS

The following RRES-RS standard operating procedures (SOPs), available at http://erproject.lanl.gov/documents/procedures.html, are applicable to the investigation methods proposed in this plan:

- LANL-ER-SOP-1.01, Rev. 1 *General Instructions for Field Investigations*
- LANL-ER-SOP-1.02, Rev. 1 *Sample Containers and Preservation*
- LANL-ER-SOP-1.03, Rev. 2 *Handling, Packaging, and Shipping of Samples*
- LANL-ER-SOP-1.04, Rev. 5 *Sample Control and Field Documentation*
- LANL-ER-SOP-1.05, Rev. 1 *Field Quality Control Samples*
- LANL-ER-SOP-1.06, Rev 2 *Management of ER Project Wastes*
- LANL-ER-SOP-1.08, Rev. 1 *Field Documentation of Drilling and Sampling Equipment*
- LANL-ER-SOP-1.10, Rev. 1 *Waste Characterization*
- LANL-ER-SOP-3.11, Rev. 1 *Coordination and Evaluating Geodetic Surveys*
- LANL-ER-SOP-4.01, Rev. 1 *Drilling Methods and Drill-Site Management*
- LANL-ER-SOP-5.03, Rev. 2 *Monitoring Well and RFI Borehole Abandonment*
- LANL-ER-SOP-5.07, Rev. 0 *Operation of LANL Owned Borehole Logging Trailer*
- LANL-ER-SOP-6.09, Rev. 2 *Spade and Scoop Method for Collection of Soil Samples*
- LANL-ER-SOP-6.26, Rev. 1 *Core Barrel Sampling for Subsurface Earth Materials*
- LANL-ER-SOP-6.31, Rev. 1 *Sampling of Sub-Atmospheric Air*
- LANL-ER-SOP-7.05, Rev. 1 *Subsurface Moisture Measurements Using a Neutron Probe*
- LANL-ER-SOP-12.01, Rev. 4 *Field Logging, Handling and Documentation of Borehole Materials*

Additional procedures may be added as necessary to describe and document quality-affecting activities.

5.1 Methods for Drilling and Sampling Boreholes A through L and N

5.1.1 Drilling Protocol

Vertical and angled boreholes will be drilled using either the hollow-stem or air-rotary method depending on worker safety requirements. To address worker safety requirements for this investigation, the potential for worker exposure to subsurface contaminants from borehole cuttings and/or core will need to be reviewed in the site specific health and safety plan and the documented safety analysis (DSA) Although the hollow-stem auger drilling method is preferred when investigating vapor phase contamination, the air-rotary drilling method provides for engineered controls (i.e., cyclone-velocity dissapator and HEPA filter) to manage downhole material at the surface, thereby reducing and/or eliminating exposure pathways. The drilling methods to be used at MDA C are described in the following paragraphs.

Hollow-Stem Auger

The hollow-stem auger consists of a hollow steel shaft with a continuous spiraled steel flight welded onto the exterior site of the stem. The stem is connected to an auger bit and, when rotated, transports cuttings to the surface. The hollow stem of the auger allows drill rods, split-spoon core barrels, Shelby tubes, and other samplers to be inserted through the center of the auger so the samples may be retrieved during the drilling operations. The hollow stem also acts to case the borehole temporarily, so that the casing (riser) may be inserted down through the center of the augers once the desired depth is reached, thus minimizing the risk of possible collapse of the borehole. A bottom plug or pilot bit can be fastened onto the bottom of the augers to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Drilling without a center plug is acceptable provided that the soil plug, formed in the bottom of the auger, is removed before sampling or installing well casings. The soil plug can be removed by washing out the plug using a side discharge rotary bit or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger.

Air Rotary

The air-rotary method uses a drill pipe or drill stem coupled to a drill bit that rotates and cuts through soil and rock. The cuttings produced from the rotation of the drilling bit are transported to the surface by compressed air, which is forced down the borehole through the drill pipe and returns to the surface through the annular space (between the drill pipe and the borehole wall). The circulation of the compressed air not only removes the cuttings from the borehole but also helps to cool the drill bit. The use of air rotary drilling is best suited for hard rock formations. In soft unconsolidated formations, casing is driven to keep the formation from caving. When using air rotary, the air compressor shall have an in-line organic filter system to filter the air coming from the compressor. The organic filter system shall be inspected regularly to ensure that the system is functioning properly. In addition, a cyclone-velocity dissipator or similar air containment/dust-suppression system shall be used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Air rotary that employs the dual-tube (reverse circulation) drilling system is acceptable because the cuttings are contained within the drill stem and are discharged through a cyclone-velocity dissipator to the ground surface.

Boreholes A through L and N will be drilled in the approximate locations shown in Figure 10. The subsurface borehole configurations are projected relative to disposal units in Figures 11 through 24. The depth, angle, and sampling protocol for each borehole are described in Table 3. Each borehole will be continuously cored using a split barrel sampler following LANL-ER-SOP-4.01, Rev. 1, to TD. Core will be screened for radiological contamination, visually inspected, and geologically logged. If radiological contamination is detected using field screening methods at the proposed TD, the boring will be advanced until contamination is no longer detected.

The exact location of each borehole will be determined after extensive and careful review of the potential risks and access limitations. Pit and shaft boundaries will be mapped via a differential global positioning system survey (+/- 2 cm X, Y, Z) following LANL-ER-SOP-3.11, Rev. 1, to further refine borehole locations. A GPR survey will also be conducted in order to define potentially hazardous utility lines in the work area. Each site will be thoroughly examined to identify potential hazards for subsurface drilling.

5.1.2 Collection of Tuff Samples

Subsurface tuff samples will be collected from the split-spoon core barrel into sealed sleeves or core-protect bags to preserve core moisture following LANL-ER-SOP-6.26, Rev. 1. The analytical suites for each borehole are listed in Table 3. The frequency of sampling and orientation relative to disposal units are shown in Figures 11 through 24.

Tuff samples will be collected at least every 20 ft in the ten angled boreholes (A through J) beginning beneath the target disposal unit. Vertical boreholes K, L, and N will be sampled at least every 20 ft beginning at the same depth as the nearest disposal unit. Samples will be collected from intervals where contamination is suspected because field screening results are elevated and/or visual inspection identifies fractures or staining.

Field documentation of samples collected from fractures will include a detailed physical description of the fracture fill material and rock matrix sampled following LANL-ER-SOP-12.01, Rev. 4. The volumes of fracture fill and rock matrix material included in the sample will be estimated from field measurements. An additional sample will be collected from the rock matrix adjacent to the fracture sample material to allow for analytical comparison. The fractures and matrix samples will be assigned unique identifiers.

Tuff samples from boreholes A through L and N will be analyzed for TAL metals, cyanide, nitrates, perchlorate, and radionuclides (americium-241, strontium-90, isotopic uranium, isotopic plutonium, and gamma spectroscopy isotopes). Additionally, tuff samples collected during the first sampling interval below each pit or shaft at boreholes A through J will be analyzed for dioxins and furans. Analysis of all tuff samples will be conducted using analytical methods specified by contract requirements of the statement of work.

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 will be collected following LANL-ER-SOP-1.05, Rev. 1, and will be collected at the frequency specified in Section IX.B.2.e of the November 26, 2002, NMED Order.

5.1.3 Collection of Pore-Gas Samples

Subsurface pore-gas samples will be collected from boreholes A through K and N and boreholes 50-09100 and 50-10131 following LANL-ER-SOP-6.31, Rev. 1. In each borehole, one sample will be collected at the depth in which the borehole is nearest the targeted disposal unit, and the second sample will be collected at TD. Pore-gas samples will be collected using a straddle packer to isolate discrete

depths within the borehole. Each interval will be purged prior to sampling until measurements of carbon dioxide and oxygen are stable and representative of subsurface conditions. Subsurface pore-gas samples will be collected in SUMMA canisters and submitted for analysis of VOCs using EPA Method TO-14 and in silica gel samplers for tritium analysis using EPA Method 906.0.

QA/QC samples for VOCs in pore-gas will consist of an equipment blank and field duplicate for each sampling round. After sampling and purge decontamination, the equipment blank will be collected by pulling zero gas (99.9% ultrahigh-purity nitrogen) through the packer sampling apparatus. This sample will be used to evaluate decontamination procedures. The field duplicate sample will be used to evaluate the reproducibility of the sampling technique. A field duplicate sample will also be collected for tritium. QA/QC samples will be collected in accordance with LANL-ER-SOP-1.05, Rev. 1, and will be collected at the frequency specified in Section IX.B.2.e of the November 26, 2002, NMED Order.

5.2 Methods for Drilling and Sampling Borehole M

5.2.1 Drilling Protocol

A single, vertical borehole will be drilled to a depth of 800 ft in the area north of Pit 5 near the head of Ten Site Canyon. The location and depth of the borehole were selected to provide information on the vertical profile of VOC and tritium concentrations in pore-gas and to determine whether perched groundwater is present below MDA C.

Hollow-stem auger drilling will be used until refusal (down to at least 400 ft) because it has proven to be capable of collecting undisturbed samples of core and subsurface vapors within the Tshirege Member of the Bandelier Tuff. Upon refusal, air-rotary drilling will be deployed down the same borehole for completion. A description of the air rotary method is provided in Section 5.1.1. The coupling of these drilling methods is practical and allows the objectives of the sampling for this borehole to be met. The vertical borehole will be cored continuously with a split-barrel sampler to 800 ft following LANL-ER-SOP 4.01, Rev. 1. Core will be screened for radiological contamination, visually inspected, and geologically logged. The exact location of this borehole will be determined in the manner and with the same scrutiny described in Section 5.1.1 for boreholes A through L and N.

5.2.2 Collection of Pore-Gas Samples

The sampling depth and analytical suites for borehole M are described in Table 3 and depicted at depth in Figure 24. Subsurface pore-gas samples will be collected every 100 ft down the borehole to the depth where hollow-stem auger drilling cannot be continued (approximately 400 ft or deeper). Pore-gas samples will be collected following LANL-ER-SOP-6.31, Rev. 1 using a straddle packer to isolate discrete depths of the borehole. Each interval will be purged prior to sampling until measurements of carbon dioxide and oxygen are stable and representative of subsurface conditions. Subsurface pore-gas samples will be collected in SUMMA canisters and submitted for analysis of VOCs using EPA Method TO-14, and collected in silica gel samplers and submitted for tritium analysis using EPA Method 906.0. An additional sample will be collected at TD (800 ft) with a single packer through the end of the air-rotary drill string; however, the potential instability of the Puye Formation and the effects of air-rotary drilling on subsurface vapors may preclude collecting a sample representative of true subsurface conditions. The subsurface vapor sample at TD will be collected only if the conditions for purge-gas stabilization according to LANL-ER-SOP-6.31 are met.

QA/QC samples for VOCs in pore-gas will consist of an equipment blank and field duplicate for each sampling round. After sampling and purge decontamination, the equipment blank will be collected by

pulling zero gas (99.9% ultrahigh-purity nitrogen) through the packer sampling apparatus. This sample will be used to evaluate decontamination procedures. The field duplicate sample will be used to evaluate the reproducibility of the sampling technique. A field duplicate sample will also be collected for tritium. QA/QC samples will be collected in accordance with LANL-ER-SOP-1.05, Rev. 1.

5.2.3 Collection of Geotechnical Data

Borehole M will be cored continuously and geologically logged to TD following LANL-ER-SOP-4.01, Rev 1, and LANL-ER-SOP-12.01, Rev. 4. Samples will be collected from core provided by a split-barrel sampler throughout the Tshirege Member of the Bandelier Tuff to allow visual inspection. Brass sleeves will then be used in the relatively unconsolidated Cerro Toledo interval, the Otowi Member, and the Puye Formation to improve recovery and maintain structural integrity in the hole for hydrogeologic characterization. Samples collected from the split-barrel sampler will be preserved in sealed sleeves or core-protect bags to preserve core moisture following LANL-ER-SOP-6.26, Rev. 1.

Moisture content and matrix potential samples will be collected every 5 ft from borehole M. Samples for chloride analysis will be collected every 20 ft from this borehole. Samples for saturated and unsaturated hydraulic conductivity, porosity, and bulk density will be collected once in each tuff unit, twice from the Cerro Toledo interval, and five times in the Otowi Member at varying depths. Five samples will also be collected from the Puye Formation. The samples collected from the Cerro Toledo interval, the Otowi Member, and the Puye Formation will be selected from core to be representative of all the textural intervals encountered. Analyses for saturated and unsaturated hydraulic conductivity, porosity, and bulk density will be performed using analytical methods specified by contract requirements of the statement of work. One field duplicate sample will be collected and analyzed to evaluate the reproducibility of the sampling technique.

5.2.4 Collection of Perched Water Samples

During drilling operations there is the potential for encountering zones of elevated moisture content, localized saturation, and groundwater. These zones may not be assignable to either an alluvial or the regional groundwater system and represent a localized phenomenon. The Laboratory's decision process for characterizing these zones is presented in the attached flowchart shown in Figure 26 and described in the following text.

If saturation is encountered as a borehole advances, drilling would be stopped to determine whether sufficient water volume is available to analyze the water quality. These analyses may include metals, anions, perchlorate, alkalinity, carbon organic carbon, total inorganic carbon, and total dissolved solids. Generally the total volume required is approximately 0.5 to one liter. Of this volume, 100 mL is unfiltered and unpreserved; another 100 mL is filtered and preserved with nitric acid. If this minimum volume of groundwater cannot be collected, the borehole would be continued to the planned TD or until saturation is encountered again and the process is repeated. A porous cup lysimeter or absorbent membrane would be installed at the depth of saturation to monitor the zone if the borehole is completed for pore gas monitoring. Insufficient water sample volumes from discreet depths would not be composited to make the required volume for screening analysis.

If sufficient volume exists, a groundwater sample would be collected and analyzed for the screening constituents on a rapid turnaround basis at a geochemistry laboratory at Los Alamos. Typically, results of groundwater screening samples are available in the R-well drilling program within 48 hr. During this time, the borehole will be advanced to the base of saturation, or the perching horizon, and halted. If possible, the perching horizon would be identified and not penetrated. This activity will determine the thickness of

the zone of saturation and the characteristics of the perching horizon. Borehole drilling will cease, and a monitoring well will be designed, and the design will be submitted to NMED for approval. Following approval of the design, the well will be installed. A borehole will be drilled adjacent to the well and the saturated zone isolated with a double wall casing advancement drilling method to isolate the known saturated zone. The additional borehole will then be completed to the planned depths and the process repeated.

5.3 Methods for Surface Sampling

5.3.1 Radiological Survey

A radiological survey will be conducted to the northeast and east of the MDA C boundary to aid in determining the extent of radionuclide surface soil contamination. This survey will be performed with a Berkeley Nucleonics Surveillance and Measurement System, a portable gamma spectroscopy instrument with an integrated multichannel analyzer. This instrument uses a sodium iodide detector to identify multiple isotopes, and the isotope specific/total dose rates, at each survey location.

The radiological survey will be conducted on a 15- by 15-ft grid. The coordinates of all survey grid locations will be coupled with the gamma spectroscopy data to determine spatial trends and the extent of radionuclide contamination in the surface soil. Based on the results of this survey, six surface soil samples will be collected and submitted for fixed laboratory analysis.

5.3.2 Surface Soil Sampling

Six surface soil samples will be collected from locations on the gamma spectroscopy survey grid. The locations of these samples will be biased towards both the highest radionuclide concentrations, and from bounding locations on the grid perimeter. The surface soil samples will be taken from an interval of 0-6 in. in depth in accordance with LANL-ER-SOP 6.09.

Surface soil samples will be submitted for fixed laboratory analysis of americium-241, isotopic uranium, isotopic plutonium, and gamma spectroscopy, using methods specified by contract requirements of the Laboratory's SMO. QA/QC samples will consist of one field duplicate per ten samples collected.

6.0 MONITORING AND SAMPLING PROGRAM

Pore-gas monitoring of two boreholes at MDA C has occurred on a quarterly basis from 2000 through the third quarter of 2003 to collect data to determine the nature and extent of contamination in the vapor phase beneath MDA C. In addition, biweekly tritium samples in the breathing zone are being collected over a 52-week period outside the northeast fence line of MDA C.

6.1 Pore-Gas Sampling

Two boreholes at MDA C, equipped with positive pressure membranes for sampling, were monitored at multiple depths on a quarterly basis for 11 quarters. Boreholes 50-9100 and 50-10131 are located in areas of elevated surface flux of VOCs, as determined by the EMFLUX® soil-gas surveys and are therefore the likely areas of maximum vertical extent. Measured VOC concentrations are in the low ppmv range near the depth of disposal and diffuse with depth. Subsurface VOC concentrations at MDA C have been monitored from the fourth quarter of 2000 until the third quarter of 2003 when quarterly pore-gas monitoring was discontinued.

Previous vapor sampling has identified that VOCs disposed in Bandelier Tuff are present in the subsurface in the form of organic vapors. The very low organic and moisture content of the Bandelier Tuff greatly limits, or excludes, sorption of VOCs to the matrix. Therefore, traditional fixed analytical laboratory analysis of core samples will not detect VOCs, which are present primarily as vapor in the pore space. Therefore, to characterize the nature and extent of potential vapor-phase contamination at MDA C at TA-50, RRES-RS initiated a pore-gas investigation utilizing technologies used elsewhere at the Laboratory and approved by NMED.

In 2002, RFI borehole 50-09100 was completed as a vapor monitoring well using a positive-pressure membrane in 2000. Ten sample ports were installed in the membrane, ranging in depth from 20 to 315 ft bgs. In 2001 a second monitoring well (50-10131) was drilled and completed with a positive-pressure membrane and with ports depths ranging from 25 to 250 ft bgs. Figure 25 is a simplified schematic of the membrane in borehole 50-09100 showing port depths and construction.

Monitoring of subsurface VOCs has been completed at MDA C for a total of eleven quarters beginning in the fourth quarter of 2000, until the third quarter of 2003. Every available port at boreholes 50-09100 and 50-10131 was screened with a Brüel and Kjaer (B&K) multigas analyzer during every quarter of the monitoring period following LANL-ER SOP 06.31. SUMMA canister samples were also collected from one port, of one borehole each quarter. SUMMAs were collected from borehole 50-09100 for 10 quarters, and borehole 50-10131 for 6 quarters. In the second quarter of 2003, all sample ports in both boreholes were sampled simultaneously to assess the potential influence of temporal variability on VOC concentrations measured between 2000 and 2002. All pore gas sampling at MDA C is completed per LANL-ER SOP-6.31, Rev. 1, "Sampling of Subatmospheric Air."

The SUMMA canister sampling method is currently being used with analysis by EPA Method TO-14 (gas chromatography/mass spectrometry; EPA 1999, 70063). SUMMA canister samples are drawn from several sampling ports available at each borehole.

Before the required sampling is performed, boreholes 50-09100 and 50-10131 are screened with the B&K multigas monitor. Each port is purged and monitored with field instruments until carbon dioxide levels have stabilized at values representative of subsurface pore-gas conditions and is then screened for four VOCs (TCE, TCA, perchloroethene, and Freon-11).

Three types of field QA samples are collected in addition to the analytical samples. These three samples include a duplicate sample, an equipment blank of zero grade air (zero-grade air is a common term for air that is certified to be free from VOC contamination) or nitrogen drawn through the sampling apparatus in the working area, and a performance evaluation sample/calibration gas sample taken from a tank of a certified gas mixture. Laboratory QA for EPA Method TO-14 includes internal standards, surrogates, replicates, blanks, laboratory control samples, and reference standards.

6.2 Tritium in Air Sampling

A RRES-Meteorology and Air Quality (MAQ) air-sampling station was set up outside the northeastern boundary (the predominant wind direction) of MDA C in March 2003 at an elevation of four ft above ground level to monitor tritium in the breathing zone. Continuous air sampling for tritium is being conducted over a one-year duration by RRES-MAQ, the Laboratory Air Quality Group in accordance with Standard Operating Procedure RRES-MAQ-204, R10, "Sampling of Ambient Airborne Tritium." Composite samples are being collected over two-week periods (biweekly) and submitted to an off-site laboratory for tritium analysis. The subsequent interpretation and analysis of these data will be performed by the RRES-MAQ Group in support of worker health and safety following their protocols, and its results will be reported in the MDA C Investigation Report.

7.0 SCHEDULE

Revision 1 of the MDA C work plan will be updated and resubmitted to NMED on January 23, 2004. Assuming a 60-day NMED review period and 30 days to resolve comments between NMED and the Laboratory, the work plan will be approved in early May of 2004.

Authorization basis (AB) documentation (DSA) is being prepared for DOE review to document that drilling beneath the MDA C inventory can be conducted in a safe manner in accordance with nuclear safety requirements in 10CFR 830. The DSA will be submitted to DOE in May 2004. Fieldwork will not be allowed to start until AB approval is received from DOE (30-day review period), but permitting and readiness review activities will proceed in parallel with the AB process.

Field activities, including drilling and surface and subsurface sampling, will take approximately four to six weeks to complete (barring any weather or other unforeseen delays). The subsurface sampling will include the first round of pore-gas sampling using SUMMA canisters and silica gel samplers. A second round of pore-gas sampling will take place during week 10. Assuming a 6-week turnaround time to receive and analyze data on the pore-gas sampling results, Laboratory and NMED representatives will meet to review the pore-gas data during week 16 and decide whether to instrument any additional boreholes for pore-gas monitoring. If required, pore-gas monitoring boreholes will be instrumented during week 22 and samples collected in week 24.

Deep vertical borehole M will be instrumented between weeks 8 and 10, and pore-gas samples collected between weeks 10 and 12.

The Investigation Report will be finalized 10 months after the work plan is approved.

8.0 REFERENCES

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author, publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the RRES-RS Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the RRES-RS project reference set titled "Reference Set for Material Disposal Areas, Technical Area 50."

Copies of the reference sets are maintained at the NMED Hazardous Waste Bureau; the DOE Los Alamos Site Office; US Environmental Protection Agency, Region 6; and RRES-RS project. The sets were developed to ensure that the administrative authority has all material needed to review this document, and they are updated periodically as needed. Documents previously submitted to the administrative authority are not included.

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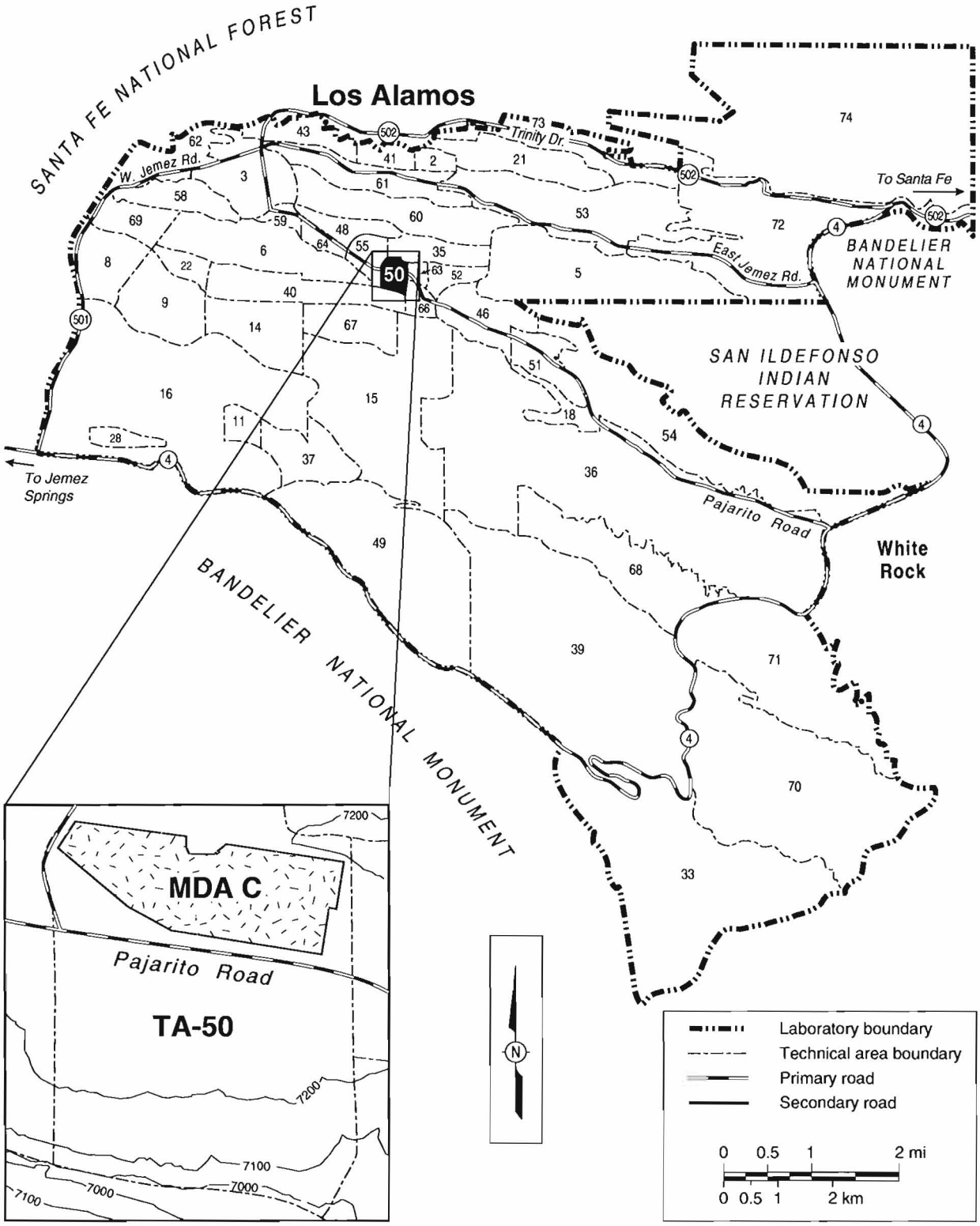
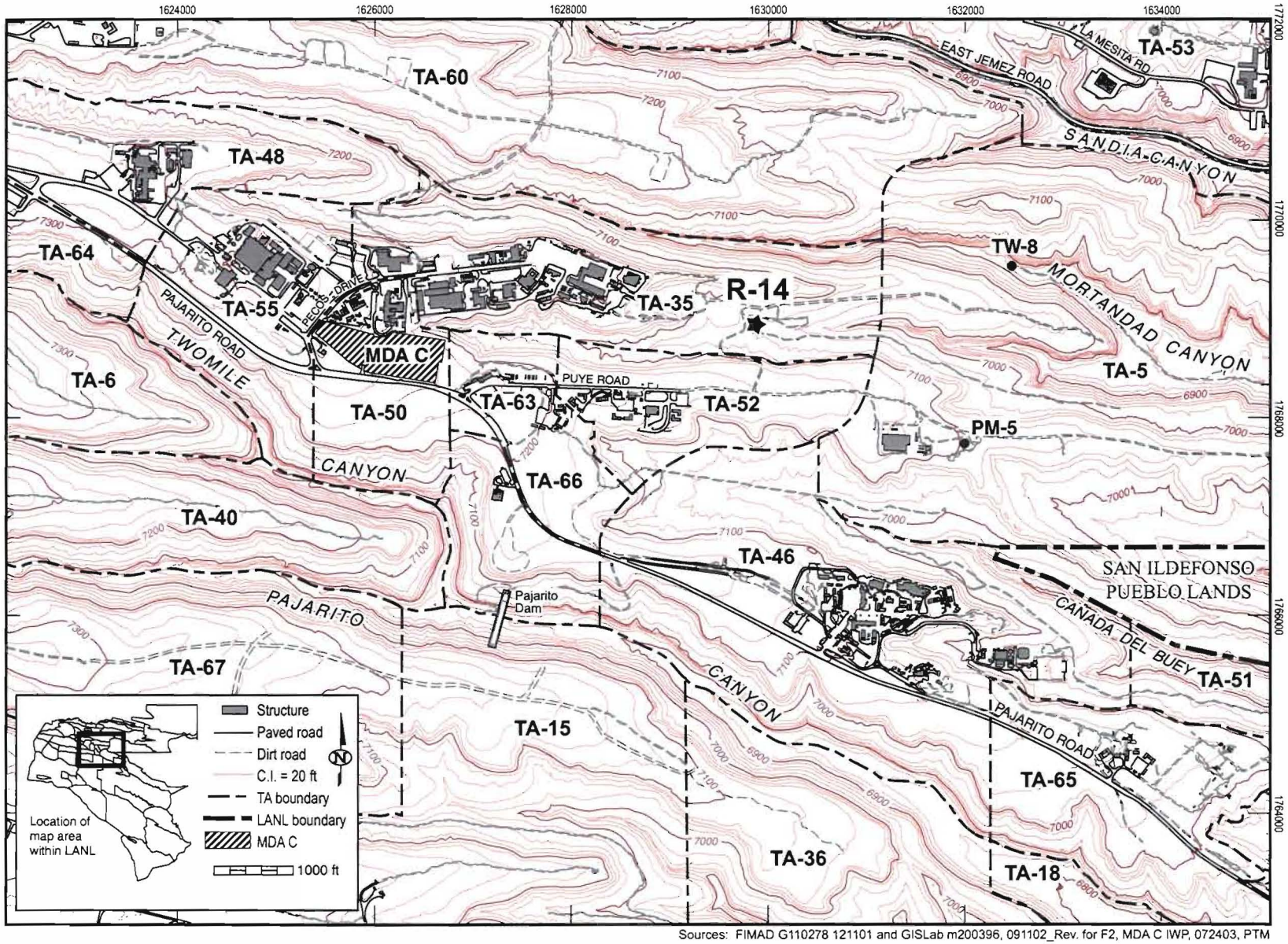


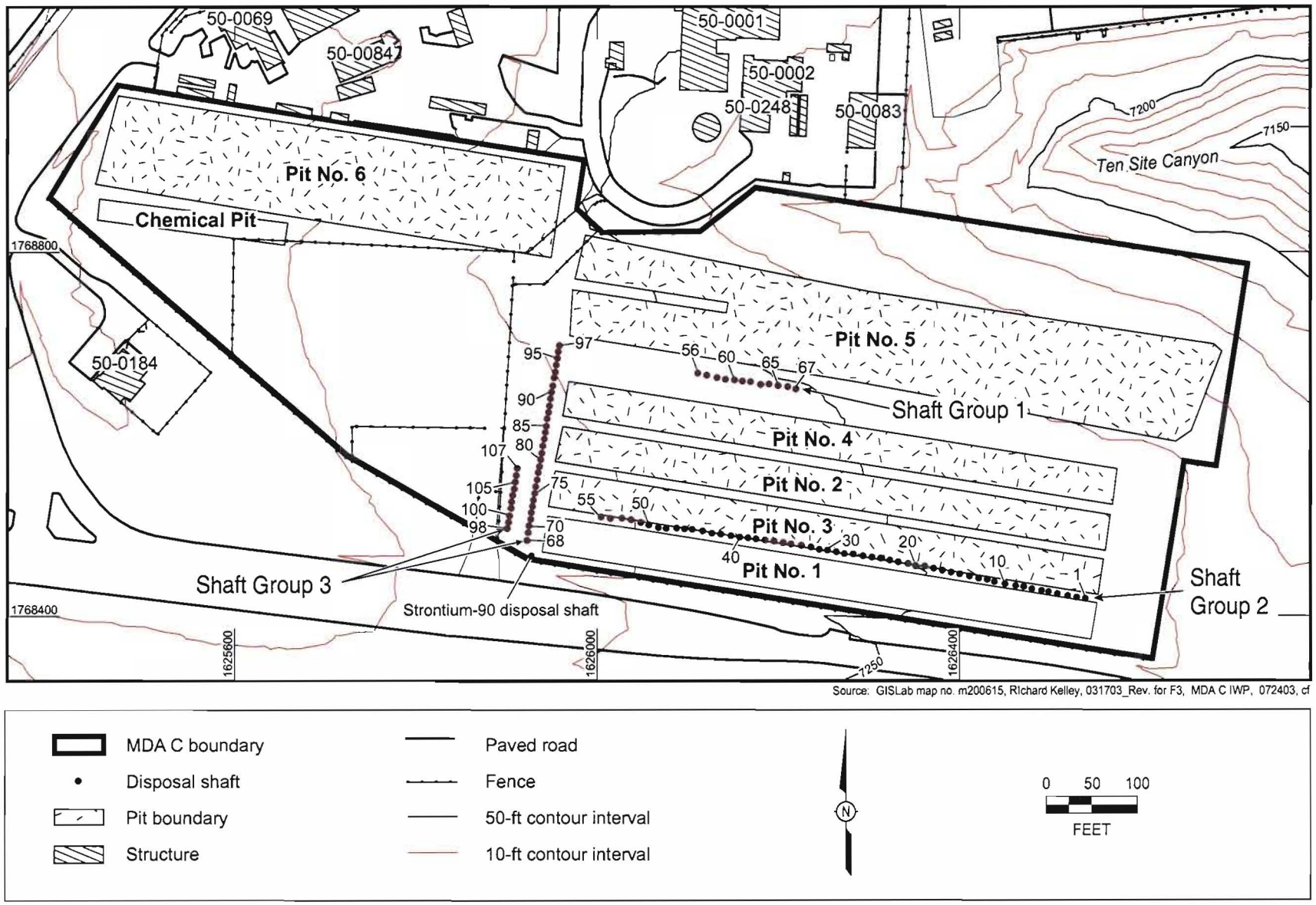
F1.0-1, 50-002d RFI RPT, 060200, PTM_Rev. for F1, MDA C IWP, 072403, cf

Figure 1. Location of MDA C with respect to Laboratory technical areas and surrounding land holdings



Sources: FIMAD G110278 121101 and GISLab m200396, 091102_Rev. for F2, MDA C IWP, 072403, PTM

Figure 2. Regional map of MDA C and locations of wells and boreholes for determining stratigraphy at MDA C



Source: GISLab map no. m200615, Richard Kelley, 031703_Rev. for F3, MDA C IWP, 072403, cf

Figure 3. Locations of pits and shafts at MDA C

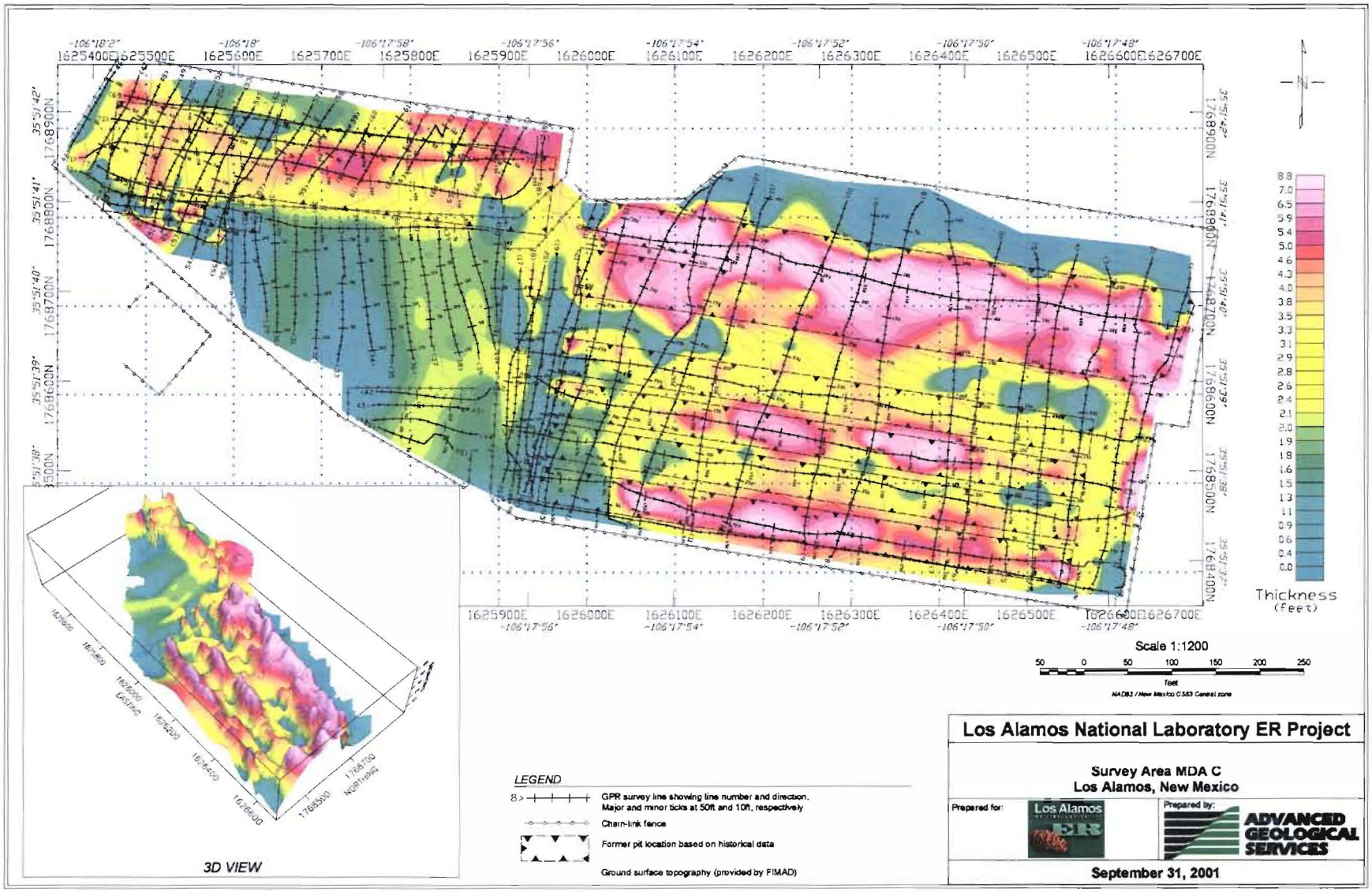
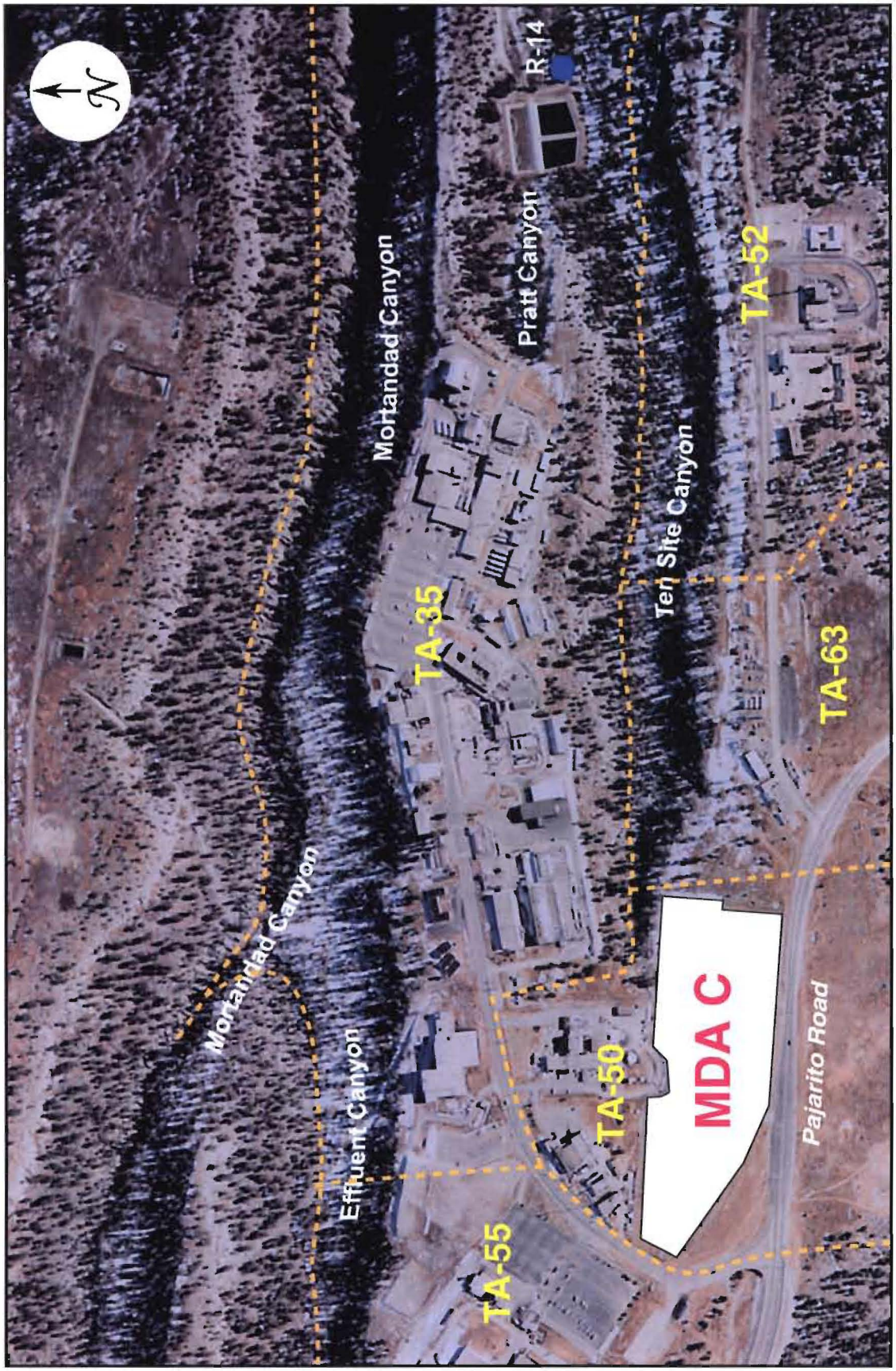
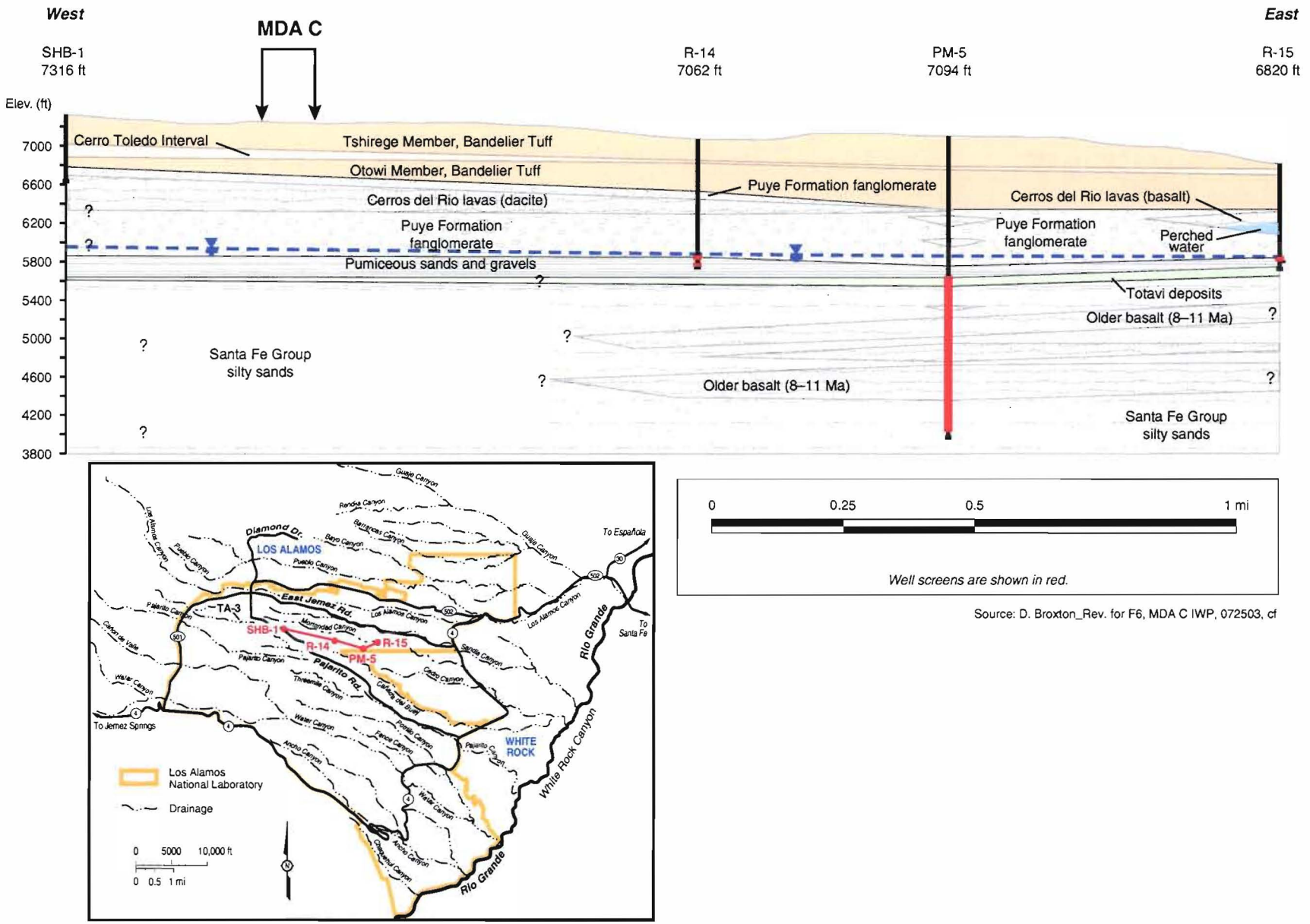


Figure 4. Thickness of fill material at MDA C, estimated by GPR survey



F5, MDA C IWP, 072103, CF

Figure 5. Locations of canyons adjacent to MDA C and regional well R-14



Source: D. Broxton_Rev. for F6, MDA C IWP, 072503, cf

Figure 6. Hydrogeologic cross section through Pajarito Plateau in the vicinity of MDA C along Mortandad Canyon

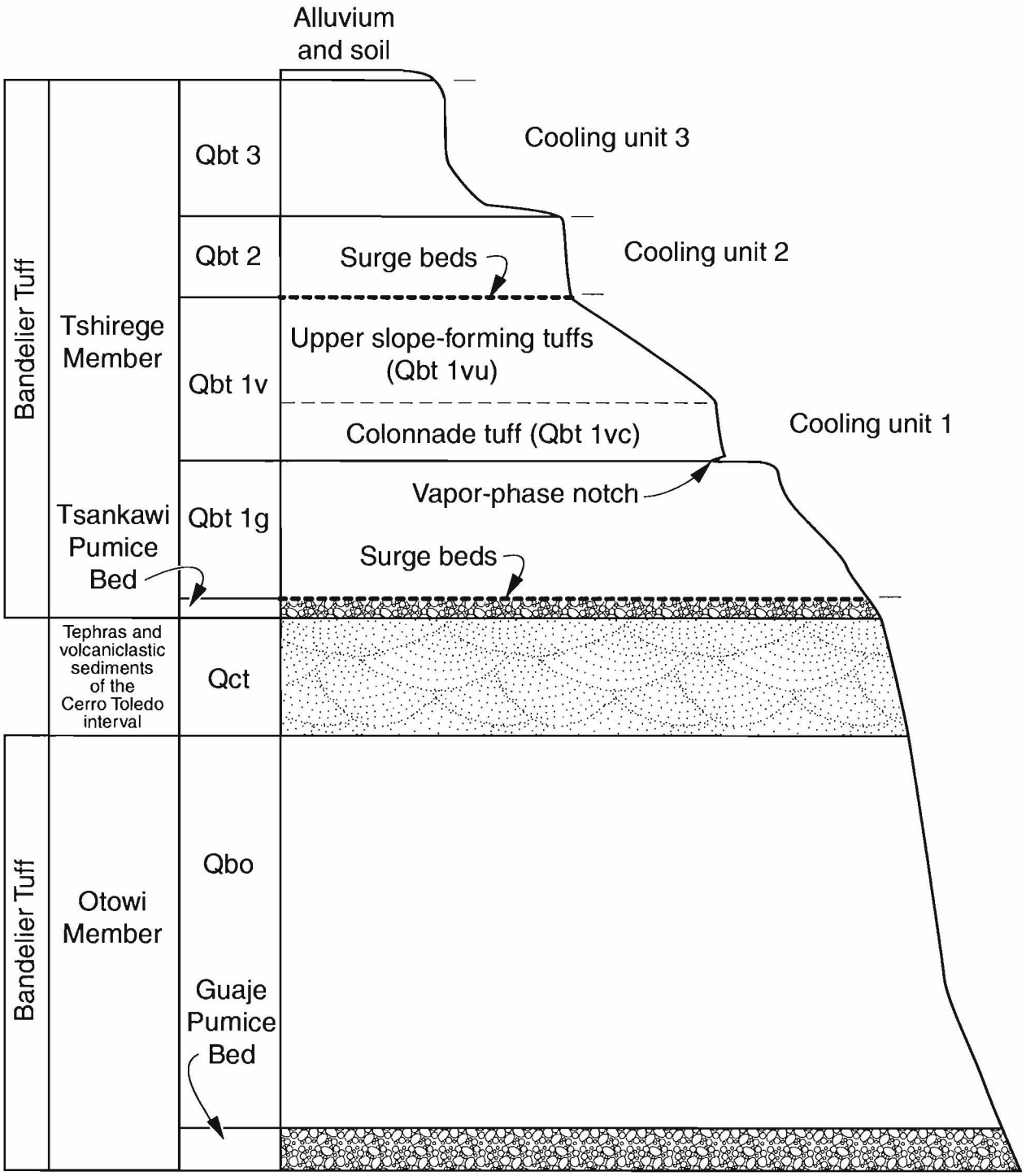


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Figure 7. Generalized stratigraphy of Bandelier Tuff at MDA C

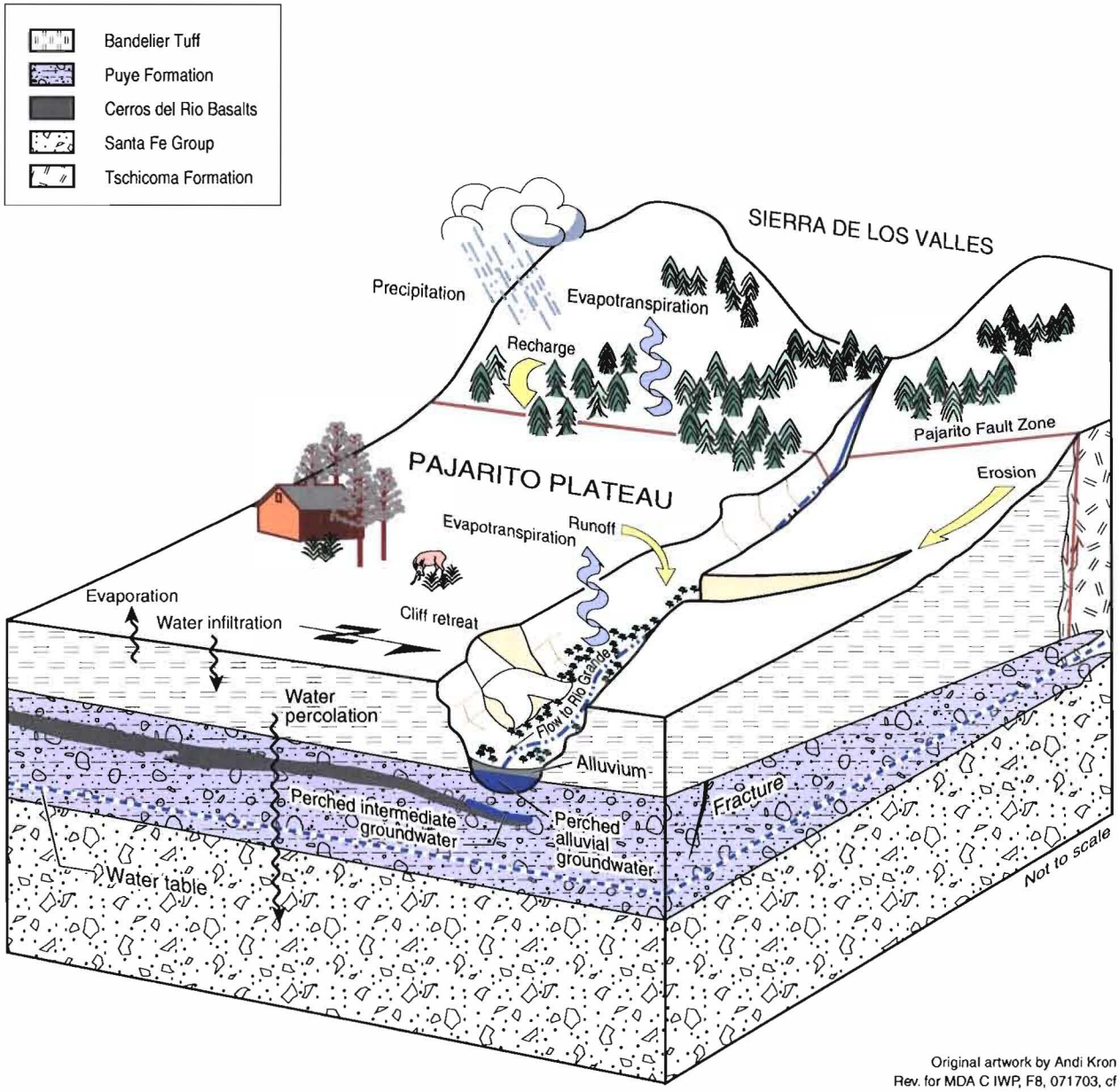
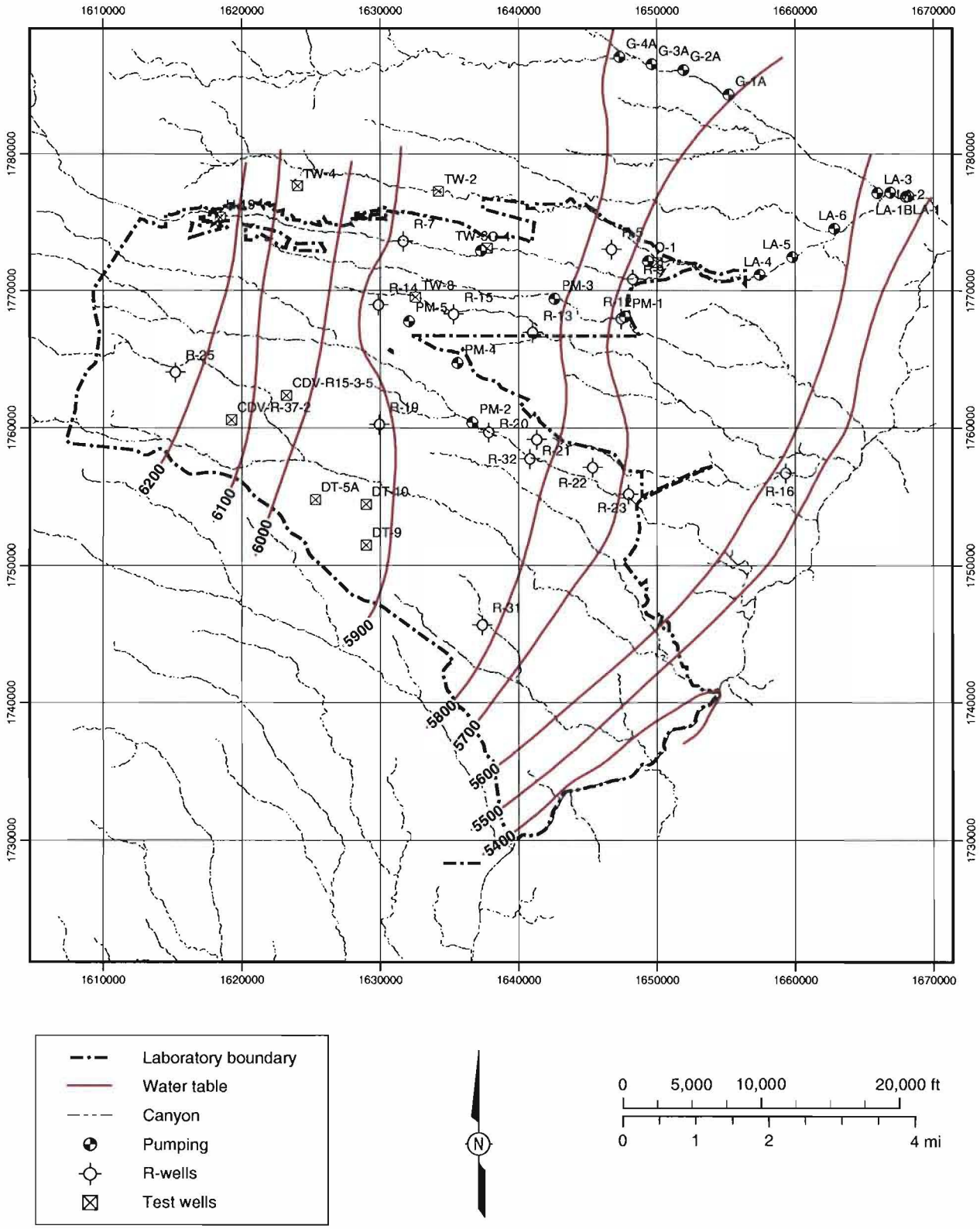
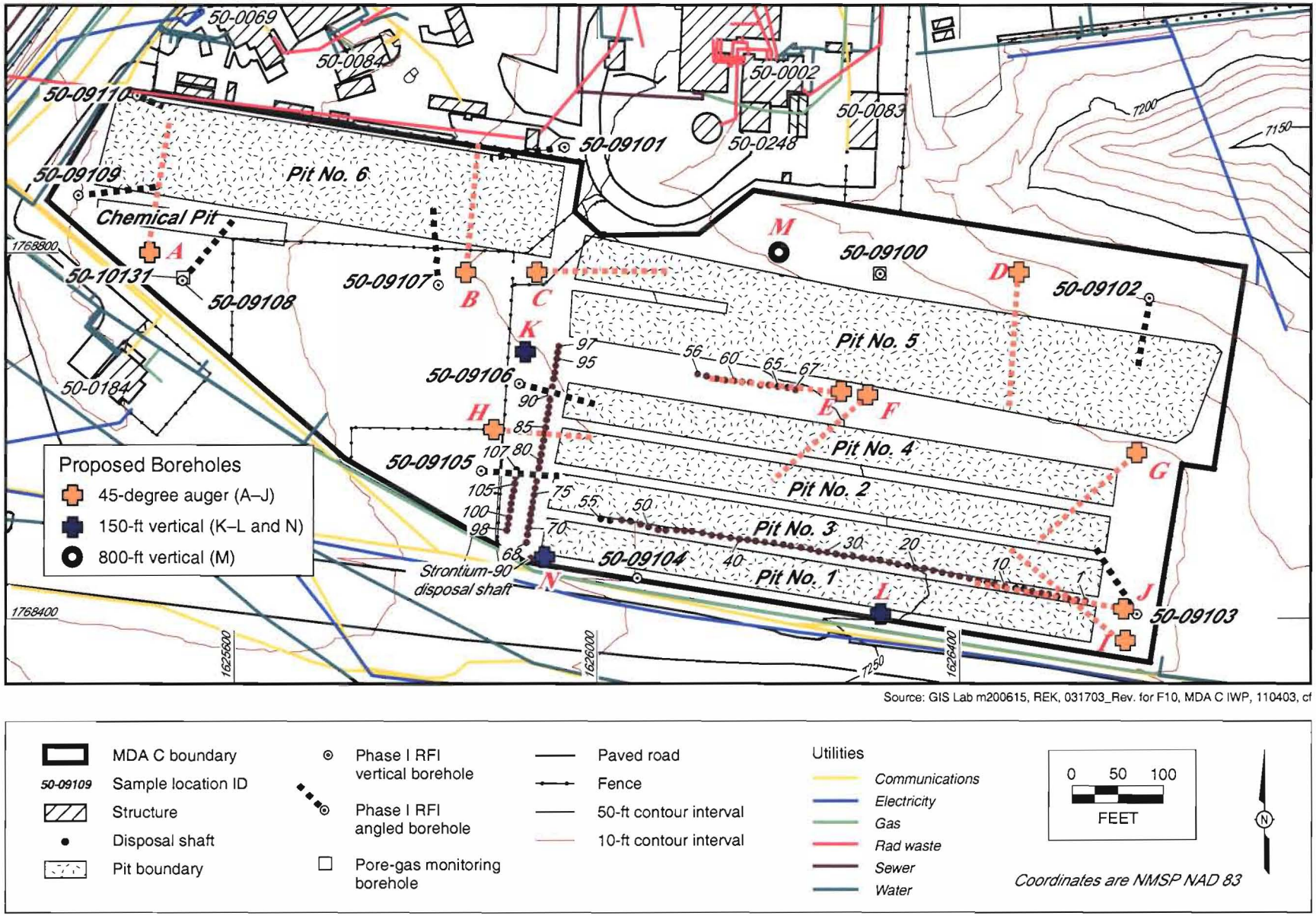


Figure 8. **Schematic of the hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599)**



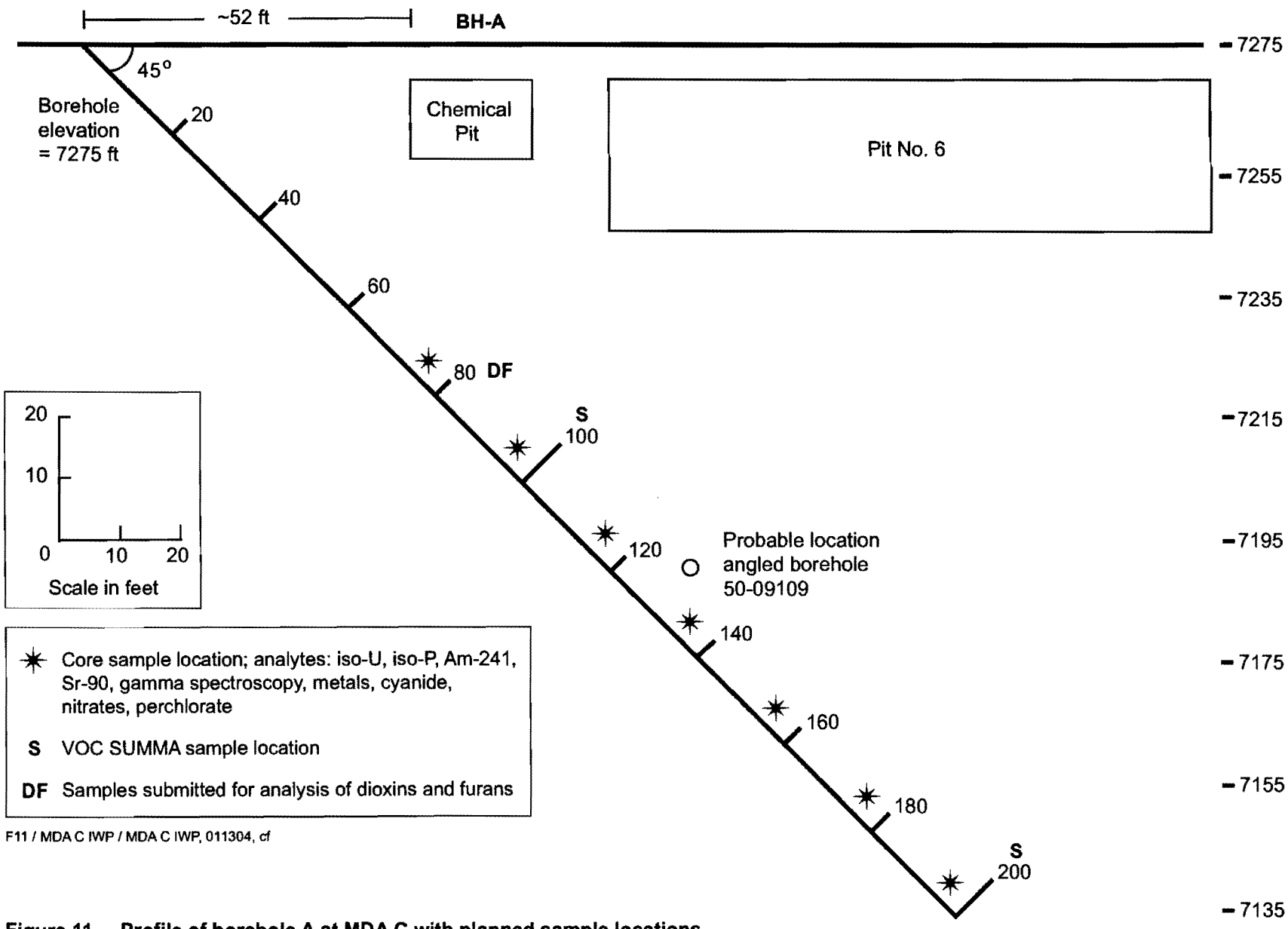
Source: GIS Lab m200714, REK, 061703_Rev. for F9, MDA C IWP, 072403, cf

Figure 9. Water table elevations at the Laboratory



Source: GIS Lab m200615, REK, 031703_Rev. for F10, MDA C IWP, 110403, cf

Figure 10. Proposed boreholes at MDA C



F11 / MDA C IWP / MDA C IWP, 011304, cf

Figure 11. Profile of borehole A at MDA C with planned sample locations

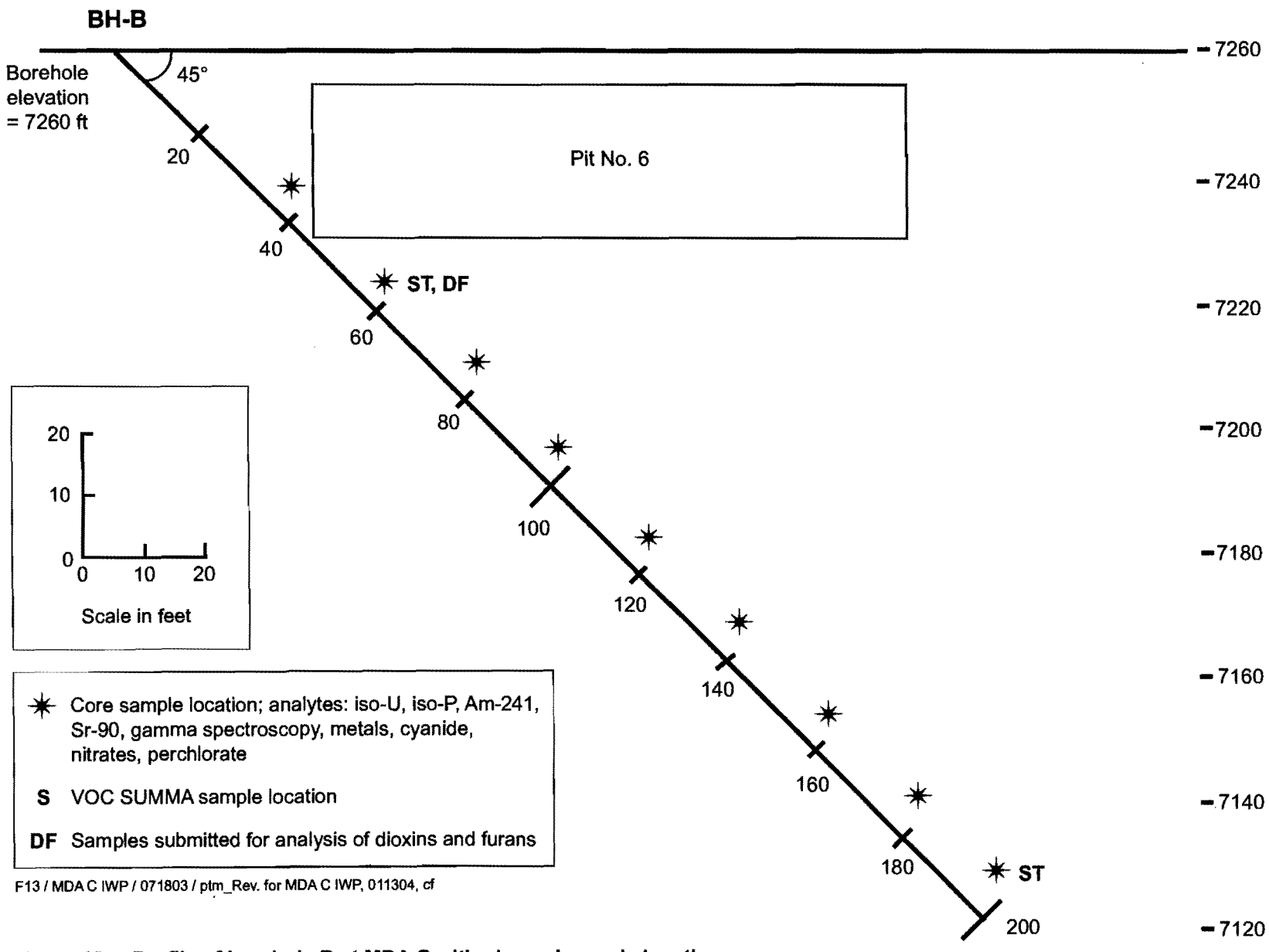


Figure 12. Profile of borehole B at MDA C with planned sample locations

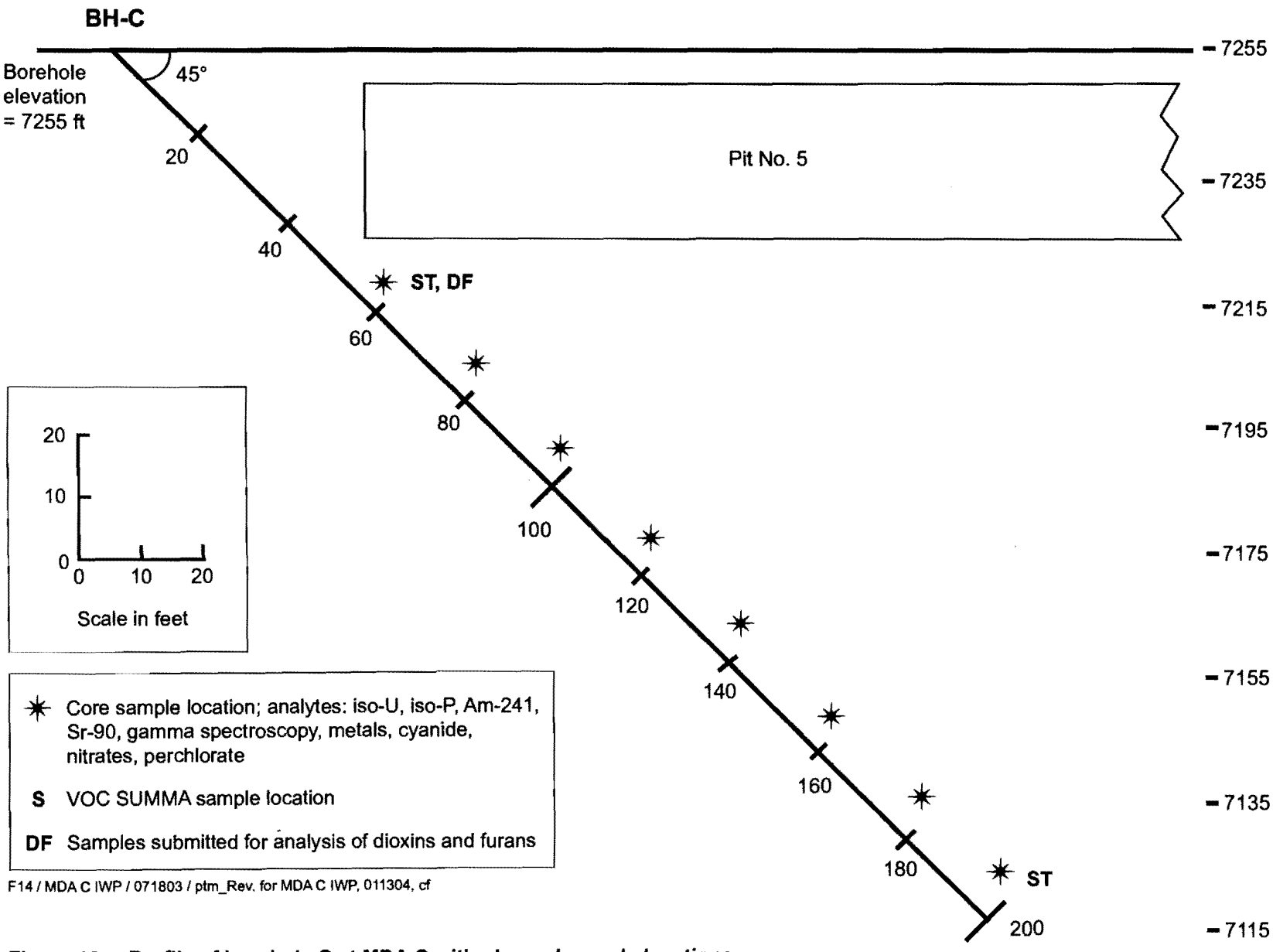


Figure 13. Profile of borehole C at MDA C with planned sample locations

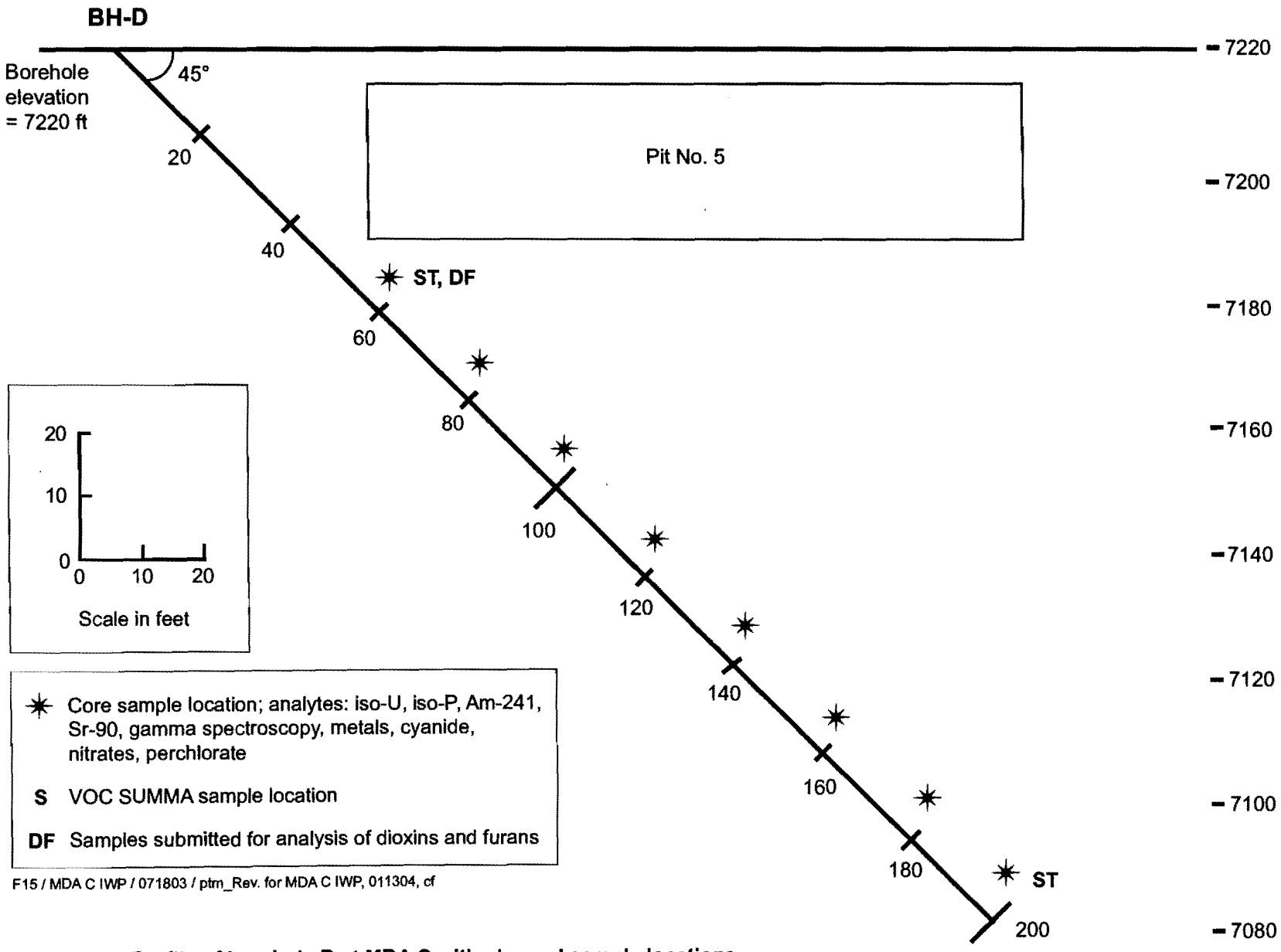


Figure 14. Profile of borehole D at MDA C with planned sample locations

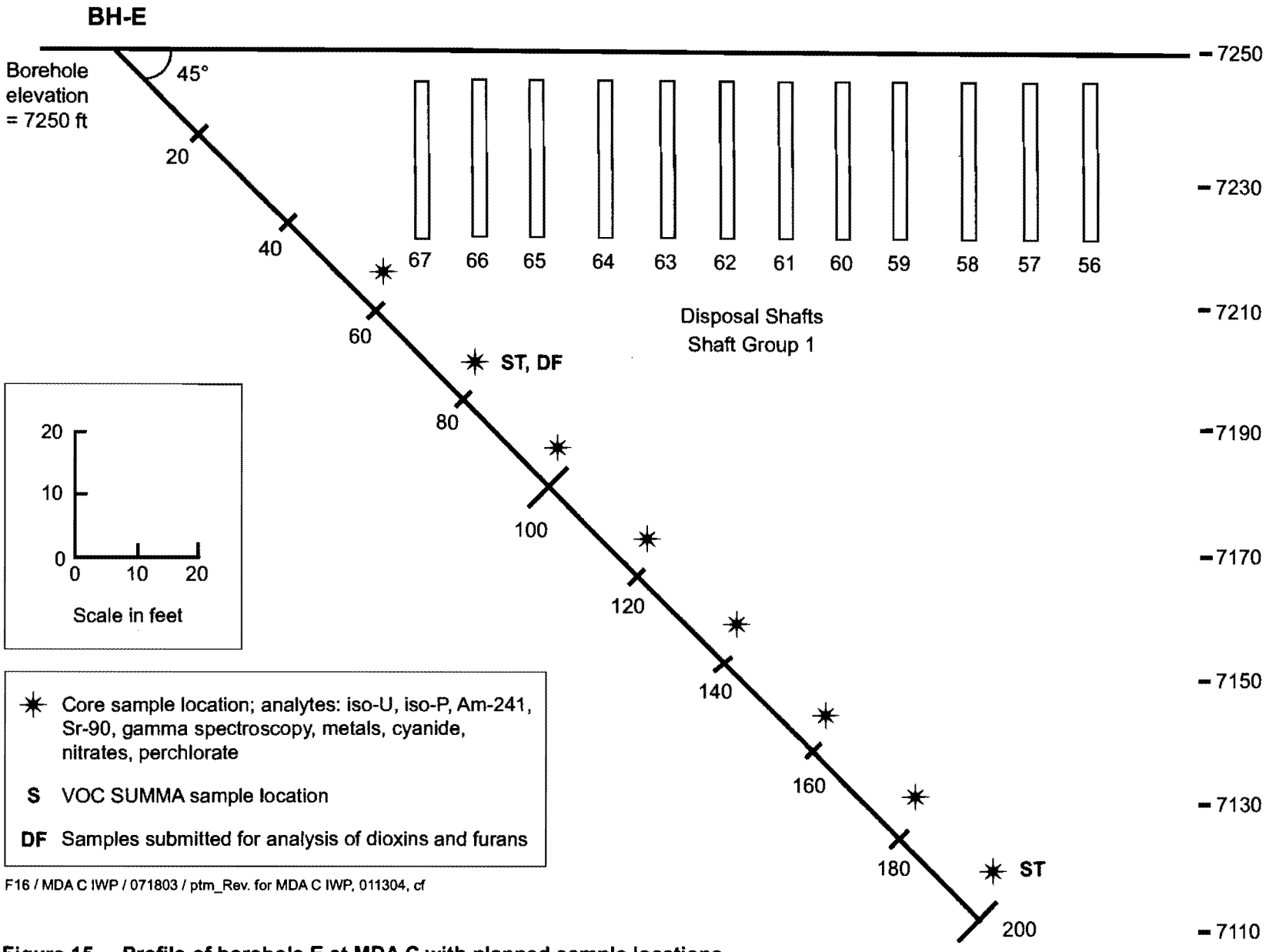


Figure 15. Profile of borehole E at MDA C with planned sample locations

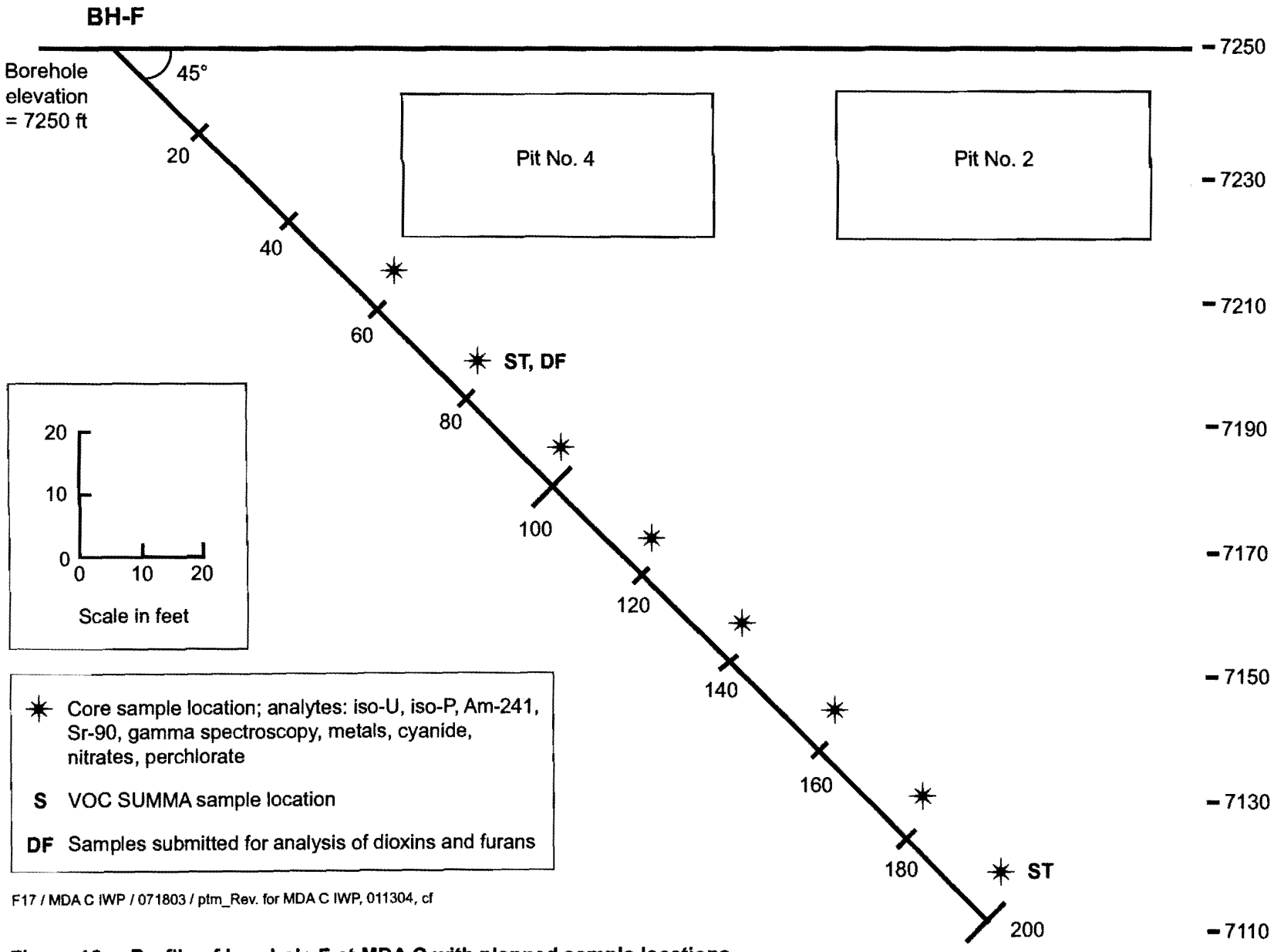


Figure 16. Profile of borehole F at MDA C with planned sample locations

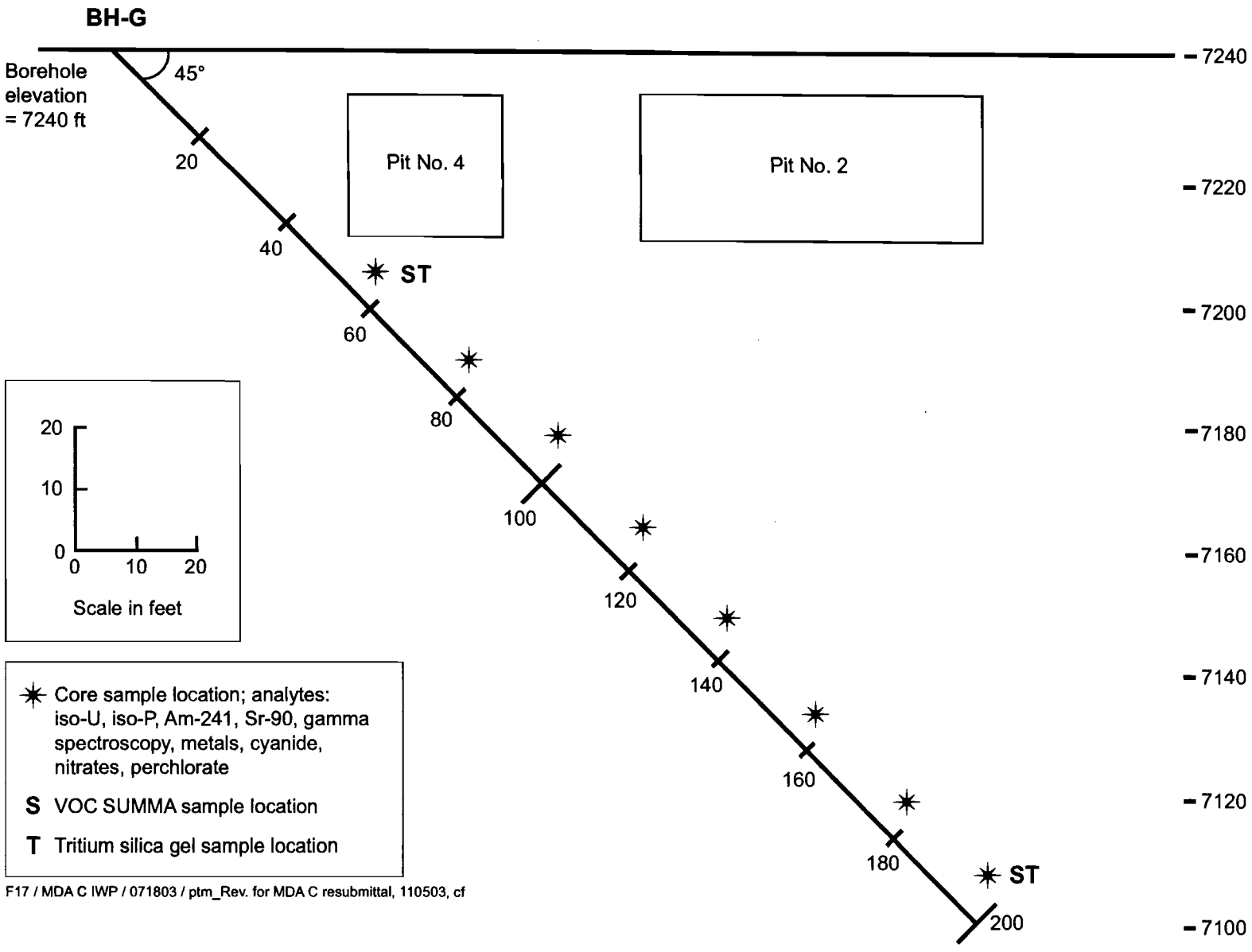


Figure 17. Profile of borehole G at MDA C with planned sample locations

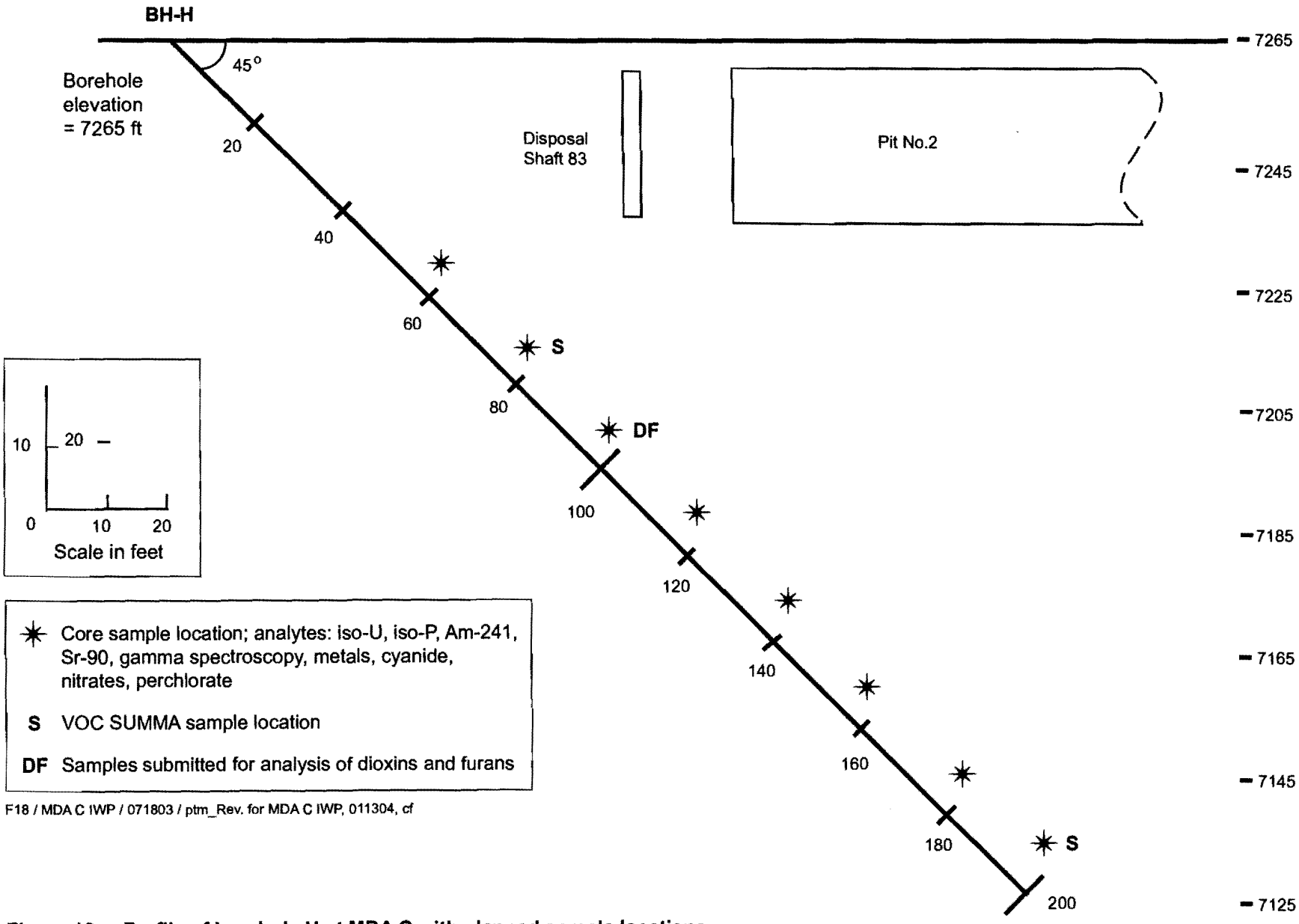


Figure 18. Profile of borehole H at MDA C with planned sample locations

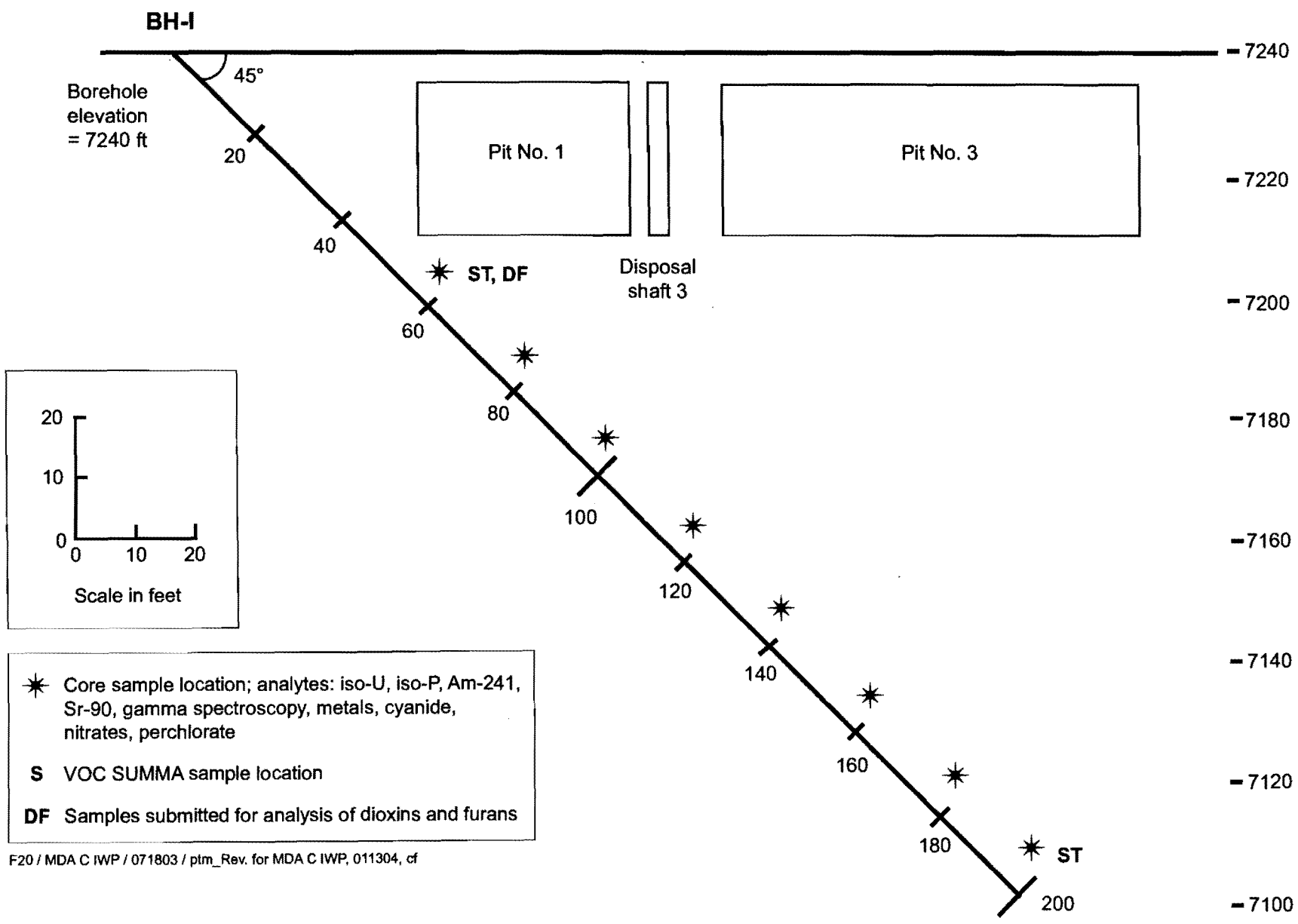


Figure 19. Profile of borehole I at MDA C with planned sample locations

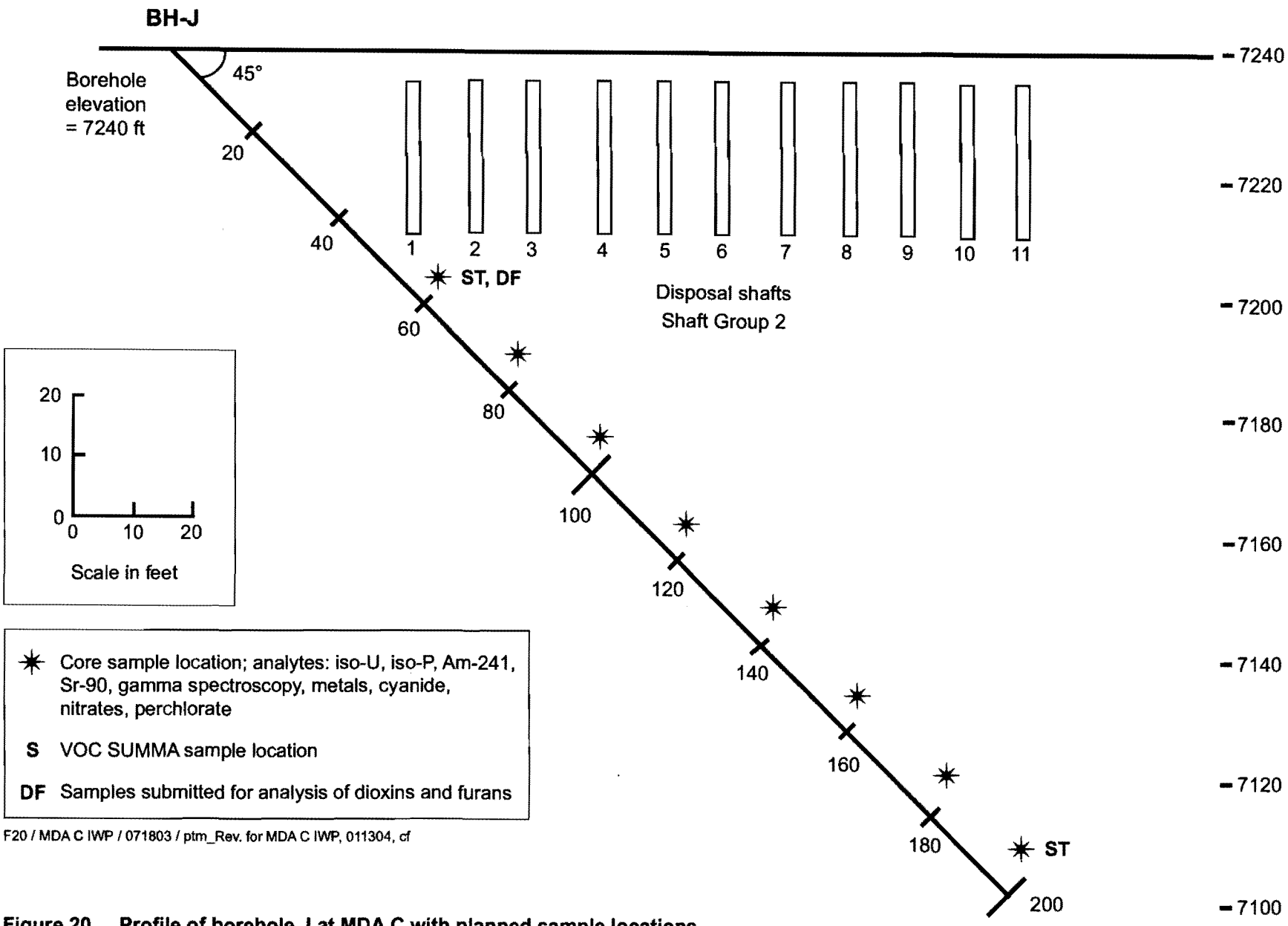


Figure 20. Profile of borehole J at MDA C with planned sample locations

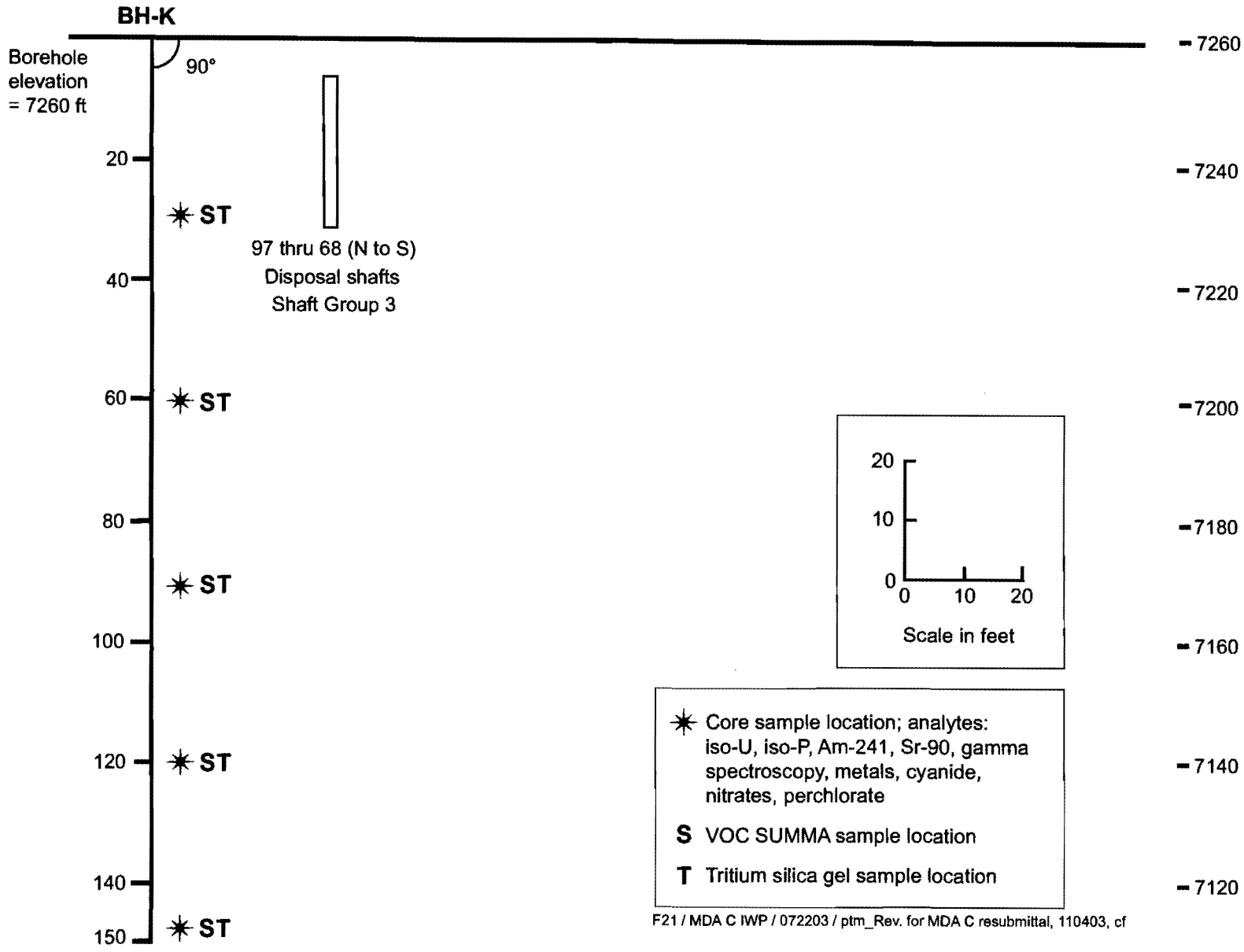


Figure 21. Profile of borehole K at MDA C with planned sample locations

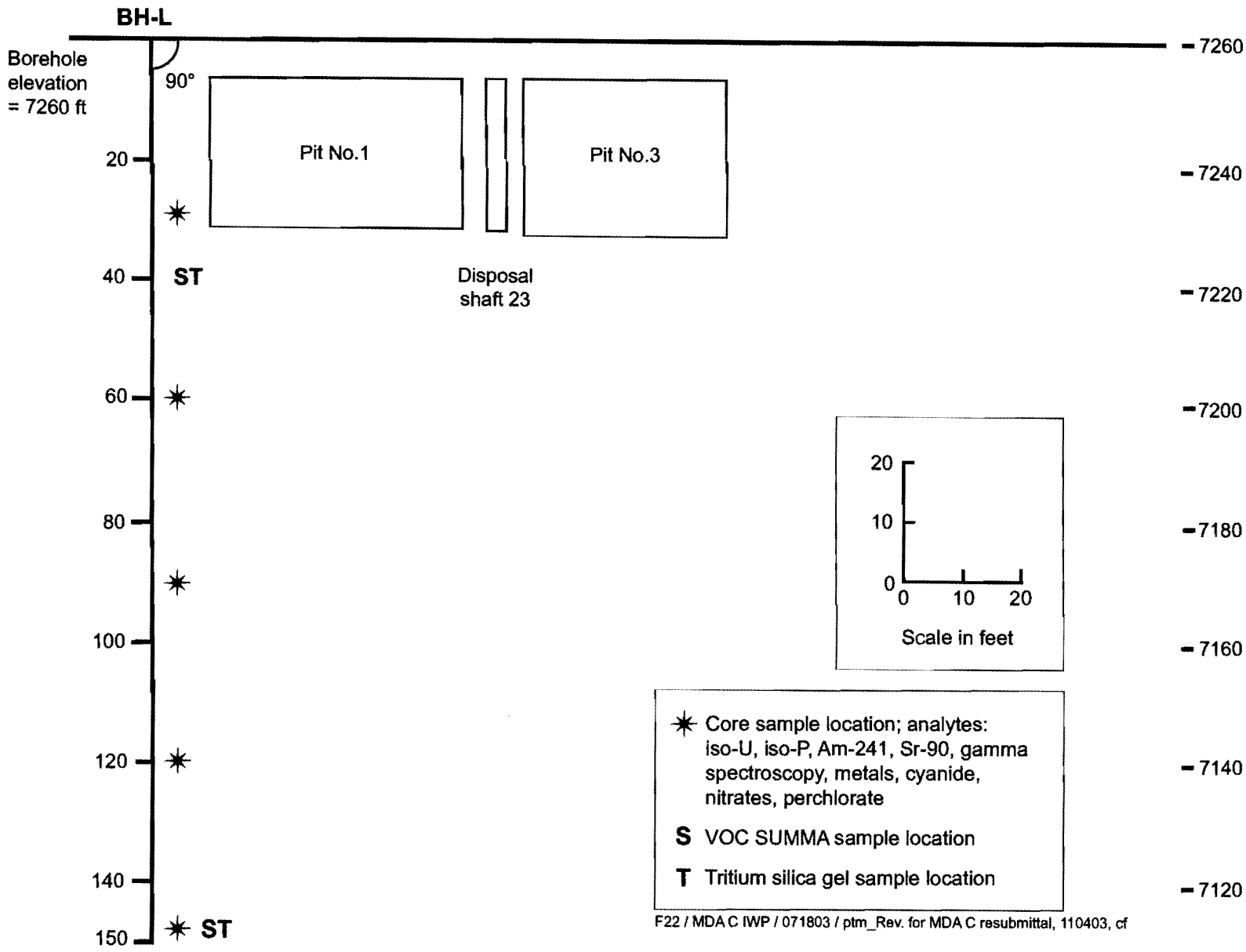


Figure 22. Profile of borehole L at MDA C with planned sample locations

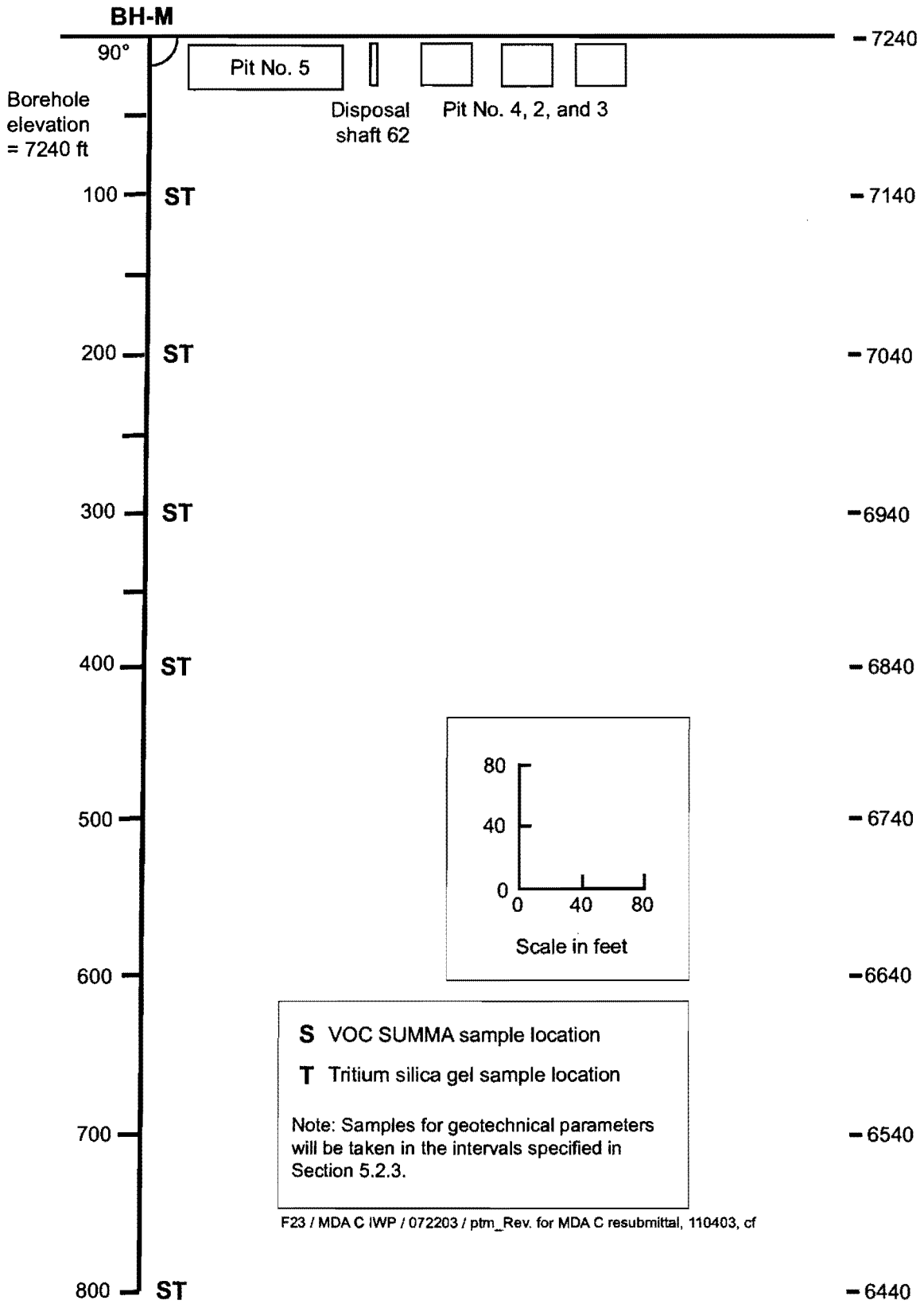


Figure 23. Profile of borehole M at MDA C with planned sample locations

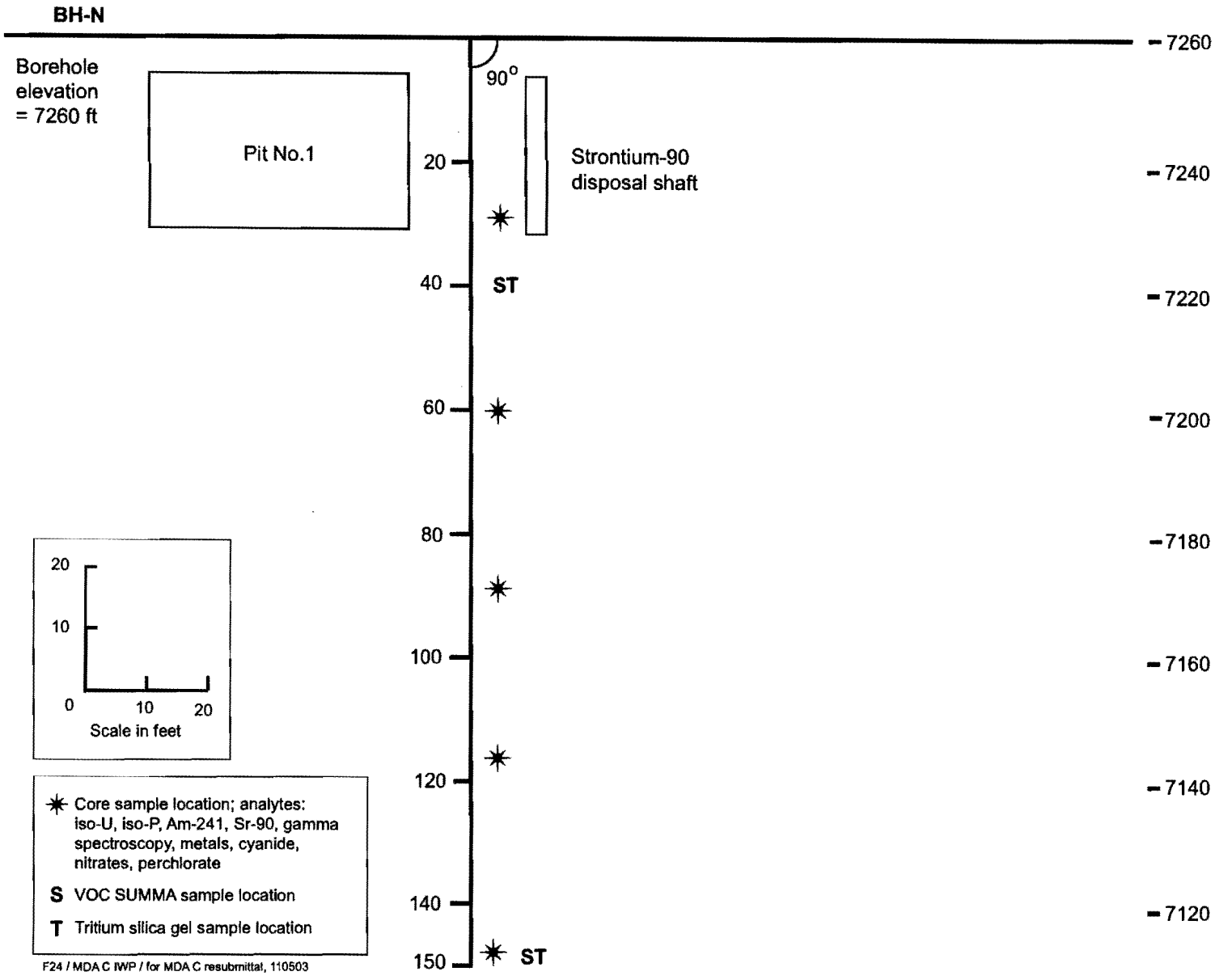


Figure 24. Profile of borehole N at MDA C with planned sample locations

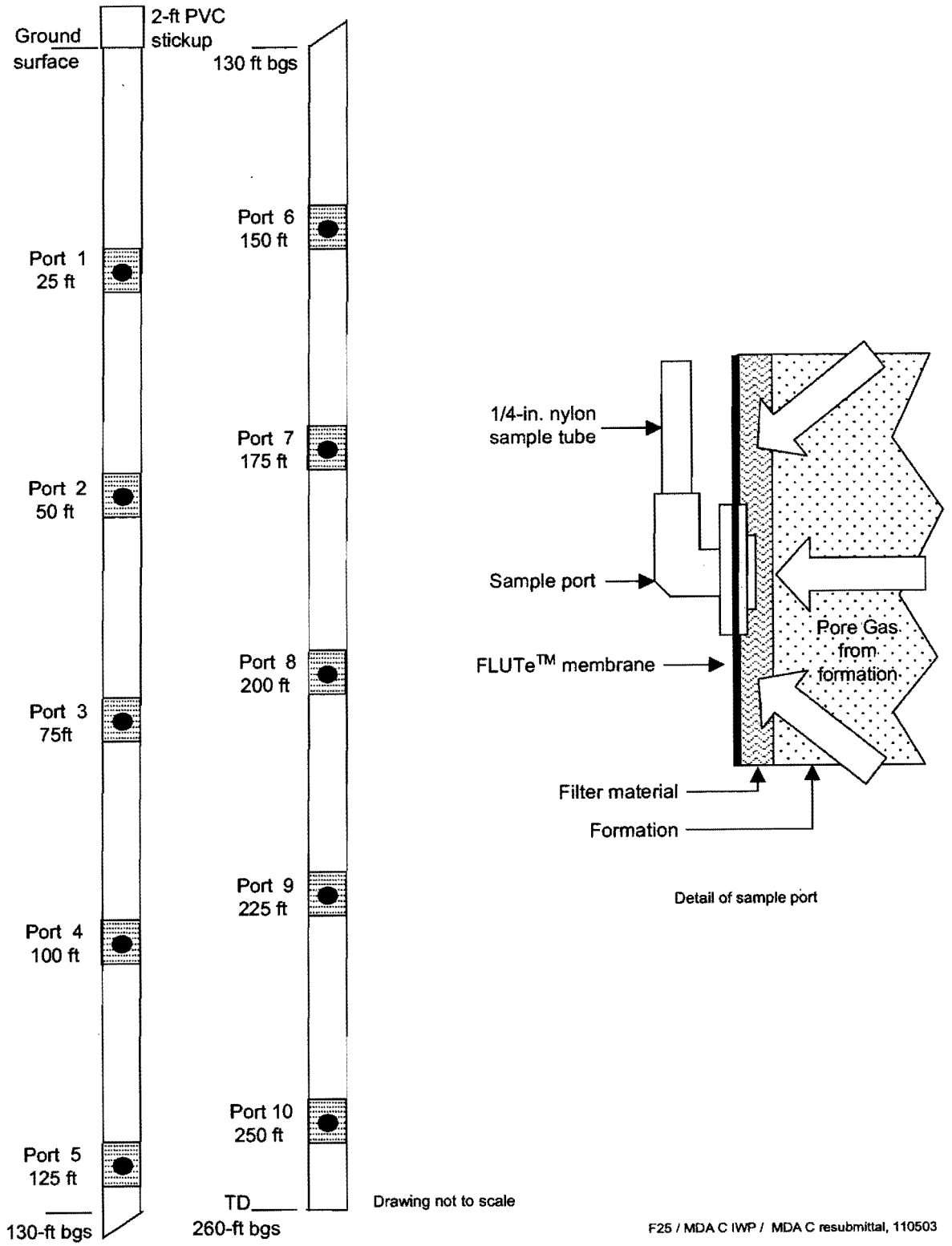


Figure 25. General diagram for construction of a vapor-monitoring borehole

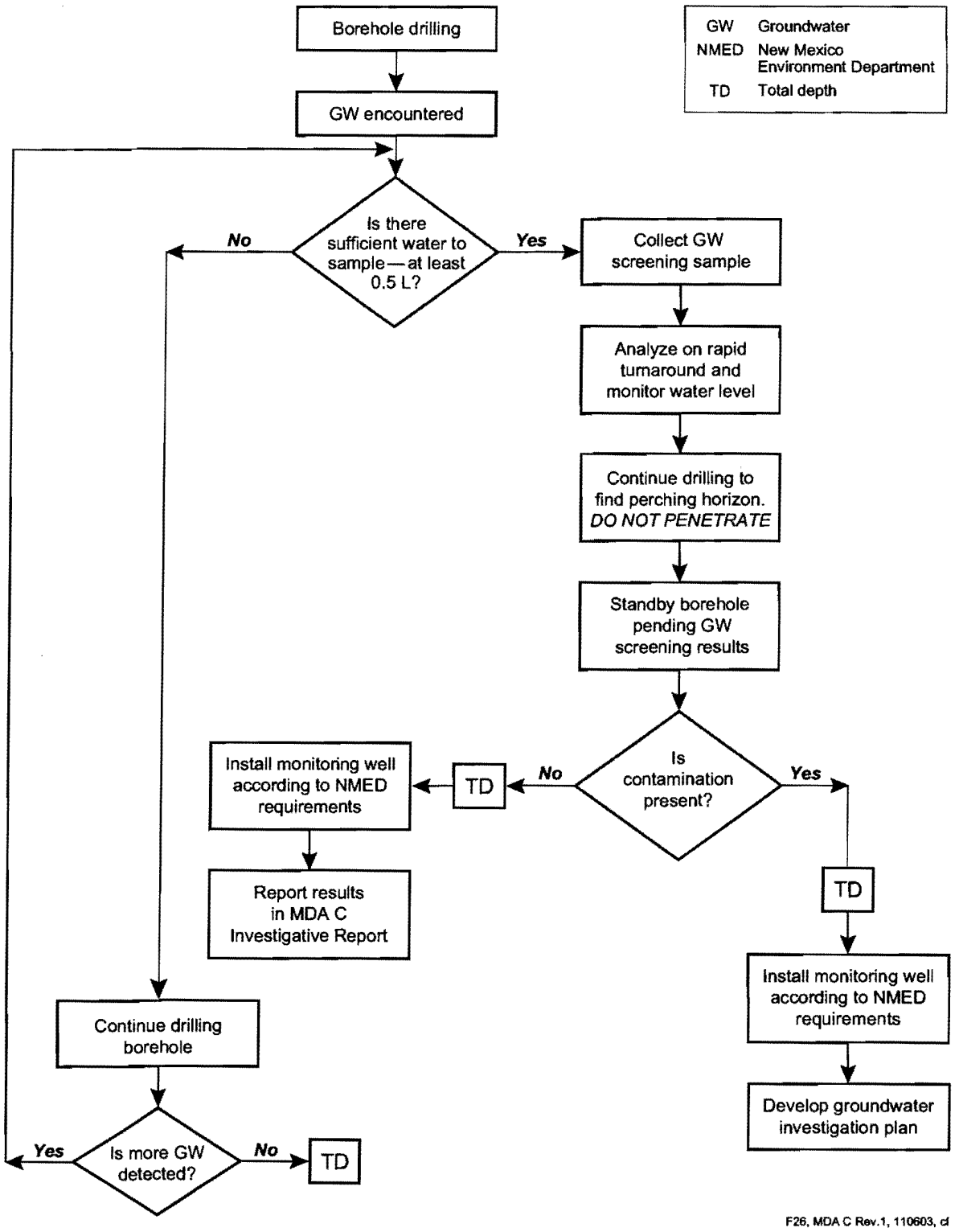


Figure 26. MDA C perched groundwater flowchart

Table 1
Dimensions of the Disposal Units at MDA C

Disposal Unit	Dimensions[a] (ft)	Period of Operations
Pit 1	610 x 40 x 25	1948–1951
Pit 2	610 x 40 x 25	1950–1951
Pit 3	610 x 40 x 25	1951–1953
Pit 4	610 x 40 x 25	1951–1955
Pit 5	705 x 110 x 18	1953–1959
Pit 6	505 x 100 x 25	1956–1959
Chemical Pit	180 x 25 x 12	1960–1964
Shaft Group 1 (12 [Shafts 56–67])	2 x 10	1959
Shaft Group 2 (55 [Shafts 1–55])	2 x 15	1959–1967
Shaft Group 3 (40 [Shafts 68–107])	1–2 x 20–25	1962–1966
Shaft 108 (Strontium-90 Disposal Shaft)	Unknown	1950s or 1960s

[a] As stated in Table 2-11 of the OU 1147 Work Plan, pit dimensions are length by width by depth; shaft dimensions are diameter by depth (LANL 1992, 07672). Dimensions are approximate.

[b] Shafts 98–107 are 1 ft in diameter and lined with 12-in.-thick concrete. Shafts 68–97 are 2 ft in diameter and unlined.

Table 2
Summary of Maximum Depth of Detections for
Inorganic Chemicals and Radionuclides in Phase I RFI Boreholes at MDA C

Inorganic Chemicals				
Borehole	Borehole Depth (ft)	Maximum Sample Depth (ft)	Maximum Depth of Inorganic > BV (ft)	Inorganic Chemicals > BV at Maximum Depth of Inorganic > BV
50-09100	316.0	163.1	43.5	CN @ 0.533 mg/kg
50-09101	82.7	81.0	69.3	Se @ 1.2 x BV
50-09102	77.8	77.8	0.0	None > BV
50-09103	84.9	82.6	43.8	Pb @ 1.4 x BV
50-09104	90.0	87.0	87.0	
50-09105	84.9	84.8	44.6	CN @ 0.26 mg/kg
50-09106	84.9	83.4	83.4	Tl @ 1.1 x BV
50-09107	83.4	78.5	34.3	Se @ 3.7 x BV
50-09108	84.9	81.3	68.9	CN @ 1.0 mg/kg
50-09109	84.9	81.1	47.4	Al @ 1.1 x BV, Ba @ 1.6 x BV, Ca @ 34 x BV, Cr @ 1.8 x BV, Co @ 1.2 x BV, Cu @ 6.6 x BV, Pb @ 1.01 x BV, Mg @ 1.6 x BV, Ni @ 2.0 x BV, Se @ 4.3 x BV, Tl @ 1.3 x BV
50-09110	85.5	84.0	57.1	Pb @ 6.7 x BV
Radionuclides				
Borehole	Borehole Depth (ft)	Maximum Sample Depth (ft)	Maximum Depth of Detected Radionuclide Other Than Tritium (ft)	Detected Radionuclides at Maximum Detected Depth
50-09100	316.0	163.1	43.5	Pu-239 @ 0.014 pCi/g (0.3 x FV)
50-09101	82.7	81.0	81.0	Am-241 @ 0.011 pCi/g (0.8 x FV)
50-09102	77.8	77.8	0.0	None detected
50-09103	84.9	82.6	82.6	Sr-90 @ 0.599 pCi/g (0.5 x FV)
50-09104	90.0	87.0	45.1	U-235 @ 2.6 x BV
50-09105	84.9	84.8	84.8	Pu-239 @ 0.080 pCi/g (1.5 x FV)
50-09106	84.9	83.4	83.4	Sr-90 @ 0.767 pCi/g (0.6 x FV)
50-09107	83.4	78.5	78.5	Am-241 @ 0.032 pCi/g (2.5 x FV)
50-09108	84.9	81.3	68.9	Pu-238 @ 0.014 pCi/g (0.6 x FV)
50-09109	84.9	81.1	81.1	Am-241 @ 0.056 pCi/g (4.3 x FV)
50-09110	85.5	84.0	46.5	U-235 @ 2.3 x BV

Table 3
Summary of Proposed Borehole Sampling

Borehole	Angle	Depth (ft)	Length (ft)	Number of Core Samples	Analytical Suites for Core Samples	Number of Subsurface Vapor Samples	Analytical Suites for Vapor Samples	Rationale for Location
A	45	140	200	9 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath Chemical Pit. Support extent of contamination at western end of Pit 6, especially 50-09109.
B	45	140	200	9 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath eastern end of Pit 6 (downgradient), especially beneath area of subsidence.
C	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath western end of Pit 5.
D	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath east-central area of Pit 5 (downgradient). Evaluate VOC tuff pore gas concentrations beneath area of high EMFLUX® surface flux.
E	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath Shaft Group 2.
F	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath central area of Pits 2 and 4.

Table 3 (continued)

Borehole	Angle	Depth (ft)	Length (ft)	Number of Core Samples	Analytical Suites for Core Samples	Number of Subsurface Vapor Samples	Analytical Suites for Vapor Samples	Rationale for Location
G	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans[a]	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath eastern area of Pits 2 and 4 (downgradient).
H	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath central area of shaft group 3, and beneath western end of Pit 2.
I	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans*	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath eastern area of Pits 1 and 3 (downgradient).
J	45	140	200	8 1	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff. Dioxins, furans[a]	2	SUMMA VOC, tritium vapor on silica gel	Establish nature and extent of contamination beneath eastern end of Shaft Group 1. No access to other portions of Shaft Group 1 because of Shaft Group 3 position and utilities along Pajarito Road.
K	90	150	150	5	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff.	5	SUMMA VOCs, tritium vapor on silica gel	Northern portion of Shaft Group 3 is potential source of near-surface tritiated water vapor measured at 50-03-21467; establish nature and extent of contamination at the north end of Shaft Group 3.
L	90	150	150	5	Iso-U, iso-Pu, Am-241, Sr-90, tritium, gamma spectroscopy, metals, cyanide, nitrates, perchlorate.	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath central area of Pit 1. Angled drilling from near Pajarito Road prohibited by utilities.

Table 3 (continued)

Borehole	Angle	Depth (ft)	Length (ft)	Number of Core Samples	Analytical Suites for Core Samples	Number of Subsurface Vapor Samples	Analytical Suites for Vapor Samples	Rationale for Location
M	90	800	800	—[b]	Geotechnical parameters: • Moisture and matric potential every 5 ft • Chloride analysis every 20 ft • Hydraulic conductivity, porosity, and bulk density—2 in Cerro Toledo interval, 5 in the Otowi Member, and 5 in Puye Formation	5	SUMMA VOCs, tritium vapor on silica gel	Evaluate possible presence of perched water in an area near Ten Site Canyon. Evaluate vertical extent of VOCs and tritium in pore gas near borehole 50-09100. Obtain geotechnical data for modeling vadose-zone transport at MDA C.
N	90	150	150	5	Iso-U, iso-Pu, Am-241, Sr-90, gamma spectroscopy, metals, cyanide, nitrates, perchlorate in tuff.	2	SUMMA VOCs, tritium vapor on silica gel	Establish nature and extent of contamination beneath western end of Pit 1 and beneath Sr-90 disposal shaft.

[a] Samples for analysis of dioxins and furans will be collected from the first sample location beneath a pit or shaft but not at subsequent depths.

[b] — = No core samples will be collected for chemical or radiological analysis.

Table 4
Summary of Proposed Alternatives to NMED Order Specifications and Justifications for Alternative

Item	NMED Order Specification	LANL Proposed Alternative	Justification for Alternative
1	A minimum of one boring shall be advanced at the following locations: 1) directly adjacent to the down-slope end of each pit; 2) at the lowest base elevation point of each disposal pit; 3) at the corners of each disposal pit, at 100-ft intervals along the sides of disposal pits 1 through 6; 4) at 70 ft intervals along the sides of the chemical pit; 5) at the ends of each shaft row; 6) at 50-ft intervals along each shaft row; and 7) adjacent to the location of the strontium-90 disposal shaft. Where practical, boring locations may be combined to address more than one of the requirements listed above. (Order Section IV.C.3.c.iii, Paragraph 1)	10 angled boreholes and 4 vertical boreholes at locations shown in Figure 10 to augment 9 angled and 3 vertical boreholes installed in Phase I RFI.	Proposed and Phase I boreholes are sufficient to meet objectives of investigation and drilling at many locations specified in Order is not possible. See Section 4.2.1 for detailed discussion of proposed boreholes. Borehole coverage at each disposal unit, including a comparison with Order requirements, is presented in Table 5.
2	The borings shall be advanced a minimum of 25 ft below the deepest detected vapor-phase, soil, rock, or groundwater contamination as detected by field screening or previous investigations, whichever is deeper. (Order Section IV.C.3.c.iii, Paragraph 6)	Proposed borehole depths are based on evaluation of Phase I data (Section 2.7.3) and are sufficient to define nature and extent of contamination.	Drilling boreholes as specified in the Order is not necessary to establish nature and extent. See Section 4.2.1 for additional details.
3	Each borehole shall be characterized using geophysical logging techniques approved by the Department. (Order Section IV.C.3.c.iii, Paragraph 7)	Proposed boreholes will not be logged.	Two boreholes installed during Phase I RFI were geophysically logged. Examination and geologic logging of continuous core from proposed boreholes will provide geologic information needed to meet objectives of investigation and geophysical logging is not necessary.
4	Each boring shall be completed as a vapor monitoring well. The screened intervals or sample port locations and methods and materials used to construct each vapor monitoring well shall be based upon information obtained during drilling activities and open-hole vapor sampling field screening results, and shall be approved by the Department prior to well construction. (Order Section IV.C.3.c.iii, Paragraph 9)	Subsurface vapor samples will be collected from each borehole immediately after drilling activities are completed, and approximately one month later. Based on analysis of these results, specific boreholes will be identified for completion as vapor monitoring boreholes.	Design of a vapor monitoring program should be based on evaluation of subsurface vapor data. Completion of all boreholes as vapor monitoring wells is not necessary to implement an effective monitoring program. See Section 4.2.2 for additional details.

Table 4 (continued)

Item	NMED Order Specification	LANL Proposed Alternative	Justification for Alternative
5	At a minimum, two borings shall be advanced at MDA C to evaluate the presence of intermediate perched groundwater and vapor-phase contamination at depth beneath the site. The boring locations, depth of the boring, the drilling and sampling program and the well design shall be approved by the Department prior to the start of drilling activities. (Order Section IV.C.3.c.iii, Paragraph 10)	One 800-ft vertical borehole will be installed to verify absence of perched aquifer. This borehole, and existing Phase I borehole 50-09100, which was installed to a depth of approximately 315 ft, will be used to evaluate vapor phase contamination at depth. All new and existing boreholes will be used to determine the extent of the VOC plume.	Previous investigations on Mesita del Buey have not encounter perched aquifers and none is expected below MDA C (see Section 3.3.2.3.1). Based on the size of MDA C, one 800-ft boring is sufficient to determine that a perched aquifer is not present below MDA C. See Section 4.2.1 for additional details.
6	At a minimum, one TA-50-specific well shall be installed that intersects the regional aquifer at a location approved by the Department. The well shall be located generally east or southeast of MDA C. (Order Section IV.C.3.c.iii, Paragraph 11)	No regional well will be installed as part of the MDA C investigation. Existing regional well R-14 will be used.	Well R-14 was installed downgradient of MDA C (Figure 5) as part of the Hydrogeologic Work Plan for LANL and no additional wells are needed to evaluate potential impacts to the regional aquifer from MDA C.
7	Soil and rock samples shall, at a minimum, be obtained from each boring at ten-ft intervals, from the bedrock directly below the base elevation of each pit or shaft, and from the maximum depth of each boring. (Order Section IV.C.3.c.iv, Paragraph 1)	Continuous core samples will be collected from each borehole.	Collection of continuous core provides better stratigraphic data than collection of samples at discrete intervals.
8	The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order. (Order Section IV.C.3.c.iv, Paragraph 2)	Samples will be screened by visual inspection and radioactivity.	Based on the low levels of contaminants detected during the Phase I RFI, the screening methods specified in Section IX.B (head space VOC analysis, X-ray fluorescence) would not be effective. See Section 4.2.3 for additional details.

Table 4 (continued)

Item	NMED Order Specification	LANL Proposed Alternative	Justification for Alternative
9	A minimum of two samples per 100 ft of drilling depth shall be selected from each boring for laboratory analysis. The samples submitted for laboratory analyses shall be analyzed for VOCs, SVOCs, pH, HE compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The selection of the samples shall include those locations outlined in Paragraphs 5 through 9 below. (Order Section IV.C.3.c.iv, Paragraph 4)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3. Core samples will not be analyzed for VOCs, SVOCs, pH, HE, and PCBs and limited samples will be analyzed for dioxins and furans.	Based on the Phase I RFI data, the nature and extent of subsurface SVOC and PCB contamination has been established (Section 2.7.3). Pore gas monitoring will be used to determine the nature and extent of subsurface VOC contamination in lieu of VOC analysis of core samples because it produces more representative results (Section 2.7.3). Based on results of Phase I RFI screening results for HE and the operational history analysis for HE is not necessary (see Section 4.2.4 for additional details). Samples collected beneath the disposal units will be analyzed for dioxins and furans.
10	The samples displaying the greatest field screening evidence of contamination shall be selected for submittal to the analytical laboratory for analysis of the analytes listed in Paragraph 4 above. (Order Section IV.C.3.c.iv, Paragraph 5)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3. Samples will be field screened for health and safety purposes. Samples showing evidence of contamination based on this field screening will be submitted for laboratory analysis as indicated in Table 3.	As described in Item 8, samples will be screened for radioactivity, but this screening is being performed for health and safety and sample transportation reasons. Based on the results of the Phase I RFI, field screening methods are not sufficiently sensitive to identify samples to be submitted for laboratory analysis. See Section 4.2.3 for additional details. See Item 9 for discussion of analytical suites.
11	If field-screening evidence of contamination is not observed in a boring, the sample obtained from the bedrock directly below the base elevation of each pit or shaft shall be submitted for chemical analysis of the analytes listed in Paragraph 4 above. (Order Section IV.C.3.c.iv, Paragraph 6)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3.	The use of 20-ft sample intervals, combined with the existing Phase I RFI data, will be sufficient to establish nature and extent of contamination. See Item 9 for discussion of analytical suites.
12	The sample obtained from the maximum depth of each boring also shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above. (Order Section IV.C.3.c.iv, Paragraph 7)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3.	See Item 9 for discussion of analytical suites.

Table 4 (continued)

Item	NMED Order Specification	LANL Proposed Alternative	Justification for Alternative
13	The sample obtained from the maximum depth in each boring that displays field screening evidence of contamination shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above. (Order Section IV.C.3.c.iv, Paragraph 8)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3.	See Item 8 for discussion of applicability of field screening for identification of samples for analysis. See Item 9 for discussion of analytical suites.
14	Samples obtained from high permeability units such as surge beds, fracture zones, and pumice beds shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above. (Order Section IV.C.3.c.iv, Paragraph 8)	Samples will be collected at approximate 20-ft intervals for laboratory analysis as indicated in Table 3. This frequency should be sufficient to assure that samples are collected in all geologic units. Fracture zones will be sampled as described in Section 5.	See Item 9 for discussion of analytical suites.
15	An investigation vapor monitoring and sampling work plan shall be prepared in accordance with the format described in Section XI.B of this Order and submitted by the Respondents to the Department for approval. (Order Section IV.C.3.c.v, Paragraph 2)	See response to item 4.	See response to item 4.
16	The Respondents shall construct a minimum of one intermediate depth groundwater monitoring well at MDA C if evidence of perched groundwater is observed during the drilling of the two borings drilled to evaluate for the presence of intermediate perched groundwater or during drilling of the regional groundwater monitoring well. (Order Section IV.C.3.c.vi)	One 800-ft borehole will be advanced to investigate the presence/absence of a perched aquifer. If a perched aquifer is determined to be present, this borehole will be completed as a monitoring well.	See Item 5.
17	The Respondents shall, at a minimum, construct one monitoring well associated with MDA C and TA-50 intersecting the regional aquifer in accordance with Section X of this Order. (Order Section IV.C.3.c.vii)	No regional well will be installed as part of the MDA C investigation. Existing regional well R-14 will be used.	See Item 6.

Table 5
Comparison of Borehole Locations Specified in November 26, 2002 NMED Order and Existing and Proposed Boreholes

Pit/Shaft Field	Borehole Locations Specified in Order	Number of Boreholes to Meet Order Specifications	Phase I RFI and Proposed WP Boreholes	Deviations from Order
Pit 1	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	5 vertical – south side of Pit 1. 4 vertical – each corner of Pit 1. (Length of E and W ends is less than 100 ft. Downslope ends and lowest elevations included with corners. N side included with SG2.)	3 vertical – S side of Pit 1 (boreholes 50-09104 and L) and SW corner (borehole N). 2 angled – SE and NE corners (boreholes I and J, respectively).	2 boreholes vs. 5 on S side based on Phase I RFI results. Angled boreholes vs. vertical boreholes at NE and SE corners to extend sample coverage. No borehole at NW corner due to insufficient drilling space.
SG 2	Each end of shaft row and 50-ft interval along shaft row.	2 vertical – each end of shaft row. 10 vertical – at 50-ft intervals.	1- angled borehole beneath E end of shaft rows extending 200 ft (borehole J).	1 angled borehole at E end vs. 1 vertical borehole at E end and 4 vertical boreholes at 50 ft intervals along E end due to insufficient drilling space for vertical boreholes along shaft row. No vertical borehole at W end or along W and central shaft field due to insufficient drilling space.
Pit 3	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	5 vertical – N side of Pit 3. 2 vertical – NE and NW corners of Pit 3. (Length of E and W ends is less than 100 ft. SE and SW corners included with Pit 1. Downslope ends and lowest elevations included with corners. S side included with SG2.)	3 angled – NW and NE corners and E end (boreholes 50-09105, 50-09103, and I, respectively).	1 angled borehole beneath E end vs. 5 boreholes along N side due to insufficient drilling space along N side and W end. Angled boreholes vs. vertical boreholes at NE and NW corners to increase sample coverage beneath Pit 3.

Table 5 (continued)

Pit/Shaft Field	Borehole Locations Specified in Order	Number of Boreholes to Meet Order Specifications	Phase I RFI and Proposed WP Boreholes	Deviations from Order
Pit 2	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	5 vertical – N side of Pit 2. 2 vertical – NE and NW corners of Pit 2. (Length of E and W ends is less than 100 ft. SE and SW corners included with Pit 3. Downslope ends and lowest elevations included with corners.)	2 angled – N side of Pit 2 (boreholes F and G).	2 angled boreholes vs. 5 vertical boreholes on N side due to insufficient drilling space and to extend sample coverage beneath Pit 2. No vertical borehole at NW corner due to insufficient drilling space. No vertical borehole at NE corner due to angled borehole under east end (G).
Pit 4	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	5 vertical – N side of Pit 4. 2 vertical – NE and NW corners of Pit 4. (Length of E and W ends less than 100 ft. SE and SW corners include with Pit 2. Downslope ends and lowest elevations included with corners.)	3 angled – N side of Pit 4 (borehole F), NE corner (borehole G), and NW corner (borehole 50-09106).	1 angled borehole vs. 5 vertical boreholes on N side based on Phase I RFI results. 1 angled borehole vs. 1 vertical borehole at NE corner to extent sample coverage beneath E ends of Pits 4 and 2. 1 angled borehole vs. 1 vertical borehole at NW corner to extend sample coverage beneath SG3 and W end of Pit 4 and insufficient drilling space adjacent to W end of Pit 4.
SG1	Each end of shaft row and 50-ft intervals along shaft row.	2 vertical – each end of shaft row. 2 vertical – at 50-ft intervals.	1- angled (borehole E)	1 angled borehole under entire length of shaft row vs. 4 vertical boreholes to improve sampling coverage.

Table 5 (continued)

Pit/Shaft Field	Borehole Locations Specified in Order	Number of Boreholes to Meet Order Specifications	Phase I RFI and Proposed WP Boreholes	Deviations from Order
Pit 5	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	6 vertical – N side of Pit 5 1 vertical – E end of Pit 5. 1 vertical – W end of Pit 5. 2 vertical – NE and NW corners of Pit 5 (S side included with SG2 and Pit 4. SE corner included with Pit 4. SW corner included with N end of SG3. Downslope ends and lowest elevations included with corners and ends.)	3 angled – N side of Pit 5 (boreholes D and 50-09102) and west end of Pit 5 (C). 2 vertical – N side of Pit 5 (boreholes M and 50-09100).	2 angled and 2 vertical boreholes vs. 6 vertical boreholes on N side based on Phase I RFI results and to extend sample coverage under Pit 5. No vertical borehole at E end due to angled borehole beneath E end from N side (50-09102). 1 angled borehole vs. 1 vertical borehole beneath W end to extend sample coverage beneath Pit 5. No vertical boreholes at NE and NW corners due to angled boreholes beneath E and W ends of Pit 5.
SG 3	At ends of each shaft row and at 50-ft intervals along each shaft row.	2 vertical – ends of western shaft rows. 1 vertical – Middle of western shaft row. 1 vertical – N end of eastern shaft row. (Eastern shaft row except N end included with west corners of Pits 1-4.)	1 vertical – N end of eastern shaft row (borehole K). 1 angled – Beneath western shaft row (borehole H).	1 angled borehole beneath western shaft row vs. 3 vertical boreholes at ends and middle of western shaft row to increase sample coverage beneath western shaft row, S end of eastern shaft row, SW corner of Pit 1 and Sr-90 Shaft.

Table 5 (continued)

Pit/Shaft Field	Borehole Locations Specified in Order	Number of Boreholes to Meet Order Specifications	Phase I RFI and Proposed WP Boreholes	Deviations from Order
Pit 6	Downslope end, lowest base elevation, corners, and 100-ft interval along sides.	4 vertical – N side of Pit 6 4 vertical – S side of Pit 6 3 vertical – NE, NW, and SW corners of Pit 6 (Length of E and W ends less than 100 ft. SE corner of Pit 6 included with Pit 5. Downslope ends and lowest elevations included with corners.)	6 angled – NE corner (borehole 50-09101), NW corner (borehole 50-09110), SW corner (borehole 50-09109), and S side (boreholes 50-09107, A, and B).	No vertical boreholes on N side vs. angled boreholes at NE and NW corners that extend under N side and two angled boreholes extending under Pit 6 to N side from S. Insufficient drilling space to drill on N side other than at corners. 3 angled boreholes vs. 4 vertical boreholes on S side to extend sampling coverage beneath Pit 6. Angled boreholes vs. vertical boreholes at NE, NW, and SW corners to extend sampling coverage beneath Pit 6.
Chemical Pit	Downslope end, lowest base elevation, corners, and 70-ft interval along sides.	2 vertical – S side of Chemical Pit. 2 vertical – SE and SW corners of Chemical Pit. (Length of E and W ends less than 70 ft. NE and NW corners of Chemical Pit included with Pit 6. Downslope ends and lowest elevations included with corners.)	2 angled – S side boreholes 50-09108 and A). 1 vertical – S side (borehole 50-10131)	2 angled and 1 vertical vs. 2 vertical boreholes on S side to extend sample coverage beneath Chemical Pit. No vertical boreholes at SE and SW corners because of use of angled boreholes beneath Chemical Pit.
Sr-90 Shaft	Adjacent to Sr-90 shaft	None – Sr-90 Shaft included with SW corner of Pit 1 (borehole N).	Addressed with Pit 1 (borehole N).	None.
TOTAL		**75 vertical.**	**19 angled and 7 vertical** **(9 angled and 3 vertical in Phase I RFI, 10 angled and 4 vertical in IWP).**	

Table 6
Summary of Radiological Field Screening Results for Samples Submitted for Laboratory Analysis of Radionuclides

Radiological Field Screening Results	Samples Within Radionuclides Other Than Tritium Within Background Range	Samples With Radionuclides Other Than Tritium Above Background
Alpha (cpm)		
Range	0–3	0–2
Median	1	1
Average	0.8	0.7
Beta/Gamma (cpm)		
Range	120–220	140–210
Median	180	165
Average	177	170

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Figure B-3. Phase I RFI surface sample locations at MDA C—1995

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Table B-11
Inorganic Chemicals Detected Above BV in Phase I RFI Surface Soil and Fill Samples at MDA C

Sample ID	Location ID	Depth (ft)	Media	Lead (mg/kg)	Silver (mg/kg)
Soil Background Value[a]				**22.3**	**1**
NMED SSL[b]				**400**	**380**
AAA3143	50-08102	0.00–0.50	Soil	27	—[c]
AAA3144	50-08154	0.00–0.50	Soil	27	—
AAA3093	50-08244	0.00–0.50	Fill	—	1.1
AAA3096	50-08290	0.00–0.50	Fill	23	—
AAA3193	50-08312	0.00–0.50	Fill	30	—
AAA3098	50-08326	0.00–0.50	Fill	26	—
AAA3099	50-08328	0.00–0.50	Fill	24	—
AAA3119	50-08340	0.00–0.50	Fill	23	—
AAA3145	50-08364	0.00–0.50	Soil	24	—
AAA3146	50-08418	0.00–0.50	Soil	—	6
AAA3151	50-08486	0.00–0.50	Fill	23	—

[a] Soil background value is used for both fill and soil.

[b] NMED soil screening level for residential soils.

[c] — = Not above the BV.

Table B-12
Frequency of Detected Radionuclides
Above BVs/FVs in Phase I RFI Surface Soil and Fill Samples at MDA C

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range[a] (pCi/g)	Background/ Fallout Value[b] (pCi/g)	Frequency of Detects Above Background Value
Americium-241	Soil	16	13	[0.005] to 1.017	0.013	11/16
Americium-241	Fill	52	37	[0.003] to 0.292	0.013	24/52
Cesium-137	Soil	16	1	[0.24] to 1.22	1.65	0/16
Cesium-137	Fill	52	1	[0.269 to 0.915]	1.65	0/52
Cobalt-60	Soil	16	0	[0.165 to 0.814]	na[c]	0/16
Cobalt-60	Fill	52	0	[0.128 to 0.761]	na	0/52
Plutonium-238	Soil	16	12	[0.004 to 0.219]	0.023	6/16
Plutonium-238	Fill	52	20	[0.002] to 0.071	0.023	11/52
Plutonium-239	Soil	16	16	0.01 to 10.687	0.054	15/16
Plutonium-239	Fill	52	46	[0.003] to 2.91	0.054	29/52
Strontium-90	Soil	16	0	[-0.54 to 0.32]	1.31	0/16
Strontium-90	Fill	52	0	[-0.62 to 0.3]	1.31	0/52
Thorium-232	Soil	16	4	[2.09] to 4.01	2.33	4/16
Thorium-232	Fill	52	11	[1.83] to 4.8	2.33	11/52
Uranium-234	Soil	16	16	1.07 to 1.89	2.59	0/16
Uranium-234	Fill	52	52	0.91 to 1.83	2.59	0/52
Uranium-235	Soil	16	0	[0.036 to 0.13]	0.2	0/16
Uranium-235	Fill	52	0	[0.023 to 0.165]	0.2	0/52
Uranium-238	Soil	16	16	1.07 to 1.99	2.29	0/16
Uranium-238	Fill	52	52	1.08 to 2.45	2.29	1/52

[a] Values in square brackets indicate nondetects.

[b] Tuff BVs obtained from LANL 1998, 59730.

[c] na = Not available.

Table B-13
Radionuclides Detected Above the BV/FV in Phase I RFI Surface Soil and Fill Samples at MDA C

Sample ID	Location ID	Depth (ft)	Media	Americium-241	Plutonium-238	Plutonium-239	Thorium-232	Uranium-238
Soil and Fill Background Value[a] (pCi/g)				**0.013**	**0.023**	**0.054**	**2.33**	**2.29**
SAL[b]				**39**	**49**	**44**	**5.0**	**93**
AAA3153	50-08010	0.00–0.50	Fill	—[c]	—	—	3.97	—
AAA2768	50-08086	0.00–0.50	Soil	—	—	10.687	—	—
AAA2769	50-08088	0.00–0.50	Soil	—	0.052	0.441	—	—
AAA3143	50-08102	0.00–0.50	Soil	0.094	—	0.446	—	—
AAA3157	50-08110	0.00–0.50	Fill	—	—	—	3.49	—
AAA2798	50-08134	0.00–0.50	Fill	—	—	—	3.732	—
AAA2770	50-08136	0.00–0.50	Soil	0.048	—	1.427	3.74	—
AAA3243	50-08137	0.00–0.50	Fill	—	—	—	3.32	—
AAA2771	50-08138	0.00–0.50	Soil	1.017	—	0.46	3.27	—
AAA2772	50-08140	0.00–0.50	Soil	0.03	—	0.347	4.01	—
AAA2773	50-08142	0.00–0.50	Soil	0.032	—	0.342	—	—
AAA2774	50-08144	0.00–0.50	Soil	0.036	—	0.276	—	—
AAA3144	50-08154	0.00–0.50	Soil	0.257	0.035	1.5	—	—
AAA2801	50-08194	0.00–0.50	Fill	—	—	—	—	2.45
AAA3191	50-08216	0.00–0.50	Fill	—	—	—	3.46	—
AAA2802	50-08222	0.00–0.50	Fill	—	—	—	3.07	—
AAA2804	50-08226	0.00–0.50	Fill	—	—	—	3.73	—
AAA3093	50-08244	0.00–0.50	Fill	—	—	—	3.34	—
AAA3250	50-08245	0.00–0.50	Fill	—	—	—	—	—
AAA3098	50-08326	0.00–0.50	Fill	—	—	—	4.8	—
AAA2775	50-08346	0.00–0.50	Soil	0.357	0.032	2.082	—	—
AAA3145	50-08364	0.00–0.50	Soil	—	—	0.103	—	—
AAA3121	50-08370	0.00–0.50	Fill	—	—	—	2.96	—
AAA2776	50-08396	0.00–0.50	Soil	0.361	0.033	2.499	—	—
AAA3147	50-08436	0.00–0.50	Fill	—	—	—	3.56	—
AAA2777	50-08446	0.00–0.50	Soil	0.192	0.027	2.13	2.75	—
AAA2778	50-08474	0.00–0.50	Soil	—	—	0.562	—	—
AAA2779	50-08494	0.00–0.50	Soil	0.454	0.068	8.69	—	—

[a] Soil background value is used for both fill and soil (LANL 1998, 59730).

[b] LANL screening action level for residential soil.

[c] — = The concentration was not above the BV.

Table B-14
Frequency of Detected Organic Chemicals in Phase I RFI Surface Soil and Fill Samples at MDA C

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range* (mg/kg)	Frequency of Detects
Acenaphthene	Fill	52	1	[0.00018] to 0.96	1/52
Aroclor-1254	Fill	43	3	[0.03] to 1	3/43
Aroclor-1260	Fill	43	4	[0.03 to 0.15]	4/43
Bis(2-ethylhexyl)phthalate	Fill	52	2	[0.00018] to 1.4	2/52
Pentachlorophenol	Soil	16	1	[0.85] to 1.9	1/16

*Values in square brackets indicate nondetects.

Table B-15
Detected Organic Chemicals Analyses in Phase I RFI Surface Soil and Fill Samples at MDA C

Sample ID	Location ID	Depth (ft)	Media	Acenaphthene	Aroclor-1254	Aroclor-1260	Bis(2-ethylhexyl)phthalate	Pentachlorophenol
NMED SSL[a]				**2800**	**1.1**	**1.1**	**350**	na[b]
EPA SSL[c]				n/a[d]	n/a	n/a	n/a	**3.0**
AAA3153	50-08010	0.00–0.50	Fill	—[e]	—	—	1.4	—
AAA3155	50-08064	0.00–0.50	Fill	—	—	0.04	1.4	—
AAA3156	50-08106	0.00–0.50	Fill	—	—	0.03	—	—
AAA3157	50-08110	0.00–0.50	Fill	—	—	0.07	—	—
AAA3158	50-08116	0.00–0.50	Fill	—	—	0.04	—	—
AAA3193	50-08312	0.00–0.50	Fill	0.96	—	—	—	—
AAA3098	50-08326	0.00–0.50	Fill	—	1	—	—	—
AAA3146	50-08418	0.00–0.50	Soil	—	—	—	—	1.9
AAA3151	50-08486	0.00–0.50	Fill	—	0.07	—	—	—
AAA3152	50-08492	0.00–0.50	Fill	—	0.17	—	—	—

Note: Units are mg/kg.

[a] NMED soil screening level for residential soils.

[b] na = Not available.

[c] EPA Region 6 soil screening level for residential soils.

[d] n/a = Not applicable.

[e] — = The analyte was not detected.

Table B-20 (continued)

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range[a] (mg/kg)	Background Value[b] (mg/kg)	Frequency of Detects Above Background Value	Frequency of Nondetects Above Background Value
Lead	Qbt 3	79	79	0.68 to 75.2	11.2	9/79	0/79
Lead	Qbt 2	2	2	3.8 to 6.4	11.2	0/2	0/2
Lead	Qbt 1v	1	1	5.1	18.4	0/1	0/1
Magnesium	Qbt 3	79	74	60.8 to 2690	1690	1/79	0/79
Magnesium	Qbt 2	2	2	93.1 to 478	1690	0/2	0/2
Magnesium	Qbt 1v	1	1	80.3	780	0/1	0/1
Manganese	Qbt 3	79	79	70 to 272	482	0/79	0/79
Manganese	Qbt 2	2	2	286 to 319	482	0/2	0/2
Manganese	Qbt 1v	1	1	358	408	0/1	0/1
Mercury	Qbt 3	79	0	[0.02 to 0.11]	0.1	0/79	11/79
Mercury	Qbt 2	2	0	[0.05]	0.1	0/2	0/2
Mercury	Qbt 1v	1	0	[0.05]	0.1	0/1	0/1
Nickel	Qbt 3	79	20	[0.2] to 13.2	6.58	1/79	0/79
Nickel	Qbt 2	2	2	0.26 to 2.9	6.58	0/2	0/2
Nickel	Qbt 1v	1	1	0.32	2	0/1	0/1
Potassium	Qbt 3	79	57	[55] to 1000	3500	0/79	0/79
Potassium	Qbt 2	2	1	[93.1] to 410	3500	0/2	0/2
Potassium	Qbt 1v	1	0	[96.9]	6670	0/1	0/1
Selenium	Qbt 3	79	5	[0.11] to 10.5	0.3	4/79	48/79
Selenium	Qbt 2	2	0	[0.44]	0.3	0/2	2/2
Selenium	Qbt 1v	1	0	[0.45]	0.3	0/1	1/1
Silver	Qbt 3	79	2	[0.1 to 2.2]	1	0/79	10/79
Silver	Qbt 2	2	0	[0.1 to 0.11]	1	0/2	0/2
Silver	Qbt 1v	1	0	[0.1 to 1]	1	0/1	0/1
Sodium	Qbt 3	79	68	59.5 to 387	2770	0/79	0/79
Sodium	Qbt 2	2	0	[60.4 to 79]	2770	0/2	0/2
Sodium	Qbt 1v	1	0	[49.8]	6330	0/1	0/1
Thallium	Qbt 3	79	17	[0.1] to 1.4	1.1	3/79	21/79
Thallium	Qbt 2	2	1	[0.48] to 0.49	1.1	0/2	0/2
Thallium	Qbt 1v	1	1	0.69	1.24	0/1	0/1
Vanadium	Qbt 3	79	70	0.42 to 10.5	17	0/79	0/79
Vanadium	Qbt 2	2	2	0.73 to 3.1	17	0/2	0/2
Vanadium	Qbt 1v	1	1	0.49	4.48	0/1	0/1
Zinc	Qbt 3	79	79	12.4 to 54	63.5	0/79	0/79
Zinc	Qbt 2	2	2	29.6 to 50.5	63.5	0/2	0/2
Zinc	Qbt 1v	1	1	28.9	84.6	0/1	0/1

[a] Value in square brackets indicate nondetects.
[b] BVs obtained from LANL 1998, 59730.
[c] na = Not available.

Table B-21
Inorganic Chemicals Detected Above the BV in Phase I RFI Subsurface Tuff Samples at MDA C

Part 1

Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Calcium
Qbt 2,3,4 Background Value[a]				**7340**	**0.5**	**2.79**	**46**	**1.21**	**2200**
Qbt 1v Background Value[a]				**8170**	**6.5**	**1.81**	**26.5**	**1.7**	**3700**
NMED SSL[b]				**74,000**	**30**	**3.9**	**5200**	**150**	**n/a[c]**
0550-95-0083	50-09104	36.60–38.60	Qbt 3	—[d]	—	—	—	1.3	—
0550-96-0105[e]	50-09104	44.10–45.10	Qbt 3	—	—	3.2	—	—	—
0550-96-0106[e]	50-09105	43.91–44.55	Qbt 3	—	—	3	—	—	—
0550-95-0046	50-09106	19.45–21.57	Qbt 3	—	—	**9.8[f]**	—	—	—
0550-95-0067	50-09106	72.12–73.54	Qbt 3	—	0.86 (J)	—	—	—	—
0550-96-0107[e]	50-09107	33.16–34.29	Qbt 3	—	—	2.8	—	—	—
0550-95-0231	50-09109	24.11–25.46	Qbt 3	—	11 (J-)	—	100	—	—
0550-96-0112[e]	50-09109	46.67–47.38	Qbt 3	7900 (J)	—	—	71.6	—	73900
0550-95-0264	50-09110	35.71–37.59	Qbt 3	—	3.1 (J)	—	—	—	—

Part 2

Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Chromium	Cobalt	Copper	Cyanide (Total)	Lead	Magnesium
Qbt 2,3,4 Background Value[a]				**7.14**	**3.14**	**4.66**	**n/a**	**11.2**	**1690**
Qbt 1v Background Value[a]				**2.24**	**1.78**	**3.26**	**n/a**	**18.4**	**780**
NMED SSL[b]				**230[g]**	**4500**	**2800**	**1200**	**400**	**n/a**
0550-95-0368	50-09100	41.50–43.50	Qbt 3	—	—	—	0.533	—	—
0550-95-0284	50-09101	10.61–12.02	Qbt 3	—	—	—	10.2	—	—
0550-95-0289	50-09101	24.5–25.60	Qbt 3	—	—	—	6.2	—	—
0550-95-0294	50-09101	38.89–39.39	Qbt 3	—	—	—	0.92	—	—
0550-96-0104[e]	50-09103	32.88–33.81	Qbt 3	—	—	—	—	16.2 (J-)	—
0550-95-0075	50-09104	10.90–12.90	Qbt 3	—	—	—	0.22 (J-)	—	—
0550-95-0079	50-09104	26.30–28.00	Qbt 3	—	—	—	0.23 (J-)	13.8	—
0550-95-0083	50-09104	36.60–38.60	Qbt 3	—	—	5	—	50.3	—
0550-95-0087	50-09104	58.00–60.00	Qbt 3	—	—	—	0.25 (J-)	—	—
0550-95-0095	50-09104	79.00–81.00	Qbt 3	—	—	—	0.3 (J-)	—	—
0550-95-0099	50-09104	85.00–87.00	Qbt 3	—	—	—	0.26 (J-)	—	—
0550-95-0046	50-09106	19.45–21.57	Qbt 3	—	—	—	—	51.1 (J)	—
0550-95-0195	50-09108	10.61–11.88	Qbt 3	—	—	—	—	65	—
0550-95-0200	50-09108	26.16–27.29	Qbt 3	—	—	—	—	22	—
0550-95-0215	50-09108	67.53–68.94	Qbt 3	—	—	—	1	—	—
0550-95-0231	50-09109	24.11–25.46	Qbt 3	—	—	11	—	41	—
0550-96-0112[e]	50-09109	46.67–47.38	Qbt 3	12.7	3.8 (J)	30.7	—	11.3 (J-)	2690
0550-95-0264	50-09110	35.71–37.59	Qbt 3	—	—	—	3.9	—	—
0550-95-0269	50-09110	55.44–57.13	Qbt 3	—	—	—	—	75.2	—

Table B-21 (continued)

Part 3								
Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Mercury	Nickel	Selenium	Silver	Thallium
Qbt 2,3,4 Background Value[a]				**0.1**	**6.58**	**0.3**	**1**	**1.1**
Qbt 1v Background Value[a]				**0.1**	**2**	**0.3**	**1**	**1.24**
NMED SSL[b]				**6.5**	**1500**	**380**	**380**	**6.1**
0550-95-0362	50-09100	10.60–12.60	Qbt 3	—	—	10.5	—	—
0550-95-0304	50-09101	67.88–69.30	Qbt 3	—	—	0.35	—	—
0550-96-0105[e]	50-09104	44.10–45.10	Qbt 3	—	—	—	—	1.2
0550-95-0071	50-09106	81.67–83.44	Qbt 3	—	—	—	—	1.2 (J)
0550-96-0107[e]	50-09107	33.16–34.29	Qbt 3	—	—	1.1	—	—
0550-96-0112[e]	50-09109	46.67–47.38	Qbt 3	—	13.2	1.3	—	1.4

Note: Units are mg/kg.

[a] Tuff BVs/FVs obtained from LANL 1998, 59730.

[b] NMED soil screening level for residential soil.

[c] n/a = Not applicable.

[d] — = The concentration was not above the BV.

[e] Tuff sample collected from curated core.

[f] Value exceeds screening level.

[g] Soil screening level is for hexavalent chromium.

Table B-22
Frequency of Detected Radionuclides Above BV in Phase I RFI Subsurface Tuff Samples

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range (pCi/g)[a]	Background Value[b] (pCi/g)	Frequency of Detects Above Background Value
Americium-241	Qbt 2	2	0	[0.002 to 0.016]	na[c]	0/2
Americium-241	Qbt 3	79	8	[–0.14] to [0.183]	na	8/79
Americium-241	Qbt 1v	1	0	[0.014]	na	0/1
Cesium-134	Qbt 3	45	2	[–0.026] to 0.32	na	2/45
Cesium-137	Qbt 2	2	0	[–0.029 to 0.002]	na	0/2
Cesium-137	Qbt 3	79	1	[–0.4 to 0.768	na	1/79
Cesium-137	Qbt 1v	1	0	[0.0272]	na	0/1
Cobalt-60	Qbt 2	2	0	[–0.050 to –0.006]	na	0/2
Cobalt-60	Qbt 3	79	1	[–0.037] to 0.32	na	1/79
Cobalt-60	Qbt 1v	1	0	[0.032]	na	0/1
Europium-152	Qbt 2	2	0	[–0.037 to 0.122]	na	0/2
Europium-152	Qbt 3	63	2	[–0.023 to 0.78]	na	2/63
Europium-152	Qbt 1v	1	0	[0.104]	na	0/1

Table B-22 (continued)

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range (pCi/g)[a]	Background Value[b] (pCi/g)	Frequency of Detects Above Background Value
Plutonium-238	Qbt 2	2	0	[0 to 0.02]	na	0/2
Plutonium-238	Qbt 3	79	1	[–0.011] to [0.014]	na	1/79
Plutonium-238	Qbt 1v	1	0	[0]	na	0/1
Plutonium-239	Qbt 2	2	0	[–0.01 to 0.005]	na	0/2
Plutonium-239	Qbt 3	79	2	[–0.005] to 0.08	na	2/79
Plutonium-239	Qbt 1v	1	0	[0]	na	0/1
Ruthenium-106	Qbt 2	2	0	[–0.309 to –0.121]	na	0/2
Ruthenium-106	Qbt 3	79	0	[–0.302 to 1.41]	na	0/79
Ruthenium-106	Qbt 1v	1	0	[0.027]	na	0/1
Sodium-22	Qbt 2	2	0	[–0.004 to 0.005]	na	0/2
Sodium-22	Qbt 3	79	3	[–0.03] to 0.22	na	3/79
Sodium-22	Qbt 1v	1	0	[–0.002]	na	0/1
Strontium-90	Qbt 2	2	0	[0.291 to 0.58]	na	0/2
Strontium-90	Qbt 3	79	4	[–0.52] to 1.44	na	4/79
Strontium-90	Qbt 1v	1	0	[0.55]	na	0/1
Thorium-228	Qbt 2	2	2	1.35 to 1.69	2.52	0/2
Thorium-228	Qbt 3	79	75	[0.083] to 1.81	2.52	0/79
Thorium-228	Qbt 1v	1	1	1.50	3.75	0/1
Thorium-230	Qbt 2	2	2	0.81 to 1.23	1.98	0/2
Thorium-230	Qbt 3	79	50	[0.289 to 1.74]	1.98	0/79
Thorium-230	Qbt 1v	1	1	1.11	3.12	0/1
Thorium-232	Qbt 2	2	2	1.23 to 1.66	2.52	0/2
Thorium-232	Qbt 3	79	77	[0.06] to 1.76	2.52	0/79
Thorium-232	Qbt 1v	1	1	1.50	3.75	0/1
Tritium	Qbt 2	2	1	1.54 to [4.26] (pCi/mL)	na	1/2
Tritium	Qbt 3	64	63	[1.4] to 649261 (pCi/mL)	na	63/64
Tritium	Qbt 1v	1	0	[2.38] (pCi/mL)	na	0/1
Uranium-234	Qbt 2	2	2	0.51 to 1.016	1.98	0/2
Uranium-234	Qbt 3	79	77	0.563 to 1.7	1.98	0/79
Uranium-234	Qbt 1v	1	1	0.993	3.12	0/1
Uranium-235	Qbt 2	2	2	0.02 to 0.05	0.09	0/2
Uranium-235	Qbt 3	79	53	[0.009] to 0.23	0.09	15/79
Uranium-235	Qbt 1v	1	1	0.045	0.14	0/1
Uranium-238	Qbt 2	2	2	0.59 to 1.03	1.93	0/2
Uranium-238	Qbt 3	79	78	0.308 to 2.36	1.93	1/79
Uranium-238	Qbt 1v	1	1	0.991	3.05	0/1

[a] Values in square brackets indicate nondetects.

[b] Tuff BVs obtained from LANL 1998, 59730.

[c] na = Not available.

Table B-23
Detected Radionuclides Above BVs in Phase I RFI Subsurface Samples at MDA C

Part 1

Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Americium-241	Cesium-134	Cesium-137	Cobalt-60	Europium-152	Plutonium-238	Plutonium-239
Qbt 2,3,4 Background/Fallout Value[a]				**n/a[b]**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
SAL[c]				**39**	**na[d]**	**5.3**	**1.2**	**2.7**	**49**	**44**
0550-95-0365	50-09100	26.50–28.50	Qbt 3	0.027	—[e]	—	—	—	—	—
0550-95-0368	50-09100	41.50–43.50	Qbt 3	—	—	—	—	—	—	0.014
0550-95-0284	50-09101	10.61–12.02	Qbt 3	0.018	—	—	—	—	—	—
0550-95-0289	50-09101	24.5–25.60	Qbt 3	0.018	—	—	—	—	—	—
0550-95-0309	50-09101	79.20–80.96	Qbt 3	0.011	—	—	—	—	—	—
0550-95-0104	50-09103	13.08–14.71	Qbt 3	—	—	—	—	0.231	—	—
0550-95-0109	50-09103	25.46–27.44	Qbt 3	0.027	—	—	—	—	—	—
0550-95-0119	50-09103	55.15–56.57	Qbt 3	0.023	—	—	—	0.297	—	—
0550-95-0075	50-09104	10.90–12.90	Qbt 3	—	0.32	—	—	—	—	—
0550-95-0079	50-09104	26.30–28.00	Qbt 3	—	—	—	0.32	—	—	—
0550-95-0135	50-09105	11.38–13.08	Qbt 3	—	—	0.768	—	—	—	—
0550-95-0145	50-09105	40.31–41.72	Qbt 3	0.038	—	—	—	—	—	—
0550-95-0160	50-09105	83.23–84.85	Qbt 3	—	—	—	—	—	—	0.08
0550-95-0166	50-09107	9.90–11.17	Qbt 3	0.012	—	—	—	—	—	—
0550-95-0181	50-09107	53.03–55.58	Qbt 3	0.007	—	—	—	—	—	—
0550-95-0186	50-09107	67.18–68.59	Qbt 3	0.009	—	—	—	—	—	—
0550-95-0191	50-09107	76.37–78.49	Qbt 3	0.032	—	—	—	—	—	—
0550-96-0109[f]	50-09108	17.32–18.03	Qbt 3	—	0.29	—	—	—	—	—
0550-95-0215	50-09108	67.53–68.94	Qbt 3	—	—	—	—	—	0.014	—

Part 2

Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Sodium-22	Strontium-90	Thorium-232	Tritium (pCi/mL)	Uranium-235	Uranium-238
Qbt 2,3,4 Background/Fallout Value[a]				**na**	**n/a**	**2.52**	**n/a**	**0.09**	**1.93**
SAL[c]				**1.5**	**5.7**	**5.0**	**17,000[g]**	**17**	**93**
0550-95-0362	50-09100	10.60–12.60	Qbt 3	—	—	—	12.2	—	—
0550-95-0365	50-09100	26.50–28.50	Qbt 3	—	—	—	622	—	—
0550-96-0100[f]	50-09100	32.70–33.70	Qbt 3	—	—	—	—	0.21	—
0550-95-0368	50-09100	41.50–43.50	Qbt 3	—	—	—	13.4	—	—
0550-95-0371	50-09100	58.20–60.00	Qbt 3	—	—	—	27.9	—	—
0550-95-0374	50-09100	71.50–73.50	Qbt 2	—	—	—	1.54	—	—
0550-95-0284	50-09101	10.61–12.02	Qbt 3	—	—	—	2.86	—	—
0550-96-0101[f]	50-09101	18.99–19.69	Qbt 3	—	—	—	—	0.22	—
0550-95-0289	50-09101	24.75–25.60	Qbt 3	—	—	—	7.33	—	-
0550-96-0102[f]	50-09101	31.11–31.89	Qbt 3	—	—	—	—	0.22	-
0550-95-0294	50-09101	38.89–39.39	Qbt 3	—	—	—	7.77	—	—

Table B-23 (continued)

Part 2 (continued)									
Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Sodium-22	Strontium-90	Thorium-232	Tritium (pCi/mL)	Uranium-235	Uranium-238
Qbt 2,3,4 Background/Fallout Value[a]				**na**	**n/a**	**2.52**	**n/a**	**0.09**	**1.93**
SAL[c]				**1.5**	**5.7**	**5.0**	**17,000[g]**	**17**	**93**
0550-96-0103	50-09101	44.19–44.69	Qbt 3	—	—	—	—	0.22	—
0550-95-0299	50-09101	53.03–54.45	Qbt 3	—	—	—	7.5	—	—
0550-95-0304	50-09101	67.88–69.30	Qbt 3	—	—	—	5.63	—	—
0550-95-0309	50-09101	79.20–80.96	Qbt 3	—	—	—	47.5	—	—
0550-95-0004	50-09102	11.31–13.44	Qbt 3	—	—	—	1.84	—	—
0550-95-0009	50-09102	26.16–28.92	Qbt 3	—	—	—	10.4	—	—
0550-95-0014	50-09102	40.31–42.43	Qbt 3	—	—	—	**23300[h]**	—	—
0550-95-0019	50-09102	51.76–53.74	Qbt 3	—	—	—	6720	—	—
0550-95-0024	50-09102	67.18–68.59	Qbt 3	—	—	—	274	—	—
0550-95-0029	50-09102	76.37–77.78	Qbt 3	—	—	—	376	—	—
0550-95-0104	50-09103	13.08–14.71	Qbt 3	—	—	—	35.8	—	—
0550-95-0109	50-09103	25.46–27.44	Qbt 3	—	—	—	7.14	—	—
0550-96-0104[f]	50-09103	32.88–33.81	Qbt 3	—	—	—	—	0.21	—
0550-95-0114	50-09103	39.60–41.58	Qbt 3	—	—	—	12.7	—	—
0550-95-0119	50-09103	55.15–56.57	Qbt 3	—	—	—	6.32	—	—
0550-95-0124	50-09103	66.96–69.30	Qbt 3	—	—	—	14.4	—	—
0550-95-0129	50-09103	81.18–82.59	Qbt 3	—	0.599	—	2.17	—	—
0550-95-0075	50-09104	10.90–12.90	Qbt 3	0.22	—	—	3.47	—	—
0550-95-0079	50-09104	26.30–28.00	Qbt 3	—	—	—	290.7	—	—
0550-95-0083	50-09104	36.60–38.60	Qbt 3	0.22	—	—	378.2	—	—
0550-96-0105[f]	50-09104	44.10–45.10	Qbt 3	—	—	—	—	0.23	—
0550-95-0087	50-09104	58.00–60.00	Qbt 3	—	—	—	43.15	—	—
0550-95-0095	50-09104	79.00–81.00	Qbt 3	—	—	—	3.26	—	—
0550-95-0099	50-09104	85.00–87.00	Qbt 3	—	—	—	1.9	—	—
0550-95-0135	50-09105	11.38–13.08	Qbt 3	—	—	—	3.84	—	—
0550-95-0140	50-09105	24.75–26.87	Qbt 3	—	—	—	1.5	—	—
0550-95-0145	50-09105	40.31–41.72	Qbt 3	—	—	—	481	—	—
0550-96-0106[f]	50-09105	43.91–44.55	Qbt 3	—	—	—	—	0.21	—
0550-95-0150	50-09105	54.45–56.36	Qbt 3	—	—	—	6.1	—	—
0550-95-0155	50-09105	68.59–70.57	Qbt 3	—	—	—	3.22	—	—
0550-95-0046	50-09106	19.45–21.57	Qbt 3	—	—	—	126	—	—
0550-95-0050	50-09106	28.99–31.11	Qbt 3	—	—	—	**38100**	—	—
0550-95-0054	50-09106	39.95–41.37	Qbt 3	—	—	—	6440	—	—
0550-95-0058	50-09106	49.85–51.62	Qbt 3	—	—	—	28	—	—
0550-95-0063	50-09106	60.81–62.58	Qbt 3	—	—	—	14.8	—	—
0550-95-0067	50-09106	72.12–73.54	Qbt 3	—	—	—	64.9	—	—
0550-95-0071	50-09106	81.67–83.44	Qbt 3	—	0.767	—	30.1	—	—
0550-95-0166	50-09107	9.90–11.17	Qbt 3	—	—	—	12.1	—	—
0550-95-0171	50-09107	25.46–27.58	Qbt 3	—	—	—	10373	—	—

Table B-23 (continued)

Part 2 (continued)									
Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Sodium-22	Strontium-90	Thorium-232	Tritium (pCi/mL)	Uranium-235	Uranium-238
Qbt 2,3,4 Background/Fallout Value[a]				**na**	**n/a**	**2.52**	**n/a**	**0.09**	**1.93**
SAL[c]				**1.5**	**5.7**	**5.0**	**17,000[g]**	**17**	**93**
0550-96-0107[f]	50-09107	33.16–34.29	Qbt 3	—	—	—	—	0.2	—
0550-95-0176	50-09107	40.31–41.72	Qbt 3	—	—	—	**649261**	—	—
0550-96-0108[f]	50-09107	66.20–67.00	Qbt 3	—	—	—	—	0.23	—
0550-95-0181	50-09107	53.03–55.58	Qbt 3	—	—	—	**207792**	—	—
0550-95-0186	50-09107	67.18–68.59	Qbt 3	—	—	—	13827	—	—
0550-95-0191	50-09107	76.37–78.49	Qbt 3	—	—	—	581.5	—	—
0550-95-0195	50-09108	10.61–11.88	Qbt 3	—	—	—	3.08	—	—
0550-96-0109[f]	50-09108	17.32–18.03	Qbt 3	—	—	—	—	0.22	—
0550-95-0200	50-09108	26.16–27.29	Qbt 3	—	—	—	12.02	-	—
0550-96-0110[f]	50-09108	31.75–32.46	Qbt 3	—	—	—	—	0.22	—
0550-95-0205	50-09108	40.31–41.72	Qbt 3	—	—	—	5.46	0.11 (U)	—
0550-95-0210	50-09108	54.16–55.58	Qbt 3	—	—	—	388.8	—	—
0550-95-0215	50-09108	67.53–68.94	Qbt 3	—	0.44	—	974	—	—
0550-95-0220	50-09108	79.20–81.32	Qbt 3	—	—	—	1660	—	—
0550-95-0226	50-09109	12.87–14.28	Qbt 3	—	1.44	—	4.63	—	2.36
0550-95-0231	50-09109	24.11–25.46	Qbt 3	—	—	—	10.3	—	—
0550-96-0111[f]	50-09109	32.53–33.23	Qbt 3	—	—	—	—	0.21	—
0550-95-0236	50-09109	40.87–42.43	Qbt 3	—	—	—	11.6	—	—
0550-96-0112[f]	50-09109	46.67–47.38	Qbt 3	—	—	—	—	0.21	—
0550-95-0246	50-09109	54.73–56.36	Qbt 3	—	—	—	6.1	—	—
0550-95-0251	50-09109	62.65–62.79	Qbt 3	—	—	—	5220	—	—
0550-95-0241	50-09109	79.90–81.11	Qbt 3	0.056	—	—	5.43	—	—
0550-95-0259	50-09110	15.97–17.85	Qbt 3	—	—	—	210	—	—
0550-96-0113[f]	50-09110	22.65–23.30	Qbt 3	—	—	—	—	0.22	—
0550-95-0264	50-09110	35.71–37.59	Qbt 3	—	—	—	**36200**	—	—
0550-96-0114[f]	50-09110	45.58–46.51	Qbt 3	—	—	—	—	0.21	—
0550-95-0269	50-09110	55.44–57.13	Qbt 3	—	—	—	4750	—	—
0550-95-0274	50-09110	69.54–71.98	Qbt 3	—	—	—	61.4	—	—
0550-95-0279	50-09110	82.69–84.01	Qbt 3	—	—	—	6.72	—	—

Note: Units are pCi/g.

[a] Tuff BVs obtained from LANL 1998, 59730.

[b] n/a = Not applicable.

[c] LANL screening action level for residential soil.

[d] na = Not available.

[e] — = The concentration was not above the BV.

[f] Tuff sample collected from curated core.

[g] 17,000 pCi/mL based on SAL of 880 pCi/g and assumed moisture content of 5%.

[h] Bold values exceed SALs.

Table B-24
Frequency of Detected Organic Chemicals in Phase I RFI Subsurface Tuff Samples at MDA C

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range (mg/kg)*	Frequency of Detects
Acetone	Qbt 3	54	8	0.003 to 0.055	8/54
Bis(2-ethylhexyl)phthalate	Qbt 3	66	7	0.037 to [0.46]	7/66
Dichloroethene[1,1-]	Qbt 3	54	4	0.003 to [0.006]	4/54
Methylene Chloride	Qbt 3	54	1	[0.004 to 0.016]	1/54
Methylphenol[2-]	Qbt 3	66	1	[0.16 to 0.39]	1/66
Toluene	Qbt 3	54	1	0.003 to [0.006]	1/54

*Values in square brackets indicate nondetects.

Table B-25
Detected Organic Chemicals in Subsurface Tuff Samples at MDA C

Sample ID	Location ID	Depth Below Ground Surface (ft)	Media	Acetone	Bis(2-ethylhexyl)phthalate	Dichloroethene[1,1-]	Methylene Chloride	Methylphenol[2-]	Toluene
NMED SSL[a]				**n/a[b]**	**350**	**8.1**	**n/a**	**n/a**	**180**
EPA SSL[c]				**70000**	**n/a**	**n/a**	**8.9**	**3100**	**n/a**
0550-95-0289	50-09101	24.75–25.60	Qbt 3	—[d]	0.037 (J)	—	—	—	—
0550-95-0294	50-09101	38.89–39.39	Qbt 3	—	0.072 (J)	—	—	—	—
0550-95-0299	50-09101	53.03–54.45	Qbt 3	—	0.041 (J)	—	—	—	—
0550-95-0109	50-09103	25.46–27.44	Qbt 3	—	—	0.003 (J)	—	—	—
0550-95-0119	50-09103	55.15–56.57	Qbt 3	—	0.3 (J)	0.004 (J)	—	—	—
0550-95-0124	50-09103	66.96–69.30	Qbt 3	0.009 (J)	—	0.006	—	—	—
0550-95-0129	50-09103	81.18–82.59	Qbt 3	0.055	—	0.004 (J)	—	—	—
0550-95-0099	50-09104	85.00–87.00	Qbt 3	—	—	—	—	0.35	—
0550-95-0145	50-09105	40.31–41.72	Qbt 3	—	0.14 (J)	—	—	—	0.003 (J)
0550-95-0046	50-09106	19.45–21.57	Qbt 3	0.013 (J)	—	—	—	—	—
0550-95-0054	50-09106	39.95–41.37	Qbt 3	0.009 (J)	—	—	—	—	—
0550-95-0200	50-09108	26.16–27.29	Qbt 3	0.028	—	—	—	—	—
0550-95-0210	50-09108	54.16–55.58	Qbt 3	—	—	—	0.0063	—	—
0550-95-0215	50-09108	67.53–68.94	Qbt 3	—	0.19 (J)	—	—	—	—
0550-95-0226	50-09109	12.87–14.28	Qbt 3	0.024	—	—	—	—	—
0550-95-0231	50-09109	24.11–25.46	Qbt 3	0.03	—	—	—	—	—
0550-95-0264	50-09110	35.71–37.59	Qbt 3	—	0.047 (J)	—	—	—	—
0550-95-0279	50-09110	82.69–84.01	Qbt 3	0.003 (J)	—	—	—	—	—

Note: Units are mg/kg.
[a] NMED soil screening level for residential soils.
[b] EPA Region 6 soil screening level for residential soils.
[c] NMED soil screening level for residential soils.
[d] — = The concentration was not above the EQL.

Appendix F

Investigation-Derived Waste Management

APPENDIX F INVESTIGATION-DERIVED WASTE MANAGEMENT

This appendix to the work plan describes how investigation-derived waste (IDW) generated during the investigation of Material Disposal Area (MDA) C at Los Alamos National Laboratory (the Laboratory) will be managed. IDW is solid waste generated as a result of field investigation activities and may include, but is not limited to, drill cuttings; purge water; contaminated personal protective equipment (PPE), sampling supplies, and plastic; fluids from the decontamination of PPE and sampling equipment; and all other wastes potentially contacting contaminants. Certain field investigation activities may also displace environmental media, which is defined as naturally occurring material indigenous to the environment, including groundwater, surface water, surface and subsurface soils, rocks, bedrock, and gravel. Consistent with the US Environmental Protection Agency (EPA) "area of contamination" policy, environmental media are not considered to be waste (and, hence, not IDW) if they are returned to their point of origin. IDW generated during the investigation of MDA C will be managed to protect human health and the environment, comply with applicable regulatory requirements, and adhere to the Laboratory waste minimization goals.

All IDW generated during field investigation activities will be managed in accordance with applicable Risk Reduction and Environmental Stewardship–Remediation Services (RRES-RS) Project Standard Operating Procedures (SOPs). These SOPs incorporate the requirements of all applicable EPA and New Mexico Environment Department (NMED) regulations, Department of Energy (DOE) orders, and Laboratory Implementation Requirements (LIRs). RRES-RS SOPs applicable to the characterization and management of IDW are

- LANL-ER-SOP-1.06, Management of Environmental Restoration Project Waste and
- LANL-ER-SOP-1.10, Waste Characterization.

These SOPs are among the SOPs applicable to the investigation at MDA C and are available at the following URL: http://erproject.lanl.gov/documents/procedures.html.

Investigation activities will be conducted in a manner that minimizes the waste generation by implementing the requirements of the RRES-RS Waste Minimization Awareness Plan, which is updated annually as a requirement of Module VIII of the Laboratory's Hazardous Waste Facility Permit.

The IDW waste streams associated with the investigation of MDA C are identified in Table F-1 and are briefly described below. Table F-1 also summarizes the waste type, estimated volume, method of on-site management, and expected disposition for each of these waste streams.

Drill cuttings. The drill cuttings waste stream will consist of cuttings from those boreholes that will be completed as vapor monitoring wells. Drill cuttings from other boreholes will be returned to the boreholes in accordance with EPA's "area of contamination" policy. Drill cuttings will be collected and containerized at the point of generation (i.e., at the drill rig). The drill cutting waste stream will be characterized in accordance with LANL-ER-SOP-01.10 in order to determine waste type and disposition. The Laboratory expects these wastes to be designated as low-level waste (LLW) that will be disposed of at TA-54 Area G.

Spent PPE. The spent PPE waste stream will consist of PPE that cannot be decontaminated. The bulk of this waste stream will consist of protective clothing such as coveralls, gloves, and shoe covers. Spent PPE will be collected in containers at the location of personnel decontamination stations. The spent PPE stream will be characterized in accordance with LANL-ER-SOP-01.10 in order to determine waste type and disposition. The Laboratory expects these wastes to be designated as LLW that will be disposed of at TA-54 Area G.

Disposable sampling supplies. The disposable sampling supplies waste stream will consist of all equipment and materials necessary for collection of samples that cannot be decontaminated. This waste stream also includes wastes associated with dry decontamination activities. This waste stream will mostly be comprised of paper and plastic items that will be collected in bags at the sampling location and transferred to accumulation drums. The sampling supplies waste stream will be characterized in accordance with LANL-ER-SOP-01.10 in order to determine waste type and disposition. The Laboratory expects these wastes to be designated as LLW that will be disposed of at TA-54 Area G.

Decontamination fluids. The decontamination fluids waste stream will consist of liquid wastes from decontamination activities (i.e., decontamination solutions and rinse waters). Consistent with waste minimization practices, the Laboratory employs dry decontamination methods to the extent possible. If dry decontamination cannot be performed, liquid decontamination wastes will be collected in containers at the point of generation and transferred to accumulation drums. The decontamination fluids waste stream will be characterized in accordance with LANL-ER-SOP-01.10 in order to determine waste type and disposition. The Laboratory expects these wastes to be designated as radioactive liquid waste that will be sent to the radioactive liquid waste treatment facility at TA-50 for disposal.

Prior to the start of field investigation activities, a Waste Characterization Strategy Form (WCSF) will be prepared and approved per requirements of LANL-ER-SOP 01.10. The WCSF will provide detailed information on IDW characterization, management, containerization, and potential volume generation. IDW characterization will be achieved through existing data and/or documentation, through direct sampling of the IDW, or sampling of the media being investigated (i.e., surface soil, subsurface soil, etc.). If sampling is necessary, it will be described in a sampling and analysis plan developed in conjunction with the WCSF.

The selection of waste containers will be based on the appropriate Department of Transportation (DOT) requirements and the type and amount of IDW planned to be generated. Immediately following containerization, each waste container will be individually labeled by waste classification, item identification number, radioactivity (if applicable), and date generated. Waste containers will be managed in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the type of IDW and its classification. Container and storage requirements will be detailed in the WCSF and approved prior to waste generation.

Table F-1
Summary of Estimated IDW Generation and Management

Waste Stream	Expected Waste Type	Estimated Volume	On-Site Management	Expected Disposition
Drill cuttings[a]	Low-level waste	2060 cubic ft 22 x B-25 boxes	B-25 boxes	Disposal at TA-54, Area G
Spent PPE	Low-level waste	2 x 55 gal.[b]	Accumulation in 55-gal. drums	Disposal at TA-54, Area G
Disposable sampling supplies	Low-level waste	3 x 55 gal.[b]	Accumulation in 55-gal. drums	Disposal at TA-54, Area G
Decontamination fluids	Low-level waste	<55-gal.[b]	Accumulation in 55-gal. drums.	Treatment at TA-50 Radioactive Liquid Waste Treatment Facility

[a] Includes only those cuttings that cannot be returned to the point of origin.

[b] Dry decontamination methods will be used to the maximum extent possible and only minimal amounts of decontamination fluids are expected to be generated.