LA-UR-03-5998
August 2003
ER2003-0504

Investigation Work Plan for Material Disposal Area L, Solid Waste Management Unit 54-006 at Technical Area 54

Los Alamos
NATIONAL LABORATORY

Los Alamos NM 87545

This document contains data regarding radioactive wastes, the management of which is regulated under the Atomic Energy Act and 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 information purposes only.

Prepared by Risk Reduction and Environmental Stewardship–Remediation Services

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the Regents of the University of California, the United States Government nor any agency thereof, nor any of their employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represent that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the Regents of the University of California, the United States Government, or any agency thereof.

Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

Investigation Work Plan for Material Disposal Area L at Technical Area 50

(SWMU 54-006)

August 2003

Preparer:

John Hopkins		Team Leader	RRES-RS	8/26/03
Printed Name	**Signature**	**Title**	**Organization**	**Date**

Responsible University of California representative:

David McInroy		Acting Deputy Project Director	RRES-RS	8/27/03
Printed Name	**Signature**	**Title**	**Organization**	**Date**

Responsible Department of Energy representative:

David Gregory		Project Manager	DOE-LASO	8/27/03
Printed Name	**Signature**	**Title**	**Organization**	**Date**

EXECUTIVE SUMMARY

This investigation work plan (IWP) presents recommendations for investigation activities required to complete the Resource Conservation and Recovery Act facility investigation (RFI) of material disposal area (MDA) L, solid waste management unit (SWMU) 54-006, at Technical Area (TA)-54 at Los Alamos National Laboratory (the Laboratory). The IWP also includes a description of sampling activities and analytical results for historical investigations at MDA L. The investigation activities described in this IWP are designed to address data gaps remaining after past investigations, including the Phase I RFI fieldwork conducted at MDA L.

The objectives of the IWP are to determine the nature and extent of hazardous waste constituents and/or radionuclide releases to the environment identified during the Phase I RFI. Evaluation of environmental data generated during the Phase I RFI consisted of comparisons of site data with background values and/or fallout values 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 L:

- methoxychlor was detected in channel sediments;
- plutonium-238 was elevated with respect to its fallout value in one channel sediment sample;
- barium, chromium, cobalt, copper, manganese, nickel, uranium, and zinc were detected in subsurface core above background beneath the disposal units;
- volatile organic compounds (VOCs) were frequently detected in pore-gas samples collected from monitoring boreholes; and
- tritium was detected in surface flux samples and in subsurface core.

The Phase I RFI data were evaluated to determine if data gaps remain related to characterizing the nature and extent of contamination. The data gaps identified include

1. vertical extent of metals in tuff beneath the shafts and impoundments;
2. nature and extent of perchlorate, nitrate, and high-explosive (HE) contamination in core;
3. concentrations and spatial extent of tritium in the vapor phase in subsurface core;
4. presence of perched groundwater beneath MDA L;
5. information on hydrogeologic properties to support contaminant transport modeling of the vadose zone at MDA L;
6. continued monitoring of vapor-phase VOC plume to track plume stability; and
7. collection of one supplemental channel sediment sample.

Once the additional fieldwork has been completed and the investigation report prepared and approved by NMED, a corrective measure study will be prepared and an alternative selected for the site.

To address data gap 1, two angled boreholes will be advanced under Impoundments B, C, and D, and one angled borehole will be advanced beneath the western shaft field. The objective of these boreholes is to collect samples to evaluate the extent of metals contamination in tuff. A minimum of two tuff samples will be collected from each borehole.

To address data gap 2, all core samples associated with data gap 1 will be analyzed for nitrates and perchlorate and field-screened for HE. Twenty percent of the samples screened for HE will also be submitted to an off-site contract laboratory for analysis.

To address data gap 3, a minimum of two tritium pore-gas samples will be collected from the three new angled boreholes and from eight existing boreholes. Samples will be collected directly beneath the nearest disposal unit and at the total depth of each borehole.

To address data gap 4, a vertical borehole will be advanced east of the MDA L fence line to a depth of 700 ft to investigate whether perched groundwater is present below MDA L. Moisture levels will be recorded at 1-ft intervals to the total depth of the borehole.

To address data gap 5, data on the geophysical properties of vadose zone core will be collected from the 700-ft borehole to evaluate contaminant fate and transport mechanisms in the subsurface at MDA L for the future corrective measure study.

To address data gap 6, continued monitoring in new and existing boreholes is required to track the plume’s stability, its migration pattern, or a potential release from the source areas (data gap 6). However, concentrations and spatial extent of VOC vapors in subsurface tuff have been defined.

To address data gap 7, one channel sediment sample will be collected at the interface of the alluvial sediments and bedrock in the historic drainage areas.

CONTENTS

Appendices

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 General Site Information

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

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 DOE operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve that 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 report (SWMU 54-006) contains both hazardous and radioactive components.[1] Depending on the type of contaminant(s) and the history of a SWMU, the New Mexico Environment Department (NMED) or the DOE has administrative authority over work performed by RRES-RS at the site. NMED, under the auspices of the State of New Mexico Hazardous Waste Act (NMHWA), has authority 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."

NMED enforces the Hazardous and Solid Waste Amendments (HSWA) Module VIII 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 US 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 Laboratory's 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) L is located on a mesa in the east-central portion of the Laboratory at Technical Area (TA)-54 (Figure 1). During the late 1950s, the Laboratory, with approval of the US Atomic Energy Commission and upon recommendation of the US Geological Survey, selected Mesita del Buey, within TA-54, for underground disposal of Laboratory-generated waste (Rogers 1977, 5707; Rogers 1977, 5708). Since that time, the main waste storage and disposal facilities for the Laboratory

---

[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.

have been located at TA-54. MDA L is one of four disposal areas on Mesita del Buey between Pajarito Canyon (south) and Cañada del Buey (north) and within TA-54 (Figure 2).

MDA L is an 1100- by 3000-ft (2.5-ac) fenced area. MDA L consists of one inactive subsurface disposal pit (Pit A); three inactive subsurface treatment and disposal impoundments (Impoundments B, C, and D); and 34 inactive disposal shafts (Shafts 1 through 34) with depths ranging from 10 to 65 ft below the original ground surface, before an asphalt cover was placed over the site. The pit, impoundments, and shafts are constructed in the Tshirege Member of the Bandelier Tuff, a consolidated tuff unit. The regional aquifer is estimated to be at a depth of approximately 930 ft, 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 L is relatively flat. The majority of the surface of MDA L is paved with asphalt to house ongoing waste management activities; surface water runoff from this area is controlled and diverted to an outfall at the northeast corner of the site.

Historically, MDA L was used for disposing of non-radiological liquid chemical wastes. Disposal of these types of wastes no longer occurs at this site. LANL drawings AB113 (LANL 1993, 76052) and ENG-C-45259 (DOE 1987, 25606) have been used to identify the locations of the pit, impoundments, and shafts at MDA L. There are no visible surface expressions of the pit or the impoundments because asphalt covers most of the surface of MDA L. Most of the shaft locations (but not all) are marked with brass caps pressed into the asphalt indicating the approximate location of each shaft. The depth of the disposal units was described in the approved RFI work plan for Operable Unit (OU) 1148 (LANL 1992, 07669) based on historical records; however, elevation data was not documented. The subsequent cover material placed over the disposal units, including the asphalt pad, has increased the elevation across the site. The elevation of the disposal units at the time of excavation has been estimated from the tuff/soil interface identified in the Phase I RFI borehole logs. Figure 3 shows the locations of the pit, impoundments, and shafts as well as other site surface features and topographical lines. The entire fenced surface area over MDA L is an active RCRA-permitted hazardous waste management unit.

This investigation work plan (IWP) provides the results of historical investigations (including the Phase I RFI) of MDA L, SWMU 54-006, at TA-54 and presents recommendations for additional investigation activities required to complete the investigation. The IWP includes site background, site conditions, scope of activities necessary to complete the investigation, investigation methods, and the anticipated schedule for completing the field activities. Appendix A includes a list of acronyms and defines terms used in this report. Appendix B describes the historical RFI activities and analytical results for MDA L, including data interpretation to establish if releases had occurred from the disposal units and to make a preliminary determination of the nature and extent of the contamination. Appendix C describes results of the quality control (QC)/quality assurance (QA) process. Appendix D on CD attached to inside back cover of this report provides all of the Phase I RFI data. Appendix E describes statistical analyses to support data interpretation. Appendix F lists relevant documents for the regulatory history of the SWMUs associated with MDA L. Appendix G includes a history of pore-gas monitoring at MDA L. Appendix H includes borehole profiles and logs. Appendix I is a copy of the report “Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions” (Stauffer et al. 2000, 69794). Appendix J contains a copy of the report “Summary Report: Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L, Revision 1.” Appendix K contains information on the stratigraphy of the MDA L area. Appendix L contains the Source Term and Batch Waste Source Term Databases.

1.2 Investigation Objectives

The objectives of the IWP for MDA L are to

- determine the nature and extent of hazardous waste constituents and/or radionuclide releases to the environment identified during the Phase I RFI;
- establish the rationale for data collection and analysis; and
- identify appropriate methods and protocols for collecting, analyzing, and evaluating data to finalize the characterization of MDA L.

The RRES-RS Project conducted Phase I RFI fieldwork at MDA L from 1993 to 2003. The results of these investigations are described in the historical investigation report (HIR) in Appendix B of this IWP. Based on an evaluation of existing environmental data collected at MDA L, several data gaps were identified that must be addressed to define the nature and extent of contamination in the environment and to evaluate potential risks to human and ecological receptors. These data gaps are described in the HIR and in Section 4.1 of this IWP.

2.0 BACKGROUND

2.1 Operational History

MDA L is a decommissioned (i.e., removed from service) MDA established for disposing of non-radiological liquid chemical waste, including containerized and uncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions; electroplating wastes, including precipitated heavy metals; and small batch quantities of treated lithium hydride. MDA L operated from the early 1960s until it was decommissioned in 1985. A chronology of the salient information pertinent to MDA L is presented in pages 5-105 through 5-108 of the approved RFI work plan for OU 1148 (LANL 1992, 07669) and in Section 1.0 of the HIR in Appendix B.

At MDA L, 1 pit, 3 impoundments, and 34 shafts were excavated into the overlying soil and unit 2 of the Tshirege Member of the Bandelier Tuff (Figure 3). The pit, impoundments and shafts were unlined. Upon decommissioning, the pit and impoundments were filled and covered with clean, crushed, consolidated tuff. When the shafts were filled to within approximately 3 ft of the surface, steel caps were placed over the opening of each shaft, and the area above the steel plate was capped with a 3-ft concrete plug (Rogers 1977, 5707; 5708).

2.2 Land Use

MDA L is located in an industrial area within TA-54, which is currently the primary site at the Laboratory for waste management activities. The Laboratory does not anticipate that land use at TA-54 will change in the foreseeable future. Public access to the site is restricted by fencing, locked gates, and restricted access to Pajarito Road and TA-54. Under present-day conditions, only Laboratory employees or contractors may enter the site for site management activities (i.e., installing best management practices), waste management operations, or collecting environmental samples.

2.3 Relationship to Other SWMUs and AOCs

To evaluate the potential impact of MDA L and to make sound decisions regarding the need for and nature of effective remedies, it is important to understand, at least qualitatively, the potential impact of nearby SWMUs and AOCs. The most significant SWMUs/AOCs near MDA L, in terms of contaminant inventory and physical size, are MDAs G and H at TA-54 (Figure 2). MDA G is located near the eastern end of Mesita del Buey approximately 1 mi east of MDA L. This 65-ac site has been the Laboratory's primary radioactive waste disposal facility since 1959 and is scheduled to operate through 2044. Investigations to date have revealed a diffuse plume of volatile organic compounds (VOCs) (probably associated with residual solvent contamination in radioactive waste) and a plume of water vapor containing tritium. As an operating nuclear facility, MDA G is subject to intensive personnel safety and environmental protection and surveillance programs, and the VOC and tritium plumes are monitored regularly. Ongoing low-level radioactive waste disposal is authorized by the DOE, and ongoing solid low-level mixed-waste and transuranic (TRU) mixed-waste management activities are authorized by the DOE and permitted, as necessary, by the NMED under agreement with the EPA. MDA H is located 0.6 mi west of MDA L. This 0.3-ac site functioned as the Laboratory's primary disposal area for classified, solid-form waste from 1960 through August 1986. Investigations conducted to date indicate that a vapor-phase release of tritium and VOCs occurred from the subsurface shafts. The corrective measures study (CMS) for MDA H was submitted to NMED on May 31, 2003 (LANL 2003, 76039).

2.4 Contaminant Transport and Potential Receptors

The inventory of wastes disposed of at MDA L includes inorganic 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, are susceptible to release and transport via infiltration of water through the interred wastes.

The primary potential release and transport mechanisms for contaminants in subsurface wastes at MDA L include the following:

- *Volatilization, diffusion, and dispersion in air.* Gas or vapor-phase contaminants diffuse from waste and mix with air in the shafts, impoundments, or pit, and then diffuse through the air-filled pores in the subsurface rock. Migration of gas or vapor-phase contaminants from the tuff into ambient air may occur by diffusion or by advection driven by barometric pressure changes.
- *Dissolution and advective transport in water.* Residual moisture under the asphalt surface moves down through the shafts, impoundments, and pit, 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.

In addition to the processes described above, which were described in the context of buried wastes, contaminants may also have impacted environmental media at MDA L from releases that occurred during the operation of MDA L. Dissolution of contaminants in infiltrating water, for example, may have been more prevalent during site operations when the pit, impoundments and shafts were open for waste disposal. At least two release mechanisms, currently inactive at MDA L, may have contributed to existing contamination in environmental media:

- *Subsurface solute-transport.* Although limited liquid-phase contaminant transport may have occurred in the past, as indicated by the presence of metals in core samples collected beneath the subsurface pit, impoundments, and shafts, boreholes drilled beneath MDA L have not provided evidence of residual free liquid (solvent or water). These findings indicate that no liquid source is present outside the disposal trenches and shafts. Nonetheless, because liquid VOCs may still be present in the MDA L inventory (e.g., intact drums in shafts), the possibility of future liquid-phase solute transport is retained as a potential contaminant transport mechanism.

- *Liquid-phase transport of solvents and associated metallic residue*. If intact drums of chemicals are still present, liquids from the drums would rapidly volatilize into pore space. It is possible that a drum or drums of liquid could fail completely, adding a pulse of liquid to the system. The depth of resultant contaminant transport would be a function of the saturated and unsaturated hydraulic conductivity and the volume of liquid released. To evaluate the potential for liquid VOC flux (aqueous-phase transport) and subsequent mobilization of residual metals, the rate of volatilization was compared to the rate of saturated and unsaturated flux. Based on conservative assumptions, a 55-gal. drum of 1,1,1,-trichloroethane (TCA) that fails completely would fully volatilize within one year, resulting in vertical liquid transport of approximately 100 ft (Appendix I of this IWP). Once the volume of liquid released fully volatilizes, saturated conditions would cease to exist, after which volatile chemicals would diffuse through the pore space in the tuff. Any metals mobilized during saturated conditions would sorb onto solid particles. The introduction of liquid pulses into the subsurface at MDA L would not result in long-term saturated flow conditions or deep vertical transport of contaminants.

Movement of VOC plumes can be characterized as advective (density driven) or diffusive (concentration driven [Conant et al. 1996, 64608]). Density-driven flow increases the downward migration rate of a VOC and affects the distribution of the plume in solid media with air permeabilities greater than 10^{-11} m^2 (10 darcies [Stauffer et al. 2002, 69794]). This is the upper limit for air permeability in the Bandelier Tuff. Based on relatively low air permeability, vapor movement beneath MDA L is expected to be dominated by diffusion, with the rate of diffusion being determined by the concentration gradient between the source and the ambient pore gas. Assuming diffusive (concentration driven) processes are dominant and using site-specific properties (e.g., geology and air-permeability), modeling results of the VOC plume evolution match the nature and extent of the plume as measured during pore-gas sampling (Appendix I). Matching the modeling to the site-specific conditions (i.e., data) would verify that the primary mechanism for VOC transport is diffusive transport in the vapor phase.

The impacts of drum failure on the VOC plume extent are evaluated in a report contained in Appendix I (Stauffer et al. 2002, 69794) to determine whether a drum failure could be detected with pore-gas monitoring. The simulation assumed that a 55-gal. drum of TCA fails, emptying its entire contents into the subsurface. The TCA was assumed to move downward, smearing homogeneously, to a depth of 100 ft below a shaft bottom or approximately 160 ft below the MDA L surface. Next, the TCA is assumed to completely volatilize, creating a TCA cloud at a concentration of 20,000 parts per million by volume (ppmv). This addition of vapor (~300 kg) is roughly 40% of the current plume inventory. After one year, the simulation predicts that 22% of the new release is lost through the surface. According to the model, after two years, 31% would be vented, and after five years, 50% would be removed by venting through the surface to the atmosphere. The concentration increase in the subsurface following drum failure would be detected by the current monitoring program. The impact on the extent of the VOC plume would be minimal. The simulation showed that the extent of the 100-ppmv-concentration contour beneath the release would expand slightly. The outer extent (10-ppmv contour) would not change measurably. The prediction calculates that after 10 yr, 70% of the release is vented, and after 20 yr, 88% has left the system. At this point, the plume would look much like its current condition, and monitoring would no longer be able to detect the release. In summary, a single drum failure does not appear to substantially change the extent of the plume, and the current monitoring system is able to detect the release (Appendix I).

Receptors potentially exposed to contamination from MDA L include workers at MDA L and TA-54 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 VOCs emanating from the site into the atmosphere is also a potential means of exposure. Ecological receptors may also be exposed via these pathways as well as via plant root uptake and the food web; in addition, these receptors may be exposed to higher concentrations of gas-phase contaminants in subsurface burrows.

Perched groundwater was not encountered, nor is suspected, beneath Mesita del Buey at MDA L at TA-54 (LANL 1998, 59599). No perched water was observed in 340 ft of drilling (to 6448 ft above sea level) in the deepest borehole (borehole 54-01004, Appendix H of this IWP). No perched water was observed in 883 ft of drilling (to 5767 ft above sea level [asl]) in regional well R-22 or in 800 ft of drilling (to 5680 ft above sea level) in regional well R-21 (Figure 4). 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 approximately 930 ft below MDA L (LANL 1998, 59599). Because of the depth to the regional aquifer and the low moisture content (1% to11% gravimetric moisture content within the first 300 ft below ground surface ([bgs] (LANL 1994, 76071) of the vadose zone, it is unlikely that contamination at MDA L could reach the regional aquifer in the foreseeable future. However, contaminants from MDA L could potentially reach groundwater, and this pathway will be investigated and evaluated in the MDA L investigation report and the future CMS report.

2.5 MDA L Waste Inventory

Waste disposal records for MDA L are found in un-numbered disposal logbooks (LANL 2003, 76036). These logbooks were used to record information on the type, date, location, and volume of waste placed in MDA L. Records prior to 1974 are incomplete, and many logbook entries contain only brief descriptions of wastes disposed of at MDA L (i.e., waste types, volumes, and disposal locations are not always provided). An estimate of the types and quantities of waste disposed of at MDA L was compiled in the OU 1148 data report (LANL 1992, 23247).

Two databases were developed based on the original logbook entries. Untreated waste deposited at MDA L between May 30, 1975, and May 7, 1985, is identified in the Source Term Database and summarized in Appendix B, Section B-1.1. Information about waste that underwent treatment before disposal at MDA L from December 20, 1974, to July 25, 1984, is provided in the Batch Waste Source Term Database and is summarized in Appendix B, Section B-1.1. Given the uncertainties and lack of information in the historical records, the data are sufficient only to estimate the general nature of inventoried waste buried of in the pit, shafts, and impoundments at MDA L. The Source Term and Batch Waste Source Term databases are included in Appendix L of this IWP.

2.6 Summary of Historical Investigations

2.6.1 Pre-RFI Field Investigations

On May 7, 1985, the Laboratory received a compliance order from the New Mexico Environmental Improvement Division (NMEID, now called NMED) that addressed numerous waste management issues at the Laboratory (NMEID 1985, 75885). The 1985 order specified the following six tasks that involved site investigation activities in and around MDA L:

- Task 1 required measuring the intrinsic permeability of the tuff,
- Task 2 required determining the soil-moisture characteristic curves,

- Task 3 required determining the unsaturated hydraulic conductivity of the Bandelier Tuff,
- Task 4 required analyzing the infiltration and redistribution of meteoric water into the tuff,
- Task 5 required characterizing the core and pore gas in the vadose zone, and
- Task 6 required analyzing the potential presence of perched water.

The results and outcomes of the above six tasks are described in a report entitled "Hydrogeologic Assessment of Technical Area 54, Areas G and L" (LANL 1987, 76068), which was submitted in 1987 to the NMED in response to the 1985 compliance order/schedule. These investigations and the associated findings are described in the HIR (Section B-1.2 of Appendix B) and in the approved RFI work plan for OU 1148 (LANL 1992, 07669).

2.6.2 Phase I RFI Field Investigations

Phase I RFI activities, including sampling of ambient air, channel sediments, subsurface core, and pore gas, are summarized in Table 1.

VOC surface flux was measured across MDA L in two surveys conducted in August 1993 and August 1994. Details of the investigation are reported in two Quadrel Services reports (Quadrel 1993, 63868; Quadrel 1994, 63869). Trujillo et al. (1998, 58242) issued a report summarizing the results of the surface flux VOC measurement investigations. During the summers of 1993 and 1994, tritium flux was measured at locations on and near the surface of MDA L. Tritium flux locations are shown on Figure B-4 and the results are presented in Table B-6 (Eklund 1995, 56033).

Between September 1993, and May 1995, 184 core samples were collected from seven vertical and nine angled boreholes drilled at MDA L and submitted to an off-site contract laboratory for analysis. Depth intervals for sample collection and analytical suites varied by borehole and are described in Section B-2.3.1 in Appendix B. The depths of these boreholes ranged from 50 to 607 ft bgs. Borehole locations and trajectories are shown on Figure B-6. Boreholes are described by depth, declination, and adjacent disposal unit in Table B-7. A total of 18 boreholes were drilled during the Phase I RFI; however, core samples were not collected from boreholes 54-01017 and 54-01018.

In 1994, channel sediments from tributaries of Cañada del Buey were collected from eight locations and field screened for alpha, beta, and gamma radiation to bias sample selection. The sample with the highest gross alpha and gross beta, the sample with the highest gross gamma, and two other samples selected at random (four total) were submitted to an off-site contract laboratory for target analyte list (TAL) metals, polychlorinated biphenyls (PCBs)/pesticides, herbicides, gamma spectroscopy for radionuclides, tritium, isotopic thorium, strontium-90, isotopic uranium, and isotopic plutonium analyses (LANL 1996, 54462).

Additionally, in 1994, ambient-air samples were collected for eight days at two sampling locations along the northern perimeter of MDA L. The samples were analyzed for VOCs. This sampling event is described in Section B-2.1.2 of Appendix B and reviewed in Appendix J of this IWP.

In 1997 and 1998, the Environmental Restoration Project (now called RRES-RS) evaluated the effectiveness of passive-vapor extraction of subsurface vapor-phase VOCs at MDA L. Passive-vapor extraction uses natural changes in atmospheric barometric pressure as a pump to exhaust VOCs through open boreholes. These activities are described in Section B-2.3.2 of Appendix B.

Sampling of subsurface pore gas for VOCs has been ongoing at MDA L from 1992 to the present. Currently, there are 18 boreholes at MDA L available for this sampling, including two Phase I RFI boreholes and 16 pre-RFI boreholes. Each quarter, ten of these boreholes are selected for pore-gas monitoring. Since 1997, pore-gas monitoring has been aided and directed using soil-gas screening with a Bruel and Kjaar (B&K) Multigas Analyzer, Model 1302. Currently all ports in the monitoring boreholes selected for that quarter are screened using the B&K, and SUMMA™ canisters are collected as needed to evaluate changes in the VOC plume based on a defined quarterly sampling schedule presented in the prior year's annual report September RRES-RS quarterly technical report [LANL 2002, 73712). Pore-gas monitoring activities are described in Section B-2.3.3 of Appendix B and in Appendix G of this IWP.

2.6.3 Phase I RFI Results

Conclusions regarding the nature and extent of contamination at MDA L that can be drawn from the results of Phase I RFI activities are as follows.

1. Concentrations of certain metals (barium, chromium, cobalt, copper, manganese nickel, uranium, and zinc) in tuff, beneath the pit, impoundments, and shafts, indicate that contamination has leached from the disposal units. The vertical extent of subsurface contamination beneath the three impoundments and shaft field has not been defined.
2. Concentrations of tritium beneath the disposal units indicate that it has migrated into the tuff. The extent of contamination has not been defined.
3. VOCs (primarily trichloroethylene [TCE], tetrachlorethane [PCA], and TCA) were detected in subsurface pore gas indicating a release. The vertical and horizontal extent of this contamination is defined.
4. Surface flux and ambient-air sampling results indicate that VOCs and tritium are being released into the atmosphere from the subsurface vapor plume residing in the vadose zone beneath MDA L.
5. Channel sediments contain low concentrations of methoxychlor and plutonium-238.

A detailed review of the Phase I RFI data is presented in Section B-3 of Appendix B. Phase I RFI data is presented in Appendix D of this IWP (CD on inside back cover).

3.0 SITE CONDITIONS

This section discusses aspects of the environmental setting at MDA L that are important to assessing the potential impacts of contaminated surface and subsurface media, including

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

3.1 Surface Conditions

MDA L is located in the central area of Mesita del Buey northwest of MDA G at TA-54 (Figure 4). Mesita del Buey is a 100- to 140-ft-high finger-shaped mesa that trends southeast. The elevation of Mesita del Buey ranges from 6775 to 6800 ft at MDA L. The mesa is approximately 500 ft wide and is bounded by

Cañada del Buey (450 ft to the north) and Pajarito Canyon (360 ft to the south). The topography at MDA L slopes gently from west to northeast, gradually steepening in the northeast quadrant of MDA L towards Cañada del Buey. The surface of MDA L is covered with a layer of asphalt.

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 on the mesa surface are thin and poorly developed; they tend to be sandy 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 (Reneau and Vaniman 1998, 63135). A discussion of soils in the Los Alamos area can be found in Section 2.5.1.3 of the installation work plan (LANL 1998, 62060).

The original soils near MDA L were poorly developed, as is typical of soils derived from Bandelier Tuff and formed under semiarid climate conditions (Nyhan et al. 1978, 5702). In general, undisturbed soils on the mesa tops are comprised of the Carjo loam, the Hackroy loam, and the Seaby loam (Nyhan et al. 1978, 5702). At MDA L, natural or undisturbed surficial soil cover is limited as a result of disposal unit and cover construction. The present-day surface of MDA L is crushed tuff covered with an asphalt pad.

Canyon bottoms (Cañada del Buey and Pajarito Canyon) near MDA L 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 L, Cañada del Buey has experienced a period of accretion, and eroded soils from MDA L as well as other areas at TA-54 have been deposited on the canyon bottom and stream banks (Nyhan et al. 1978, 5702). Potentially, these soils can be redistributed downstream during storm runoff events. The drainages between the mesa and canyon bottoms were sampled during the Phase I RFI; the canyon bottoms will be investigated under separate canyon 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 north and the south. Storm water flows at a number of points along the perimeter of TA-54, as identified and characterized in the “Stormwater Pollution Prevention Plan” (LANL 2002, 74009), prepared for the Laboratory’s National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit. Therefore, flooding at the site facility is not a concern. As a result of runoff, surface erosion occurs primarily as shallow sheet erosion on the relatively flat parts of the mesa and as channel erosion in major drainages from the mesa top. Runoff from summer storms reaches a maximum in less than 2 hr and lasts less than 24 hr. In contrast, runoff from spring snowmelt occurs over a period of several weeks at a low discharge rate. The amount of eroded material transported in runoff waters is generally higher during summer rainfall events than during snowmelt (LANL 1997, 63131, pp. 2–33).

In 2001, RRES-RS conducted a surface water assessment of the surface of MDA L, which is paved and is used as an active RCRA-permitted hazardous waste management unit. The area received a score of 10.6, indicating low erosion potential. The calculated erosion matrix score includes 3.6 for site setting, an erosion runoff score of 0.0, and a run-on score of 7.0 (Appendix K of this IWP).

3.2 Subsurface Conditions

3.2.1 Stratigraphy

The RRES-RS Project drilled and cored 18 boreholes (Figure 5), and sampled 16 of the boreholes at MDA L to characterize potential contaminant releases and transport in the subsurface. Borehole logs from the site (Figure 6; Appendix H) provide details on the stratigraphy to a depth of approximately 607 ft bgs (borehole 54-01015) and are included in Appendix H. The locations and depths of regional wells (R-20, R-21, R-22), were also used to infer the stratigraphy beneath MDA L (Figure 7). Figure 7 shows east-west cross sections beneath and near MDA L. The stratigraphy beneath MDA L includes the Bandelier Tuff and the Cerros del Rio basalt. The regional aquifer is primarily Santa Fe Group, Puye Formation, and Cerros del Rio basalts. Descriptions of the stratigraphic units beneath MDA L are included in Appendix K.

3.2.2 Hydrogeology

The proposed hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599) is presented in Figure 8. The model predicts that infiltration of water into the subsurface and subsequent transport of water, vapor, and solutes through the upper regions of the vadose zone is 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 only weakly influenced by surface conditions and is influenced more by the 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, groundwater, and stratigraphy in the vicinity of MDA L.

Infiltration

Surface and near-surface conditions (topography, precipitation, surface runoff) control the infiltration of water and the transport of contaminants into the shallow subsurface. In this respect, the behavior of mesas and canyons forming the plateau differ from one another (LANL 1998, 59599). Mesas are generally quite dry, both on the surface and within the rock forming 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.

Relatively small volumes of water move beneath mesa tops under natural conditions because of low rainfall, run-off into canyons, high evaporation, and efficient water use by vegetation. Liquid water generally infiltrates into the mesa, and water vapor generally moves upward, undergoing evapotranspiration along the top and sides of the mesa. Air readily circulates through the mesa-top units because of the relatively dry pore spaces and the topographic relief. Air circulation may be driven by temperature variations, barometric pumping, or surface winds. This process promotes atmospheric evaporation, which may extend deep within the mesa and further inhibit the downward liquid-water flow.

Mesita del Buey is one of the drier mesas at the Laboratory and the Pajarito Plateau. Infiltration into the mesa appears to be very low, possibly only 0.04 in./yr (LANL 1997, 63131), and occurs during snowmelts or intense summer thunderstorms, which leads 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 drying the mesa (Turin and Rosenberg 1996, 63559).

3.2.3 Groundwater

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

3.2.3.1 Perched Intermediate Waters

Perched intermediate groundwater is rarely observed on the Pajarito Plateau, and the causes for perching have not been fully determined (Nylander et al. 2003, 76059). 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 groundwater has been observed in some locations elsewhere on the plateau, none has been observed in the regional wells in the vicinity of MDA L (R-22, R-21, R-20, R-16) (LANL 1998, 59599). No perched groundwater was observed in 340 ft of drilling (to 6448 ft) in the deepest vertical borehole drilled to date (borehole 54-01004) at MDA L.

3.2.3.2 Regional Aquifer

The regional aquifer of the Pajarito Plateau is the only aquifer capable of supplying large-scale municipal water (Purtymun 1984, 6513). The regional aquifer extends throughout the Española Basin (an area roughly 2300 mi^2 [6000 km^2]) and reaches its maximum thickness beneath the Pajarito Plateau (over 9800 ft thick; Cordell 1979, 76049).

Depths to the regional aquifer range between about 1200 ft along the western edge of the plateau and about 600 ft east. Beneath MDA L, the water table elevation is approximately 5810 ft (5767 ft at R-22; 5860 ft at R-32 or approximately 930 ft bgs). Figure 9 depicts water table elevations across the plateau, i.e., a cross section of hydraulic head data (water table elevations) collected in the regional aquifer.

Groundwater flow in the regional aquifer between TA-54 and the Rio Grande (approximately 4 mi) occurs primarily in the Santa Fe Group (see Figure 7). Pump test results in individual water supply wells throughout the plateau indicate that the hydraulic conductivity (K) of the Santa Fe Group along the eastern edge of the plateau is the lowest of any aquifer unit ([average K for LA well field = 0.7 ft/day]; Purtymun 1995, 45344). More recent analysis of water-level trends over a 55-yr span indicate that these K estimates, although accurate locally, may be higher than the large-scale, effective permeability of the Santa Fe Group (0.2 ft/day) because of the flow impedance of north-south trending faults. Assuming a porosity of 0.2 (typical of sedimentary rocks [Freeze and Cherry 1979, 64057]) and the measured gradient of 0.02, pore water velocities in this portion of the aquifer would be slow (approximately 0.02-0.07 m/yr [Nylander et al. 2003, 76059]). This result indicates that travel times within the regional aquifer (Santa Fe Group rocks) from TA-54 to the Rio Grande would be, on an average, over 1000 yr.

3.2.3.3 Vadose Zone

The region beneath the ground surface and above the regional aquifer is called the vadose (unsaturated) zone. The source of moisture in the vadose zone beneath TA-54 is infiltrating precipitation, but most of the precipitation is removed as runoff or evaporation and transpiration in the upper region of the vadose zone (LANL 1997, 63131). The subsurface movement of the remaining water (often referred to as recharge) is predominantly vertical and is influenced by properties and conditions of the vadose zone.

Two geologic properties of the Bandelier Tuff that influence the fluid flow in the unsaturated zone are the degree of welding and the devitrification, both effects of prolonged presence of residual gases and high temperatures when the rock was deposited. Because different tuff units were deposited at different temperatures, and because individual units were laid out in variable thicknesses over different landscapes, cooling was not uniform. Consequently, welding varies spatially, both between and within separate depositional layers. Welded tuffs tend to be more fractured than nonwelded 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 L are relatively low (1% to 13% gravimetric moisture content [LANL 1994, 76071]). At these saturation levels, most of the fractures beneath MDA L are completely dry and water is found only in the tuff matrix. Only in situations when substantial infiltration occurs from the ground surface do the fractures become wet and conduct water. However, modeling studies at MDA G predict that when fractures disappear at contacts between stratigraphic subunits, if fracture fills are encountered, or if coatings are interrupted, fracture moisture is absorbed into the tuff matrix (LANL 1997, 63131).

In summary, the groundwater flow and contaminant transport in the vadose zone is difficult to characterize. The flow rates and transport velocities/directions can be expected to be variable in both time and space. Between the ground surface and regional aquifer, the flow is predominantly vertical. Nevertheless, the groundwater transport velocities through the vadose zone in the region of TA-54 are slow, likely in the order of several centimeters per year (Birdsell et al. 1995, 70012; Birdsell et al. 1999, 69791).

4.0 SCOPE OF ACTIVITIES

Phase I RFI data for MDA L, evaluated in Section B-4 of Appendix B, identified several data gaps to be addressed to establish the nature and extent of environmental contamination that will be used to evaluate potential risks to human and ecological receptors. Data interpretation and the associated data gaps are summarized in Section 4.1.

4.1 Data Gaps

Seven data gaps were identified based on evaluation of the Phase I RFI data presented in Appendix B and supporting statistical evaluation in Appendix E. The rationale for identifying these data gaps is described in Sections 4.1.1 and 4.1.2 and includes

1. vertical extent of subsurface metal contamination;
2. lateral extent of tritium in the vapor phase in subsurface tuff;
3. nature and extent of perchlorate, nitrate, and high-explosive (HE) contamination in tuff beneath MDA L;

4. presence of perched groundwater beneath MDA L;
5. information on hydrogeologic properties and fracture characteristics of the vadose zone to support contaminant transport modeling for the future MDA L CMS;
6. information on vapor-phase VOC plume stability: continued monitoring is necessary to track plume stability, migration, or a release from the source areas, although the concentrations and the spatial extent of the vapor-phase VOC plume have been identified; and
7. collection of a supplemental channel sediment sample.

4.1.1 Extent of Metals Contamination Beneath the Pit, Shafts, and Impoundments

Subsurface data from the Phase I RFI investigation indicate that a release of metals has occurred beneath the pit, shafts, and impoundments at MDA L. Barium, chromium, cobalt, copper, manganese, nickel, uranium, and zinc were detected at concentrations above background values (BVs) in one or more boreholes in two out of three consecutive sampling depths (Appendix B). Other inorganic chemicals detected at concentrations above BV at discrete locations (i.e., in single samples taken from two or three different boreholes at different sampling depths) provided insufficient evidence of a release. The nature and extent of contamination is reviewed in the following subsections by specific impoundments, a pit, and shafts.

Impoundments B, C, and D. Boreholes 54-01012, 54-01013, and 54-01014 were drilled to angle beneath Impoundments B, C, and D, respectively. Concentrations of chromium and copper above their respective BV were detected at three consecutive sampling depths in core samples beneath Impoundment B. Beneath Impoundment C, concentrations of copper were above BV at three consecutive sampling depths, and nickel concentrations exceeded the BV at two out of three consecutive sampling depths. Based on these results, it was concluded that copper and chromium have been released from Impoundment B, and copper and nickel have been released from Impoundment C. In borehole 54-01014, uranium was the only inorganic chemical detected at several consecutive sampling depths. Samples were collected from the unit 2/unit 1v interface and uranium was detected in concentrations slightly above the unit 2 BV (2.40 mg/kg) but below the unit 1v BV (6.22 mg/kg [see Appendix L for a description of the stratigraphy of the area]). The pattern indicates that a release of uranium may have occurred from Impoundment D to the surrounding subsurface tuff. The vertical extent of inorganic chemical contamination is not completely bounded beneath the impoundments.

Pit A. Boreholes 54-01010 and 54-01011 were drilled at an angle to pass beneath the eastern and western portions of Pit A, respectively. In borehole 54-01011, barium was detected in one sample at approximately twice the BV (LANL 1998, 59730). In borehole 54-01010, cadmium, mercury, and uranium were detected above their respective BVs in one sample each, and chromium was detected above the BV in two samples separated by four sampling depths (LANL 1998, 59730). The results from the angled boreholes drilled beneath Pit A do not provide evidence of a release (no consecutive depths with detects greater than BV), and the vertical extent of the release is defined beneath Pit A.

Shafts 1 through 28. This shaft field is located on the east end of MDA L and was evaluated by samples collected from boreholes 54-01007 and 54-01009. The pattern of metal concentrations in these boreholes provided evidence of a release. The primary component of the release was copper, with smaller contributions from chromium, barium, and zinc. Nickel was also detected above BV in the lower tuff strata (units 1v and 1g [see Appendix L for a description of the stratigraphy of the area]).

Copper, chromium, barium, and zinc were detected in borehole 54-01007 at concentrations above their respective BVs at 146 ft (Appendix B). Copper concentrations were greater than BV in 10 of 13 core samples, often by more than a factor of 10. Chromium concentrations were greater than BV (LANL 1998, 59730) in 5 of 13 samples but did not exceed BV by more than a factor of 2. Copper and chromium remained elevated at the deepest sampling location (146 ft). Barium and zinc concentrations were more than twice their respective BVs in a single core sample and at concentrations marginally above their BVs at two and four sampling depths (some consecutive depths), respectively. Concentrations of barium and zinc decreased to less than their respective BVs at the deeper sampling intervals. Distributions of copper, barium, and zinc in samples taken from borehole 54-01009 were similar to those noted for borehole 54-01007. Based on this analysis, the vertical extent of copper, chromium, and zinc has not been established.

Shafts 29 through 34. This shaft field is located on the west end of MDA L and was evaluated using data from borehole 54-01008, a vertical 150-ft borehole located about 20 ft to the southeast of Shafts 29 through 34. The inorganic chemicals measured at concentrations above background included copper, zinc, and chromium. Copper concentrations exceeded the BVs in a majority of the samples (10 of 12); concentrations detected were more than 10 times the BV. Zinc and chromium were detected at three or more consecutive sampling depths at concentrations exceeding their BVs by a factor of two or less. Manganese and cobalt concentrations above their BVs were reported at two consecutive sampling depths: manganese was marginally above its BV, and one cobalt concentration was more than twice the BV. Based on this analysis, it was concluded the vertical extent of chromium, cobalt, copper, manganese, and zinc have not been established beneath the western shaft group (Shafts 29 through 34). Figures 10, 11, and 12 show the concentrations for chromium, copper, and zinc.

4.1.2 Nature and Extent of Tritium Vapor Plume

Core samples from seven boreholes were analyzed for tritium. Five shallow boreholes (up to 60 ft bgs) were angled beneath Pit A and Impoundments B, C, and D (Figure 5). Two deep angled boreholes (54-01015 and 54-01016) were drilled beneath Shafts 1 through 34 and Pit A (Figure 5). The tritium sample results for the shallow boreholes beneath Pit A ranged from 0.03 pCi/g to 11.6 pCi/g, and concentrations decreased with depth. Tritium was detected twice at very low concentrations in the deep, angled boreholes. Tritium was detected at 0.13 pCi/g at approximately 524 ft in borehole 54-01015, and detected at 0.001 pCi/g at approximately 593 ft in borehole 54-01016. A tritium release beneath MDA L was evident from the sampling results (Figure 13). The data from the deep angled borehole indicates that the vertical extent of the tritium contamination is bounded.

4.1.3 Extent of Perchlorate, Nitrate, and High-Explosive Contamination in Tuff at MDA L

Tuff samples collected from MDA L during the Phase I RFI were not analyzed for perchlorate, nitrates, and HE. Nitrates and perchlorate are very soluble and, therefore, susceptible to migration with infiltrating surface water. Nitrates are associated with fertilizers and are 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. Hence, from the perspectives of potential occurrence in disposed waste at MDA L and mobility of contaminants, analysis for nitrates and perchlorate in core samples collected from new boreholes is appropriate.

Some HE compounds are also relatively soluble in water and subject to transport from the disposed waste. However, the presence of HE in appreciable quantities in the disposed waste at MDA L is unlikely because it has always been Laboratory policy to “flash” (burn) HE-contaminated material prior to disposal. However, because disposal records at MDA L are incomplete and because certain HE compounds are relatively soluble, samples collected from the new boreholes should be analyzed for HE.

4.1.4 Potential Presence of Perched Groundwater Beneath MDA L

There is no site-specific information on intermediate-depth groundwater to determine whether perched groundwater exists beneath MDA L. The deepest Phase I RFI borehole sited on Mesita del Buey is 54-01004, located approximately 150 ft southeast of MDA L; it extends to a depth of approximately 340 ft bgs. The nearest well completed in the regional aquifer, R-22, is approximately 1 mi east of MDA L (Figure 4). No evidence of a zone of saturation (i.e., perched water) was found in borehole 54-01004 or in R-22. However, perched groundwater may be highly localized and the presence of groundwater beneath MDA L at depths below 340 ft has not been definitively determined.

4.1.5 Hydrogeologic Properties and Fracture Characteristics of the Vadose Zone at MDA L

Information relating to hydrogeologic properties and fracture characteristics is necessary for evaluating the potential transport of contaminants in the vadose zone tuff beneath MDA L. The Bandelier Tuff consists of several units with differing hydrogeologic properties and different fracture characteristics. Fractures in the tuff are evident only in the Tshirege Member, which consists of units 2 and 1 at MDA L, as described in Appendix L. Within these units, information relating to whether contamination is primarily associated with fractures or the tuff matrix is needed to evaluate the potential extent of past or future liquid-phase transport in the tuff. Additional information pertaining to the fractures needed to validate transport modeling in the tuff includes fracture density, fracture orientation and angle, fracture aperture, and fracture coatings or fill. Information on hydrogeologic properties of the vadose zone, including parameters such as saturated and unsaturated hydraulic conductivity, chloride-ion concentration, porosity, bulk density, matric potential, and moisture content, is also critical for modeling the potential transport of contaminants from the disposal units via liquid- or vapor-phase migration.

4.1.6 Information on Vapor-Phase VOC Plume Stability

Several organic chemicals were detected in subsurface tuff samples near Pit A and Shafts 1 through 28. The organic chemicals detected at concentrations near the estimated quantification levels (EQLs) are not reliably quantified. These measurements do not represent the extent of VOCs in the subsurface because the subsurface media (volcanic tuff) at MDA L contains almost no organic carbon, has a low moisture content, and has a low specific surface area. Therefore, the nature and extent of the vapor phase VOC plume at MDA L is best defined by sampling and analyzing pore-gas rather than by analyzing core samples.

The following statements can be made about to the nature and extent of the VOC release from MDA L:

- VOCs are transported from source areas mainly in the vapor phase;
- TCA is the dominant contaminant, followed by TCE;
- vertically, the plume extends between ground surface and the top of the basalt (approximately 320 ft bgs);
- laterally, the plume extends north-south about 1000 ft in diameter, and east-west it extends the width of the mesa (approximately 450 ft);
- the ratio of the major contaminants (TCA, TCE, and R-113 [Freon 113]) is approximately 1:0.3:0.2;
- the plume is changing very little in location or content with time; and
- vapor diffusion modeling fits the measured geographic distribution of TCA concentration.

Both field-screening results and analytical results indicate that the highest concentrations of vapor-phase VOCs exist nearest the two source areas (east side and west side of MDA L). Concentrations of vapor-phase VOCs decrease in all directions from the two source areas.

The analytical data for VOCs in pore gas define the organic chemicals present in the vapor phase plume. The suite of organic chemicals detected has remained consistent over time and the concentrations of the chemicals have decreased over time (Appendix B). Furthermore, the relative concentrations among the major organic chemicals have remained constant over time. Measurements prior to 1993 detected much higher concentrations of VOCs within the plume than those detected today, especially in the source area. However, historical screening and analytical methods did not produce consistent results and the methodologies were not well developed; therefore, the pre-1993 data are of limited use. A discussion of historical and present pore-gas sampling methodologies is provided in Appendix G. Sampling and analytical methods have greatly improved since the late 1990s, resulting in consistent, good quality data from both the analytical chemistry and B&K screening. These data allow for evaluation of trends within the plume.

Field-screening results using a B&K multigas analyzer show a VOC plume that is stable or decreasing in concentration (Figures 14, 15, and 16). Figures 14 and 15 show the lateral and vertical extent by the 10-ppm concentration contour. Outside this contour, concentrations drop rapidly to below the quantification capability of the B&K instrument; analytical samples from this region indicate TCA concentrations in the part per million (ppm) range. Since 1999, the long-axis plume aerial extent, defined by the 10-ppm contour, has varied between 700 and 1000 ft. The short-axis extent has not varied considerably because of the physical constraint of the mesa walls. Vertically, the maximum extent of the 10-ppm TCA contour is approximately 300 ft below the mesa top and has not varied noticeably since 1999. The 10-ppm TCA contour is approximately 650 ft above the regional aquifer. Analytical results and screening results from pore-gas monitoring boreholes with ports in the basalt located between the lower plume boundary and the regional aquifer have not consistently detected VOCs. The deepest TCA concentration measured in a SUMMA™ canister sample (MD54-99-0025) analyzed by an off-site contract laboratory is 0.083 ppm in borehole 54-01016 at a depth of 390 ft. Figure 16 shows the two-dimensional characteristic profile of the plume. Concentrations increase to a depth of approximately 85 ft below the surface of MDA L, followed by a decrease in concentrations through the total depth of the plume.

Figures 17, 18 and 19 present SUMMA™ canister data for the VOCs with the highest concentrations in the plume. These samples were collected each quarter from the same borehole locations. Figure 17 presents data from borehole 54-02002, which is representative of the eastern shaft field. Figure 18 presents data from borehole 54-02023, which is representative of a medium to low concentration zone of the plume. Figure 19 presents data from borehole 54-01015, which is representative of the plume at a greater depth (approximately 400 ft bgs). As illustrated in these figures, the concentrations of the top 11 detected VOCs have remained relatively constant over time or have decreased slightly. Therefore, it is concluded that the plume is in a near steady-state condition.

Stauffer et al. (2002, 69794) modeled the evolution of the vapor-phase VOC plume using a three-dimensional finite element program; the report is provided in Appendix I. An independent review of the report conducted by the Innovative Technology and Remediation Demonstration Program and studies of passive and active venting are provided in Appendix J. The model assumed vapor diffusion emanating from two source areas located at the two shaft fields at MDA L. It was calibrated using the quarterly pore-gas monitoring data. The resulting model closely matches the shape, concentration gradients, and extent of the plume as measured by existing data. In addition, the model predicts that the plume should be at or near steady state. This modeling supports the conclusion that the VOC plume exists predominantly in the vapor phase, the VOCs move by diffusion, and the plume is stable. Stauffer et al. (2002, 69794) also predicted the evolution of the plume over a 50-yr period. If the assumed source remains constant, the plume should not change in size and concentration appreciably during the simulation period, which further verifies the stability of the plume. If a constant source were not assumed, the plume would gradually decrease in size and concentration over time.

Any remaining intact drums may rupture and add to the source of the plume. Since it is not possible to determine how many drums of liquid hazardous constituents remain intact in the shafts at MDA L, it is not possible to assume a constant or decreasing source term. Therefore, it will be necessary to monitor the stability of the vapor-phase VOC plume over time.

4.1.7 Channel Sediments

Phase I RFI analytical data showed that channel sediment samples at MDA L contained low concentrations of methoxyclor and plutonium-238. A location near previous Phase I RFI sediment sample location 54-05148 will be selected to collection a supplemental channel sediment sample to complete the characterization of the channel that drained storm water from the surface of MDA L before it was paved.

4.2 Proposed Sampling and Analysis Activities to Address Data Gaps

Acquisition of data to address the gaps described in Section 4.1 require drilling four additional boreholes to collect subsurface core, VOC pore-gas, and tritium samples. The key components of the drilling and sampling program are the location, depth, and angle of boreholes, sample collection methods and frequency of sampling, and the analytical suites requested. The proposed drilling and sampling program uses information from the existing Phase I RFI boreholes, surface flux, and pore-gas sampling results to delineate these components. The borehole locations were selected to provide the additional data required to determine the nature and extent of contamination in the subsurface of MDA L.

The technical approach and rationale for the drilling and sampling activities related to the seven data gaps described in Section 4.1 are discussed below. A summary of these drilling and sampling activities is provided in Table 2. The locations and cross sections of the proposed boreholes in relation to the disposal units at MDA L and the existing boreholes are shown in Figure 20. Figures 21 through 24 illustrate profiles of the four proposed characterization boreholes with planned sample locations and depths.

4.2.1 Proposed Drilling and Sampling to Address Data Gap 1

Impoundment D. One angled borehole (borehole A, Figure 21) will be advanced beneath Impoundment D to determine the vertical extent of metal contamination. Borehole A will be sited to the south of Impoundment D and will be advanced towards the northeast beneath the long axis of the impoundment. This siting is proposed because of the limited space between surface structures and fencing at MDA L. Borehole A will also be angled so that samples can be collected beneath locations in RFI borehole 54-01014 to determine the vertical extent of metals contamination.

Impoundments B and C. One angled borehole (borehole B, Figure 22) will be advanced beneath these impoundments to determine the vertical extent of metal contamination. It will be sited to the southeast of Impoundment B and advanced towards the northwest, passing beneath Impoundments B and C. This siting is proposed because of the limited space between surface structures and fencing at MDA L. This borehole will also be angled to allow for collection of samples from depths beneath the Phase I sample collection depths in RFI boreholes 54-01012 and 54-01013 to determine the vertical extent of metals contamination.

Shafts 29 through 34. One steeply angled borehole (borehole C, Figure 23) will be advanced beneath these shafts to determine the vertical extent of metals contamination. Borehole C will be sited between Shafts 30 and 34 and advanced northwest towards Shaft 29. A FLUTe™ liner will also be installed in this borehole for monitoring of pore gas in the northwest shaft field.

Shafts 1 through 28. One vertical borehole (borehole D, Figure 24) will be drilled immediately east of these shafts. Samples will be collected from the augured portion (approximately 300 ft) of this borehole to determine the vertical extent of metal contamination. The borehole is located within 50 ft of Shafts 1 through 5 and at the down-slope end of the shaft group (Figure 20).

All angled boreholes will pass no closer than 15 ft from any disposal unit. Before final siting of these boreholes, historical disposal records and RFI borehole logs will be examined to ensure that boreholes will not be advanced through the disposal units.

Tuff samples will be collected approximately every 30 linear ft down the boreholes, once the borehole passes beneath an impoundment or shaft. However, actual sampling will be biased according to the presence of fractures and/or the results of radiation field screening. Fractures will be used to bias sampling because they may play a role as conduits for liquid transport. Where fractures are encountered, paired samples of the fracture and the tuff matrix near the fracture will be obtained to evaluate whether potential contamination has migrated predominantly in fractures. This paired sampling is described in Section 5.3.

Tuff samples collected from boreholes A, B, and C will be submitted to an off-site contract laboratory for analysis of isotopic uranium, isotopic plutonium, americium-241, strontium-90, radionuclides by gamma spectroscopy (including cesium-134, cesium-137, cobalt-60, europium-152, ruthenium-106, and sodium-22), TAL metals and cyanide, HE (a subset of samples; see Section 4.2.3), nitrates, and perchlorate. Protocols for collecting tuff samples from boreholes A, B, and C are described in Section 5.1.2.

Required analytical detection limits for metals, cyanide, radionuclides, nitrates, perchlorate, and HE compounds are driven by the need to measure concentrations below BVs accurately, if these values are available. Detection limits for analytical methods specified by contract requirements of the Laboratory's analytical statement of work (SOW) are adequate for this purpose (LANL 2000, 71233).

4.2.2 Proposed Drilling and Sampling to Address Data Gap 2

In situ subsurface samples will be collected from pore gas to determine the lateral extent of the subsurface tritium release at MDA L. Samples will be collected as water vapor by pulling pore gas through columns filled with absorbent silica gel. A minimum of two tritium pore-gas samples will be collected in the following boreholes: 54-02002, 54-02014, 54-02016, 54-02020, 54-02021, 54-02022, 54-02023, 54-02025 and proposed boreholes A, B, and C to sample the center and boundaries of the potential plume.

Tritium in water extracted from the core sample will be measured by EPA Method 906.0. At gravimetric moisture contents less than 10%, a 3-in. length of 2-in.-diameter core will yield less water than the minimum required volume of 5 mL. To reach the necessary volume, the analytical laboratory adds de-ionized water to the extracted water. The analytical laboratory then corrects the reported activity and uncertainty resulting from the dilution. Therefore, any moisture from a core sample lost before analysis may substantially increase the uncertainty of the measurement. In addition, the method requires grinding the core material to a fine mesh before the water is extracted; thus, moisture loss is inevitable. Given these concerns, RRES-RS has concluded that tritium is best characterized in low moisture content environments using sorbent materials to extract and retain in situ subsurface water samples from pore gas.

4.2.3 Proposed Sampling to Address Data Gap 3

The NMED has requested additional analytical suites for subsurface tuff samples because certain analytes were not included in the Phase I RFI analytical suites. These analytes include HE, dioxins/furans, nitrates, and perchlorate. The rationale for analyzing HE, nitrates, and perchlorate is presented in Section 4.1.3. PCBs and semivolatile organic compounds (SVOCs), which were not detected in Phase I RFI tuff samples, are characterized by low solubilities in water. To an even greater extent, low solubility is also characteristic of dioxins and furans. Hence, the presence of these four classes of chemicals in subsurface tuff in appreciable quantities as a consequence of dissolution in water is highly unlikely. A review of waste inventory records does not indicate the presence of dioxins or furans in the disposed waste or provide evidence that chemicals had been burned (Appendix K). Therefore, dioxins and furans will not be included the analytical suite. All tuff samples collected from boreholes A through C will be analyzed for nitrates and perchlorate.

Core collected from 30-ft intervals will be screened using immunoassay test kits for nitroaromatics (e.g., trinitrotoluene [TNT]) and nitrosamines (e.g., 1,3,5-trinitro-1, 3,5-triazacyclohexane [RDX]). Screening samples will be biased toward fractures, visibly stained media, paleosols, and core with elevated radioactivity field-screening results. These test kits (D-Tech) have a low detection limit (ppm range in soil) and have proven effective in biasing samples for laboratory analysis (LANL 1997, 55653). Of the tuff samples to be collected from boreholes A through C, at least three samples will be screened for HE. Because real-time qualitative results will be obtained in the field with the immunoassay test kits, 20% of the core samples will be submitted to an off-site contract laboratory for analysis of HE to verify immunoassay field-screening results and define the nature and extent of contamination. The lower sampling frequency reflects the low probability of encountering HE at MDA L.

4.2.4 Proposed Sampling to Address Data Gap 4

A single, vertical borehole (borehole D, Figure 24) will be drilled to a depth of 700 ft in the area immediately outside of the eastern boundary of MDA L to determine whether perched groundwater is present beneath MDA L. Borehole D is proposed for an area immediately east of MDA L within 100 ft of the eastern shaft field. The borehole site is adjacent to the eastern storm water discharge channel and downgradient of MDA L to provide the best chance of encountering perched water. Sampling of this borehole is described in Section 4.2.5 of this IWP.

4.2.5 Proposed Sampling to Address Data Gap 5

Geotechnical samples will be collected from borehole D to support transport modeling by characterizing site-specific hydrogeologic properties at MDA L. The geotechnical properties to be analyzed include saturated and unsaturated hydraulic conductivity, chloride-ion concentration, porosity, bulk density, matric potential, and moisture content. After drilling, borehole D will be logged for moisture content using a neutron probe. Logging will be conducted at 1-ft intervals to total depth following the applicable standard operating procedures (SOPs). A detailed profile of moisture content will ensure an adequate data set for calibrating a neutron probe for moisture logging. A profile of matric 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 will also support modeling of liquid migration in the vadose zone. Tuff samples for analysis of chloride-ion concentration will support evaluation of the rates of water infiltration and evaporation.

4.2.6 Proposed Sampling to Address Data Gap 6

As discussed in Section 4.1.5, the continued monitoring of the vadose zone VOC plume beneath MDA L is required. To supplement the current pore-gas monitoring program, borehole C will be completed as a vapor monitoring well by installing a FLUTe™ soil-gas sampling positive-pressure membrane. This borehole will then be incorporated into the proposed pore-gas monitoring program at MDA L (Section 6).

4.2.7 Proposed Sampling to Address Data Gap 7

To complete the characterization of the drainage channel, one sediment sample will be collected at the interface of the alluvial sediments and bedrock (Figure B-2) and submitted to an off-site contract laboratory for analysis of TAL metals and cyanide, pesticides/PCBs, nitrates, perchlorate, americium-241, isotopic plutonium, isotopic uranium, strontium-90, and tritium.

5.0 INVESTIGATION METHODS

The following RRES-RS SOPs 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 Transporting Field Samples
- LANL-ER-SOP-1.04, Rev 4, Sample Control and Field Documentation
- LANL-ER-SOP-1.05, Rev. 0, Field Quality Control Samples
- LANL-ER-SOP-1.08, Rev. 1, Field Documentation of Drilling and Sampling Equipment
- LANL-ER-SOP-3.11, Rev 1, Geodetic Surveys
- LANL-ER-SOP-4.01, Rev. 1, Drilling Methods and Drill Site Management
- LANL-ER-SOP-5.07, Rev. 0, Operation of LANL Owned Borehole Logging Trailer
- LANL-ER-SOP-5.03, Rev. 2, Monitoring Well and RFI Borehole Abandonment
- LANL-ER-SOP-6.09, Rev. 1, Spade and Scoop Method for Collection of Soil Samples
- LANL-ER-SOP-6.14, Rev. 0, Sediment Material Collection
- LANL-ER-SOP-6.26, Rev. 1, Core Barrel Sampling for Subsurface Earth Materials
- LANL-ER-SOP-6.31, Rev. 1, Atmospheric and Sub-Atmospheric Air Sampling
- 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 Material

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

5.1 Methods for Drilling and Sampling Boreholes A through C

5.1.1 Drilling Protocol

Boreholes A through C will be drilled using the hollow-stem auger method because it allows for collecting undisturbed samples of core and subsurface vapors within the Tshirege Member of the Bandelier Tuff.

Borehole profiles for boreholes A through C illustrate their location relative to disposal units in Figures 20 through 23. The depth, angle, and sampling protocol for each borehole are described in Table 2. Each borehole will be continuously cored using a split-barrel sampler to total depth. Core will be screened for radiation and organic vapors, visually inspected, and geologically logged. The total depth of boreholes may increase if field screening indicates elevated readings of radionuclides and organic vapors. The boreholes will be located in the approximate areas shown in Figure 20. The proposed location of each borehole has been determined by best estimates of impoundment and shaft boundaries from historical documents and RFI borehole logs. Other factors such as the presence of utilities and access restrictions will also affect the exact location of each borehole.

5.1.2 Collection of Core Samples

Subsurface core samples will be collected from the split-barrel sampler into sealed sleeves or core-protect bags to preserve the moisture content of the core. The analytical suites for samples to be collected from each borehole are listed in Table 2. The frequency of sampling and orientation to disposal units is displayed in Figures 21 through 23.

Tuff samples will be collected at least every 30 ft in boreholes A, B, and C; the first samples will be collected at the depth of the target disposal unit, and the last sample will be collected at total depth of each borehole. Samples will be collected from intervals where contamination is suspected because of elevated field screening measurements and/or fractures or staining identified by visual inspection.

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. A discussion of paired fracture sampling is in Section 5.3.

Tuff samples from boreholes A through C will be analyzed for TAL metals and cyanide, HE, nitrates, perchlorate, and radionuclides (americium-241, strontium-90, isotopic uranium, isotopic plutonium, and gamma spectroscopy radionuclides) using analytical methods specified by contract requirements of the Laboratory’s Analytical SOW (LANL 2000, 71233).

QA/QC samples will include field duplicate samples collected following the applicable SOPs listed in Section 5.1. To confirm decontamination procedures, rinsate blanks will also be collected.

5.1.3 Collection of Pore-Gas Samples

Subsurface vapor samples will be collected from boreholes A through C at the depth of the nearest adjacent disposal units and from the bottom of the borehole for analysis of VOCs and tritium. Vapor samples will be collected 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. Subsurface vapor samples will be collected in SUMMA™ canisters and submitted for analysis using EPA Method TO-14 for VOCs. In situ subsurface water samples will be collected on silica gel in sealed columns and submitted for analysis using EPA Method 906.0 for tritium.

QA/QC samples for VOCs and tritium in pore gas will consist of an equipment blank and a field duplicate. The equipment blank will be collected through the packer sampling apparatus, after sampling and purge decontamination, to observe potential cross contamination. The field duplicate sample will indicate the precision of collection and analysis.

5.1.4 Borehole Completion

Once borehole C is drilled and sampled and core and initial pore-gas samples are collected, the borehole will be completed as a vapor-monitoring borehole. A FLUTe™ soil-gas sampling positive-pressure membrane will be installed, and the borehole will be incorporated into the pore-gas monitoring network.

Boreholes A and B will remain open at depth and sealed at the surface with a capped steel casing. These boreholes will remain available for vapor extraction or monitoring as necessary beneath Impoundments B, C, and D.

5.2 Methods for Drilling and Sampling Borehole D

5.2.1 Drilling Protocol

A single, vertical borehole will be drilled to a depth of 700 ft just east of the MDA L boundary. The location and depth of the borehole were selected to determine whether perched groundwater is present below MDA L.

Hollow-stem auger drilling will be used until refusal (at least 280 ft bgs) because auger drilling results in collecting undisturbed samples of core within the Tshirege Member of the Bandelier Tuff. Upon drill refusal, air-rotary drilling will be deployed to complete the borehole. The coupling of these drill methods is practical and allows the objectives of the sampling for this borehole to be met. The vertical borehole will be continuously cored with a split-barrel sampler to 700 ft bgs. Core will be radiologically screened, visually inspected, and geologically logged. The borehole will be located in the approximate location shown in Figure 20. The proposed location of this borehole has been determined by best estimates of impoundment and shaft boundaries and RFI borehole logs. Other factors such as the presence of utilities and access restrictions will also affect the exact location of each borehole.

5.2.2 Collection of Tuff Samples

Subsurface tuff samples will be collected from the split-barrel sampler into sealed sleeves or core-protect bags to preserve the core moisture content. The analytical suites for the borehole samples are listed in Table 2. The frequency of sampling and orientation to disposal units is shown in Figure 24.

Tuff samples will be collected at the depth of the target disposal unit and from the Cerro Toledo interval, approximately 280 ft below MDA L. Samples will also be collected from intervals where contamination is suspected because of elevated field screening and/or identification of fractures, staining or paleosols. 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. Section 5.3 discusses the paired fracture sampling method.

Two tuff samples from borehole D will be analyzed for TAL metals and cyanide, HE compounds, nitrates, perchlorate, and radionuclides (americium-241, strontium-90, isotopic uranium, isotopic plutonium, and gamma spectroscopy radionuclides) using analytical methods specified by contract requirements of the Laboratory’s analytical SOW (LANL 2000, 71233). QA/QC samples will include field duplicate samples that will be collected following the applicable SOPs listed in Section 5.1. To confirm decontamination procedures, rinsate blanks also will be collected.

5.2.3 Collection of Geotechnical and Hydrogeological Samples

Moisture content and matric potential samples will be collected every 5 ft from borehole D and samples for chloride analysis will be collected every 10 ft. Samples for saturated and unsaturated hydraulic conductivity, porosity, and bulk density analyses will be collected once in each tuff unit and twice from the Cerro Toledo interval, and at five depths in the Otowi Member. Five samples will also be collected from the Puye Formation. The samples collected from the Cerro Toledo interval, Otowi Member, and 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 the methods specified by contract requirements of the Laboratory's analytical SOW (LANL 2000, 71233). One field duplicate sample will be collected and analyzed. Samples will be collected, handled, packaged, and analyzed in accordance with applicable Laboratory SOPs.

5.3 Collection of Paired Fracture Samples

Empirical evidence of the role of fractures in facilitating contaminant transport in tuff will be obtained by collecting paired samples of fracture material and tuff matrix when tuff fractures are encountered during drilling. Because fracture fill may not be present, or may exist in minute quantities, fracture samples will include 3 in. of tuff both above and below the fracture. Detailed descriptions and photographs will be made for each fracture sample. To compare contaminant concentrations between fractured and unfractured tuff, a second sample of unfractured tuff will be collected 24 in. above the fracture sample (Figure 25). These paired samples collected from boreholes A, B, C, and D will be submitted to an offsite contract laboratory for analysis of isotopic uranium, isotopic plutonium, americium-241, strontium-90, radionuclides by gamma spectroscopy (including cesium-134, cesium-137, cobalt-60, europium-152, ruthenium-106, and sodium-22), TAL metals and cyanide using analytical methods specified by contract requirements of the Laboratory's analytical SOW (LANL 2000, 71233). This method of fracture collection and analyses provides information about potential preferred pathways of contaminant transport beneath MDA L.

5.4 Collection of Pore Gas for Tritium Analyses

Pore-gas samples for tritium analyses will be collected from ports in boreholes 54-02002, 54-02014, 54-02016, 54-02020, 54-02022, 54-02023, 54-02025, and proposed boreholes A, B, and C. These samples will be collected by pulling pore gas through columns filled with absorbent silica gel according to LANL-ER-SOP 6.31, Revision 1, and analyzed at an off-site fixed laboratory by EPA Method 906.0. QA/QC samples will be collected per applicable SOPs.

5.5 Collection of Sediment Sample

The sediment sample will be collected in accordance with LANL-ER-SOP-6.09, Rev. 1, Spade and Scoop Method for Collection of Soil Samples.

6.0 MONITORING AND SAMPLING PROGRAM

An investigation report will be prepared following implementation of this work plan. The investigation report will contain recommendations for future activities at MDA L, including any monitoring and sampling program beyond those described in Sections 4 and 5 of this IWP.

An interim monitoring program is recommended for MDA L to replace the current quarterly pore-gas monitoring program required by Module VIII of the Laboratory's Hazardous Waste Facility permit. The current quarterly pore-gas monitoring program focuses on defining the nature and extent of the vapor phase VOC plume for the RFI. While the historic investigation report concludes that the nature and extent of the VOC vapor phase plume has been defined, the plume will continue to be monitored to ensure that it behaves as predicted and to detect any potential release from the source area.

For the last two years, the quarterly pore-gas monitoring program has focused on collecting samples from the same locations and depths during each event. This data set will allow for statistical trend analysis of concentration and analyte through time from locations within the MDA L plume. Results for these samples have been reported in the RRES-RS quarterly technical reports (LANL 2002, 73712). A summary of the trend analysis will be included in the fiscal year (FY) 2003 annual report in October 2003.

The proposed interim pore-gas monitoring program will monitor the source areas and the vertical extent of the VOC vapor plume annually; the lateral extent of the plume will be monitored biannually. Sampling on an annual basis versus quarterly monitoring is adequate to detect changes in extent and identify potential new releases. Biannual sampling at the lateral perimeter of the plume is sufficient to confirm estimates of long-term extent. Boreholes 54-02002, 54-02014, and proposed borehole C will be used to monitor the source areas and the vertical extent of the plume. Boreholes 54-02021, 54-02022, and 54-02034 will be used to monitor the western extent of the plume, while boreholes 54-02020, 54-0024, and 54-02027 will be used to monitor the eastern extent of the plume. Figure 26 shows the locations of the current and proposed boreholes at MDA L, and Table 3 contains a summary of monitoring borehole vapor port depths, and the frequency of sampling. Samples will be collected using SUMMA™ canisters from all available ports in the monitoring boreholes, and will be completed using the latest revision of LANL-ER-SOP 6.31, Sampling of Sub-Atmospheric Air. The laboratory analysis method for the SUMMA™ samples is EPA TO-14. Once NMED approves a revised vapor-monitoring plan, the Laboratory will submit a Class III permit modification request.

Data collected from the monitoring boreholes will be evaluated for plume changes that are not consistent with the conceptual and computer models for new releases and will provide data for evaluating alternatives for plume remediation/containment in the CMS. A new release could be identified by changes in long-term trends, changes in the relative concentration of contaminants (e.g., ratio of TCA to PCE), or the appearance of a new contaminant.

7.0 SCHEDULE

The MDA L IWP will be submitted to NMED on August 29, 2003. Assuming a 90-day NMED review period, and 45 days to resolve comments between NMED and the Laboratory, field activities will start on February 1, 2004. Field activities, including drilling and sampling, will take approximately four weeks. Pore-gas monitoring borehole C will be instrumented during week 5 and samples will be collected in week 6.

The investigation report is scheduled for submittal to NMED on December 23, 2004.

8.0 REFERENCES

The following list includes all references cited in this document. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of actual documents at the RRES-RS Records Processing Facility.

Birdsell, K. H., A. V. Wolfsberg, D. Hollis, T. A. Cherry, and K. M. Bower, September 1, 1995. “Numerical Modeling of Unsaturated Groundwater Flow and Radionuclide Transport at MDA G,” Los Alamos National Laboratory document LA-UR-95-2735, Los Alamos, New Mexico. (Birdsell et al. 1995, 70012)

Birdsell, K. H., A. V. Wolfsberg, D. Hollis, T. A. Cherry, and K. M. Bower, June 2000. “Groundwater Flow and Radionuclide Transport Calculations for a Performance Assessment of a Low-Level Waste Site,” *Journal Of Contaminant Hydrology*, Vol. 46, pp. 99–129. (Birdsell et al. 2000, 69791)

Conant, B. H., January 1996. “Vapor Transport of Trichoroethylene in the Unsaturated Zone: Field and Numerical Modeling Investigations,” *Water Resources Research*, Vol. 32, No. 1, pp. 9–22. (Conant 1996, 64608)

Cordell, L., 1979. “Gravimetric Expression of Graben Faulting in Santa Fe County and the Española Basin, New Mexico,” New Mexico Geological Society Guidebook, 30th Annual Field Conference, Santa Fe, New Mexico, pp. 59–64. (Cordell 1979, 76049)

DOE (US Department of Energy), February 1987. Engineering Drawing ENG-C-45259, number LA-ZU-B-C4, prepared by Black and Veatch for the US Department of Energy, Los Alamos Area Office, Los Alamos, New Mexico. (LASL 1987, 25606)

EPA (US Environmental Protection Agency), May 23, 1990. “Transmittal of Hazardous Waste Permit for Los Alamos National Laboratory (NM0890010515),” Los Alamos, New Mexico. (EPA 1994, 44146)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 1585)

Eklund, B., March 15, 1995. "Measurement of Emission Fluxes from Technical Area 54, Areas G and L, Final Report," prepared under DOE Subcontract No. 63545L0014-31 by Radian Corporation, Austin, Texas. (Eklund 1995, 56033)

Freeze, R. A., and J. A. Cherry, 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey. (Freeze and Cherry 1979, 64057)

Glatzmaier, T. June 1994. “Proposed Modification to the Resource Conservation and Recover Act (RCRA) Facility Investigation (RFI) for Operable Unit (OU) 1148,” Los Alamos National Laboratory letter (EM/ER:94-A199) to T. Taylor, DOE-LAAO, from T. Glatzmaier, EM, Los Alamos, New Mexico. (Glatzmaier 1994, 52015)

Jansen, J., and T. Taylor, July 17, 1996. “Modification to Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1148, Field Unit 5, MDA G,” Los Alamos National Laboratory letter (EM/ER:96-234) to B. Garcia, NMED, from J. Jansen, LANL (ER/EM) and T. Taylor, DOE, Los Alamos, New Mexico. (Jansen and Taylor 1996, 54959)

LANL (Los Alamos National Laboratory), 1987. “Hydrogeologic Assessment of Technical Area 54, Areas G and L, Los Alamos National Laboratory,” Docket Number NMHWA 001007, Los Alamos, New Mexico. (LANL 1987, 76068)

LANL (Los Alamos National Laboratory), September 1992. “Operable Unit 1148 Data Report,” Los Alamos, New Mexico. (LANL 1992, 23247)

LANL (Los Alamos National Laboratory), July 1991. “Review of Soil Vapor Sampling Wells and Data from TA-54 Areas G and L, Los Alamos National Laboratory,” Los Alamos, New Mexico. (LANL 1991, 11729)

LANL (Los Alamos National Laboratory), May 1992. "RFI Work Plan for Operable Unit 1148," Los Alamos National Laboratory document LA-UR-92-855, Los Alamos, New Mexico. (LANL 1992, 7669)

LANL (Los Alamos National Laboratory), 1993. Engineering Drawing AB-113, number C1, prepared by Johnson Controls for Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 1993, 76052)

LANL (Los Alamos National Laboratory), June 1994. “Laboratory Analysis of Soil Hydraulic Properties of Boreholes 54-1001, 1002, 1003, and 1006,” prepared by Daniel B. Stephens & Associates, Inc., Albuquerque, New Mexico. (LANL 1994, 76071)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for Channel Sediment Pathways from MDAs G, H, J, and L, TA-54,” Los Alamos National Laboratory document LA-UR-96-110, Los Alamos, New Mexico. (LANL 1996, 54462)

LANL (Los Alamos National Laboratory), March 1997. "Performance Assessment and Composite Analysis for Los Alamos National Laboratory Material Disposal Area G," Los Alamos National Laboratory document LA-UR-97-85, Los Alamos, New Mexico. (LANL 1997, 63131)

LANL (Los Alamos National Laboratory), March 1997. “Voluntary Corrective Action Plan for Potential Release Sites at TA-16 16-005(d), 16-006(g, h), 16-013, 16-017, 16-025(x), 16-026(q), 16-029(g2, h2, w, x), 16-031(c, d), 16-034(p), C-16-065, C-16-068, C-16-074 Field Unit 3,” Los Alamos National Laboratory document LA-UR-97-640, Los Alamos New, Mexico (LANL 1997, 55653)

LANL (Los Alamos National Laboratory), May 22 1998. “Hydrogeologic Workplan,” Los Alamos, New Mexico. (LANL 1998, 59599)

LANL (Los Alamos National Laboratory), September 1998. “Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 59730)

LANL (Los Alamos National Laboratory), November 1998. “Installation Work Plan for the Environmental Restoration Project,” Revision 7, Los Alamos National Laboratory document LA-UR-98-4653, Los Alamos, New Mexico, (LANL 1998, 62060)

LANL (Los Alamos National Laboratory), December 2000. “University of California Los Alamos National Laboratory (LANL) I8980SOW0-8S Statement of Work for Analytical Laboratories, December 2000,” Rev. 1, Los Alamos, New Mexico. (LANL 2000, 71233)

LANL (Los Alamos National Laboratory), August 01, 2002. “TA-54 Storm Water Pollution Prevention Plan,” Plan-WFM-036, Rev.0, Los Alamos, New Mexico. (LANL 2002, 74009)

LANL (Los Alamos National Laboratory), November 2002. “Quarterly Technical Report: July–September 2002,” Los Alamos National Laboratory document LA-UR-02-6976, Los Alamos, New Mexico. (LANL 2002, 73712)

LANL (Los Alamos National Laboratory), August 2003. TA-54, Area G, Los Alamos National Laboratory, Logbooks from January 1966 to January 1996, RRES Record Package 661, Los Alamos New Mexico. (LANL 2003, 76036)

NMEID (New Mexico Environmental Improvement Division), May 1985. In the Matter of LANL EPA ID #NM0890010515, Docket Number NMHWA 001007, Compliance Order/Schedule. (NMEID 1985, 75885)

Nyhan, J. W., June 1978. “Soil Survey of Los Alamos County, New Mexico,” Los Alamos National Laboratory report LA-6779-MS, Los Alamos, New Mexico. (Nyhan 1978, 5702)

Nylander, C. L., K. A. Bitner, G. Cole, E. H. Keating, S. Kinkead, P. Longmire, B. Robinson, D. B. Rogers, and D. Vaniman, March 2003. “Groundwater Annual Status Report for Fiscal Year 2002,” Los Alamos National Laboratory document LA-UR-03-0244, Los Alamos, New Mexico. (Nylander et al. 2003, 76059)

Purtymun, W. D., January 1984. “Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Groundwater Supplies,” Los Alamos National Laboratory report LA-9957-MS, Los Alamos, New Mexico. (Purtymun 1984, 6513)

Purtymun, W. D., January 1995. “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area,” Los Alamos National Laboratory report LA-12883-MS, Los Alamos New Mexico. (Purtymun 1995, 45344)

Quadrel (Quadrel Services, Inc.), September 1993. “EMFLUX® Soil-Gas Survey of Technical Area 54 (MDA G) Los Alamos National Laboratory,” Quadrel Report Number QS1135, Maryland Spectral Services, Inc., Forest Hill, Maryland. (Quadrel 1993, 63868)

Quadrel (Quadrel Services, Inc.), September 1994. “EMFLUX® Soil-Gas Survey of Technical Area 54, Los Alamos National Laboratory,” Quadrel Report Number QS1190, Maryland Spectral Services, Inc., Forest Hill, Maryland. (Quadrel 1993, 63869)

Reneau, S., and D. Vaniman, December 1998. "Fracture Characteristics in a Disposal Pit on Mesita del Buey, Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13539-MS, Los Alamos, New Mexico. (1998, 63135)

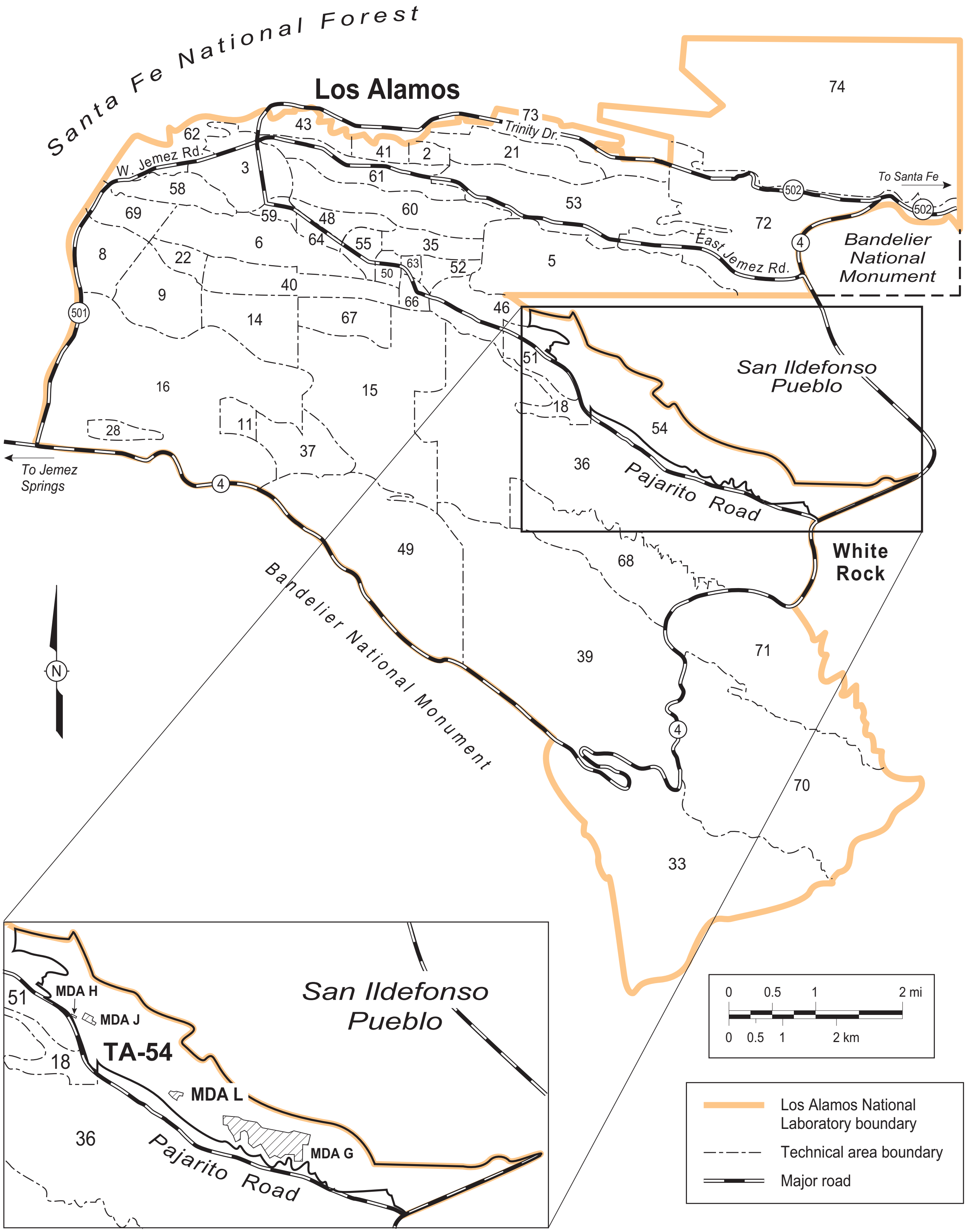
Rogers, M. A., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory report LA-6848-MS, Volume I, Los Alamos, New Mexico. (Rogers 1977, 5707)

Rogers, M., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory report LA-6848-MS, Volume II, Los Alamos, New Mexico. (Rogers 1977, 5708)

Stauffer, P., K. Birdsell, M. Witkowski, T. Cherry, and J. Hopkins, April 2000. “Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions,” Los Alamos National Laboratory document LA-UR-00-2080, Los Alamos, New Mexico. (Stauffer et al. 2000, 69794)

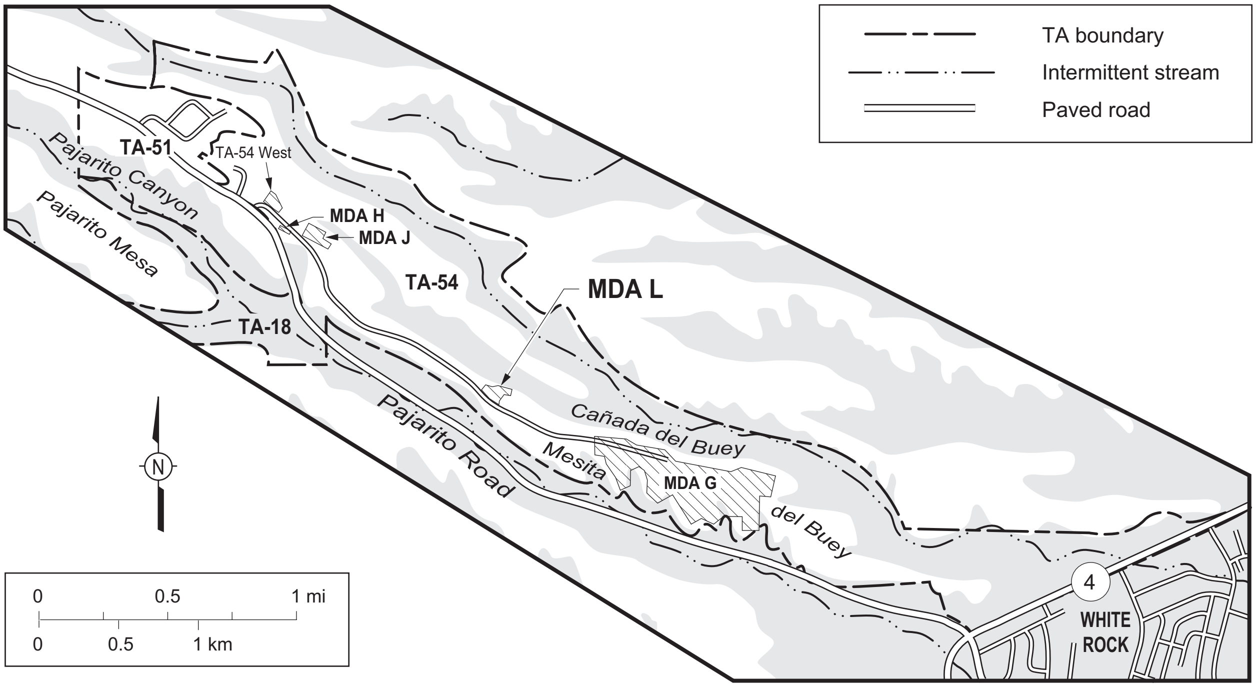
Trujillo, V., R. Gilkeson, M. Morgenstern, and D. Krier, June 1998. “Measurement of Surface Flux Rates for Volatile Organic Compounds at Technical Area 54,” Los Alamos National Laboratory report LA-13329, Los Alamos, New Mexico. (Trujillo et al. 1998, 58242)

Turin, H., and N. Rosenberg, January 1996. “A Conceptual Model for Flow in the Vadose Zone Beneath the Finger Mesas of the Pajarito Plateau,” in New Mexico Geological Society 48th Annual Field Conference, September 25–28, 1996, F. Goff, et al. eds., Santa Fe, New Mexico. (Turin and Rosenberg 1996, 63559)



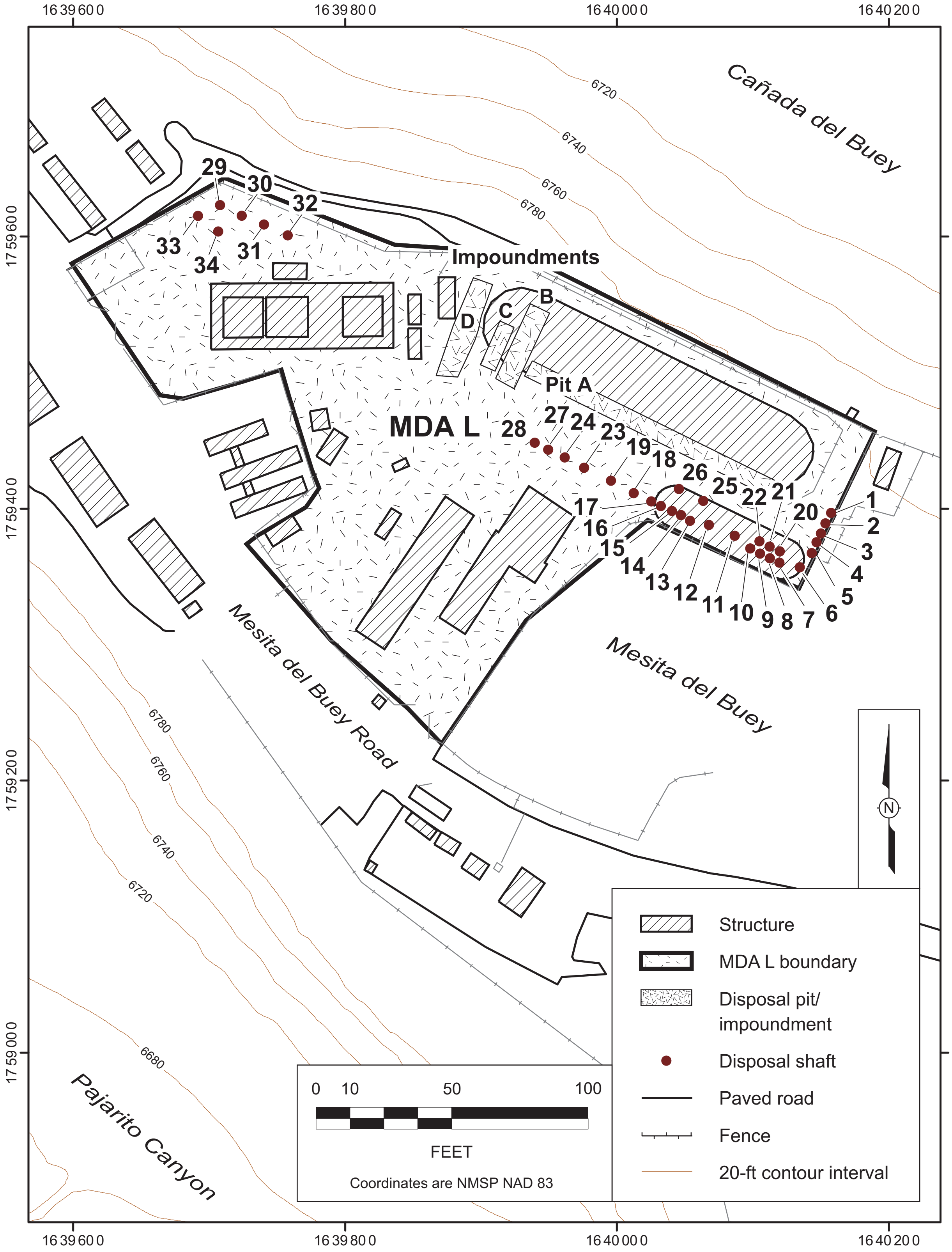
F1.2-1, MDA H RSI, 122001, RLM_Rev. for F1, MDA L IWP, 082203, cf

Figure 1. **Location of MDA L within TA-54 with respect to other Laboratory TAs and surrounding land holdings**



Source: A. Kron_MDA L RFI Rpt., 120302, PTM_Rev. for F2, MDA L IWP, 073103, cf

Figure 2. **Location of MDA L within TA-54**



Source: RRES-RS map R03074, 082003, MO_Rev. for F3, MDA L IWP, 082503, cf

Figure 3. Locations of subsurface disposal units at MDA L

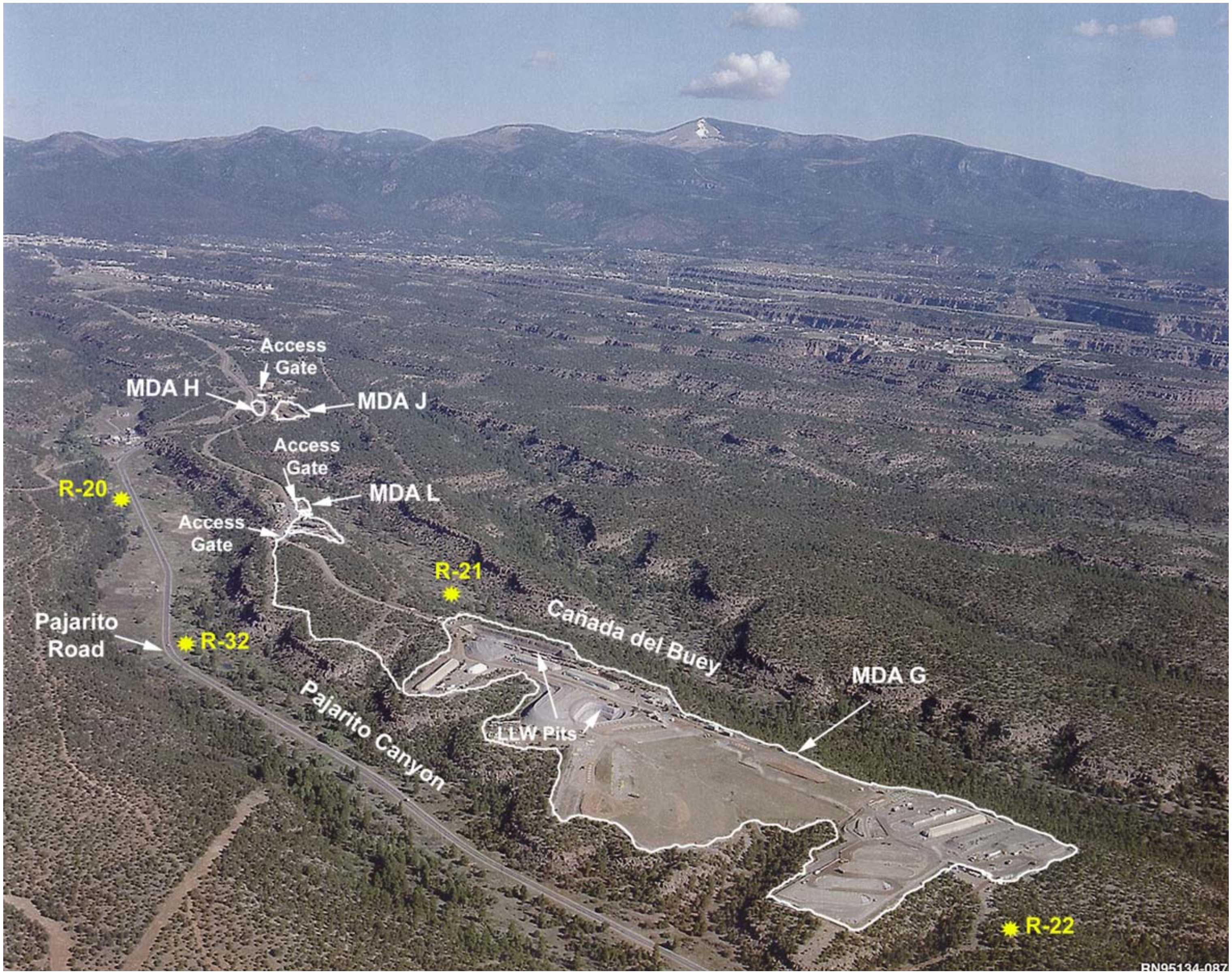
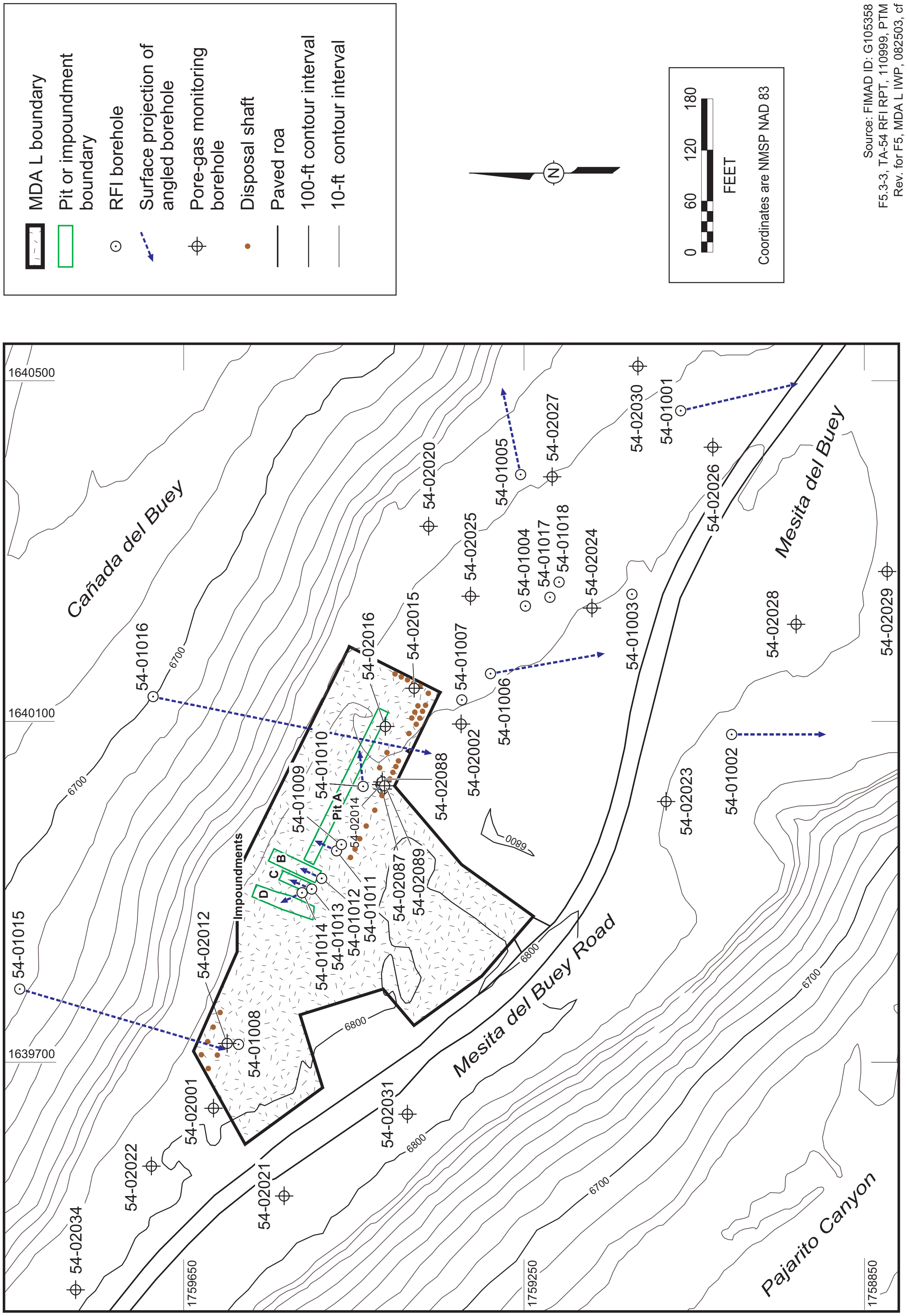
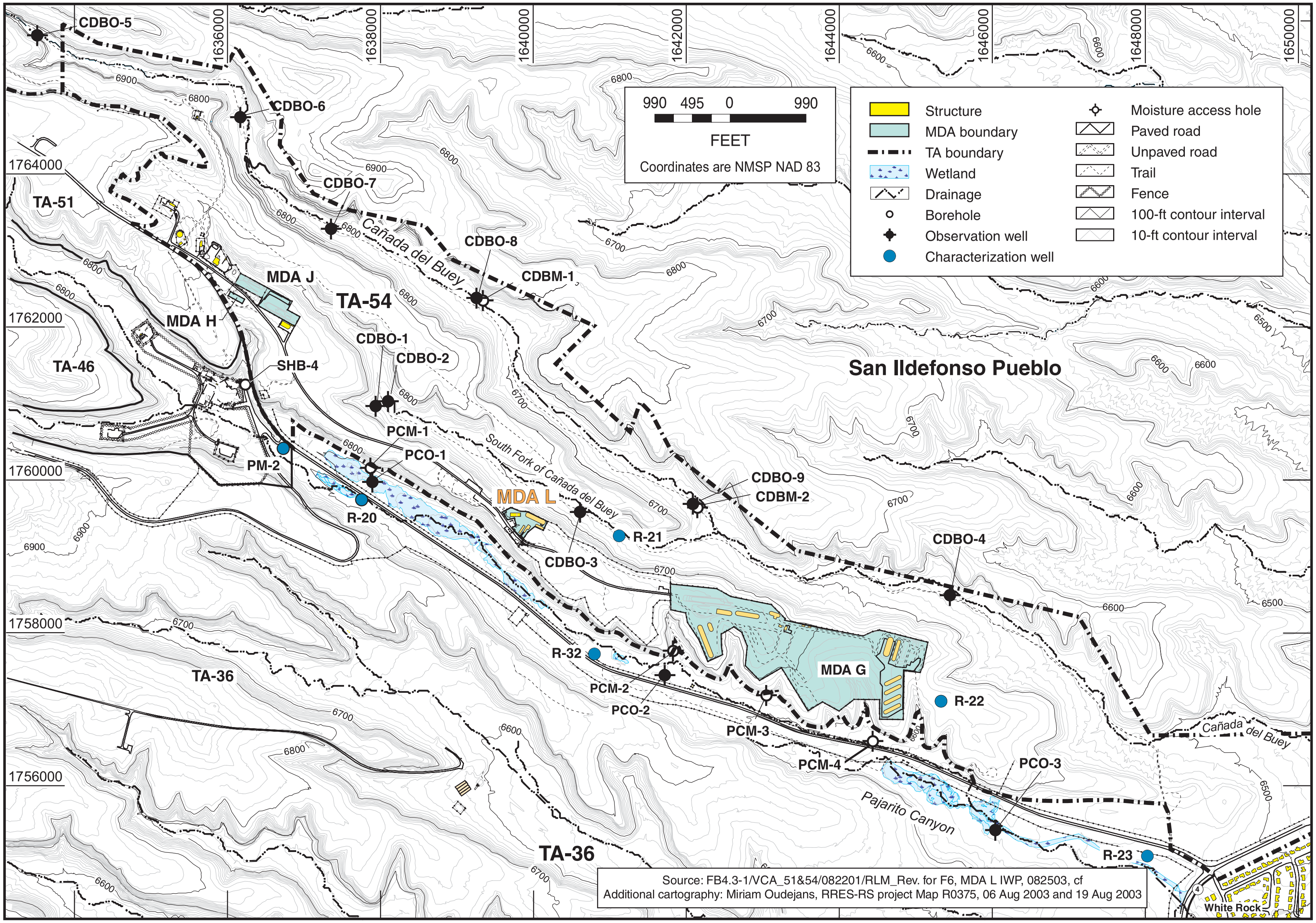


Figure 4. Aerial photograph of Mesita del Buey showing MDAs, gates, and deep boreholes in the vicinity of MDA L (characterization wells R-20, R-21, R-22, and R-32)



Source: FIMAD ID: G105358
F5.3-3, TA-54 RFI RPT, 110999, PTM
Rev. for F5, MDA L IWP, 082503, cf

Figure 5. Locations of Phase I RFI boreholes at MDA L



Source: FB4.3-1/VCA_51&54/082201/RLM_Rev. for F6, MDA L IWP, 082503, cf
Additional cartography: Miriam Oudejans, RRES-RS project Map R0375, 06 Aug 2003 and 19 Aug 2003

Figure 6. Locations of wells and boreholes used to locate alluvial and perched groundwater at TA-54

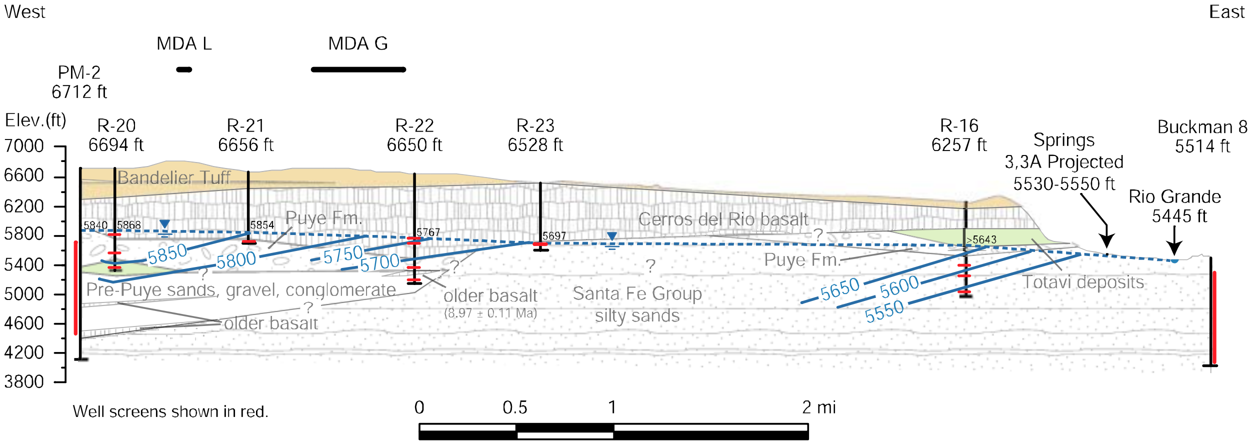


Figure 7. **Hydrogeologic cross section through Pajarito Plateau in the vicinity of TA-54**

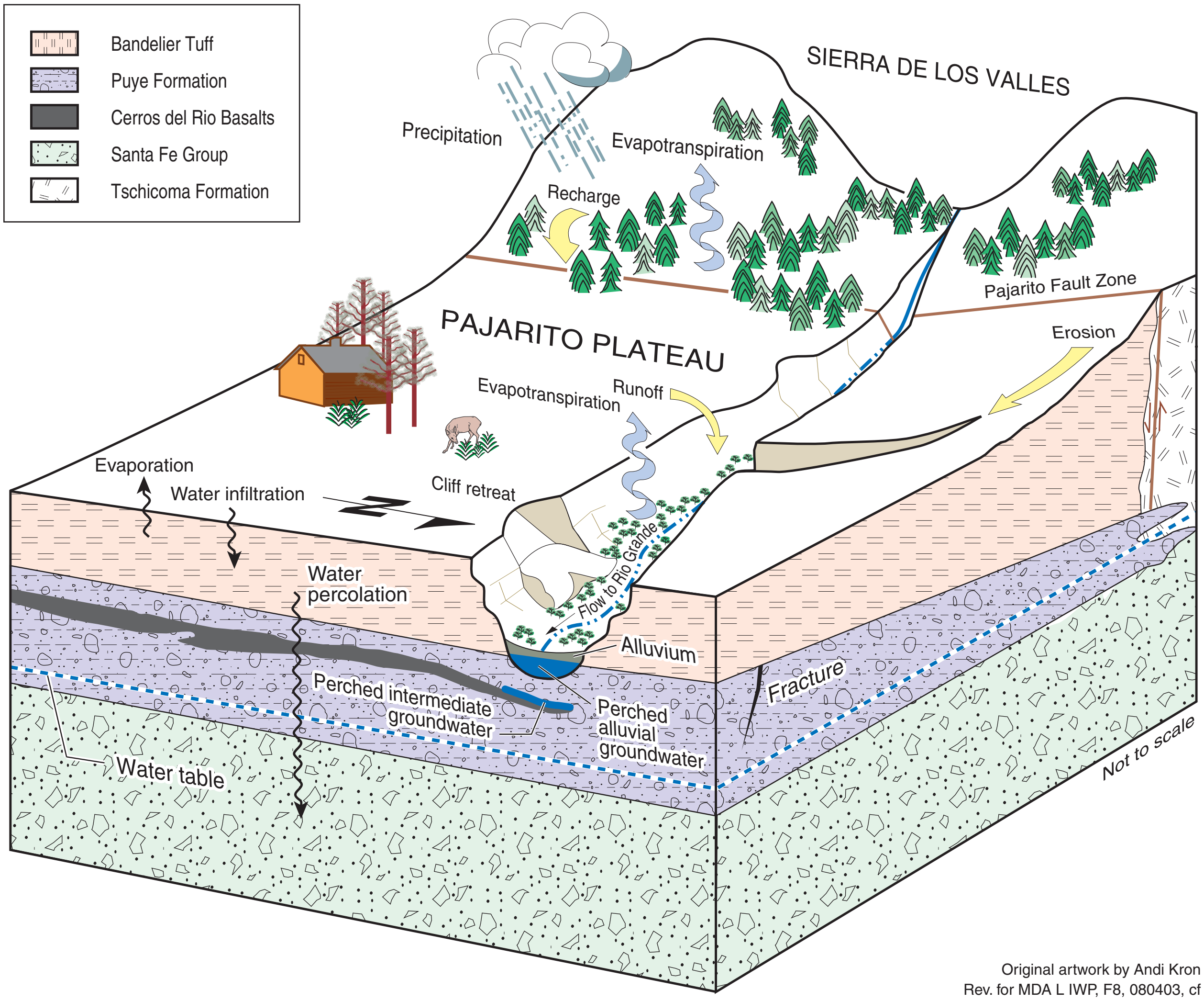
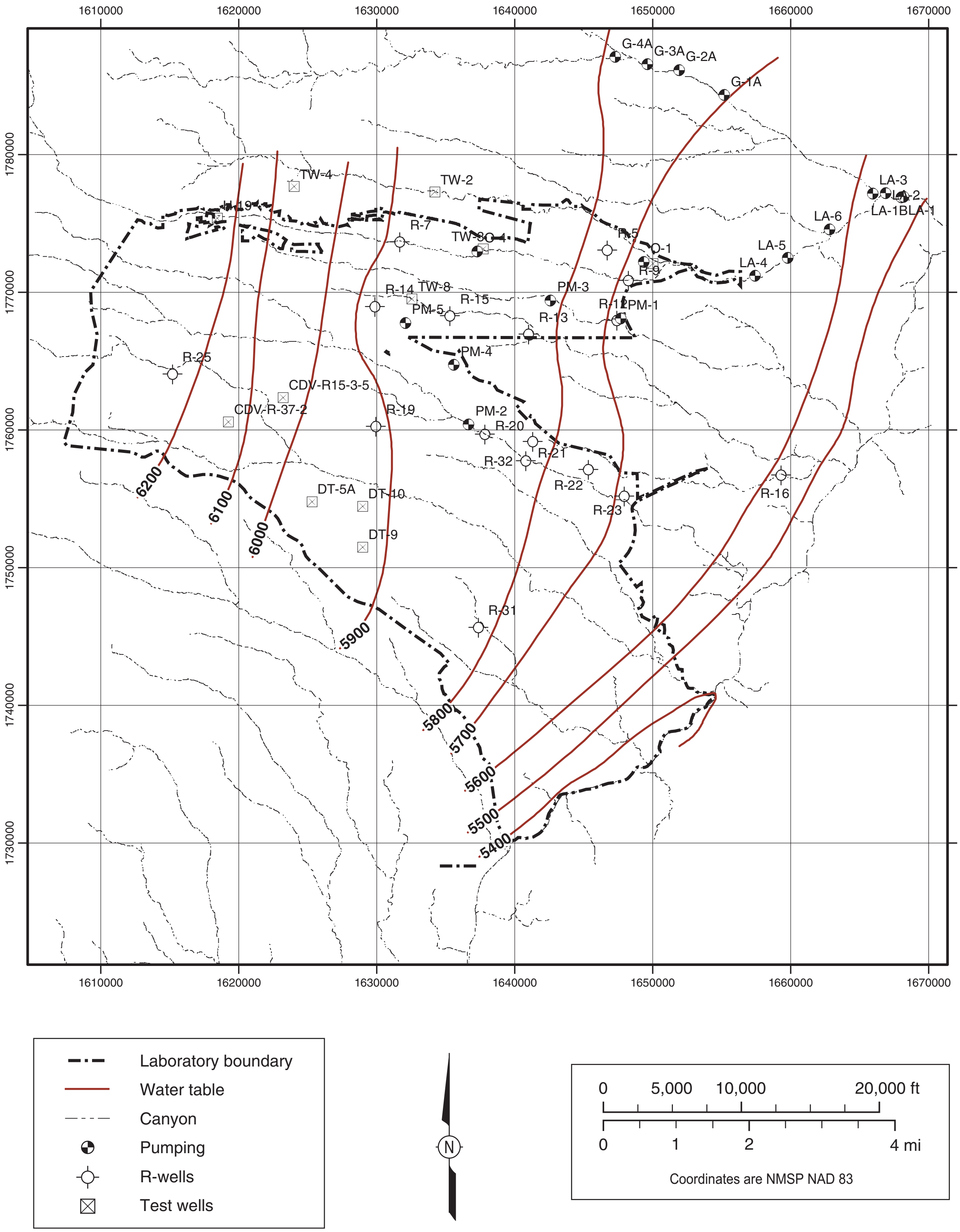
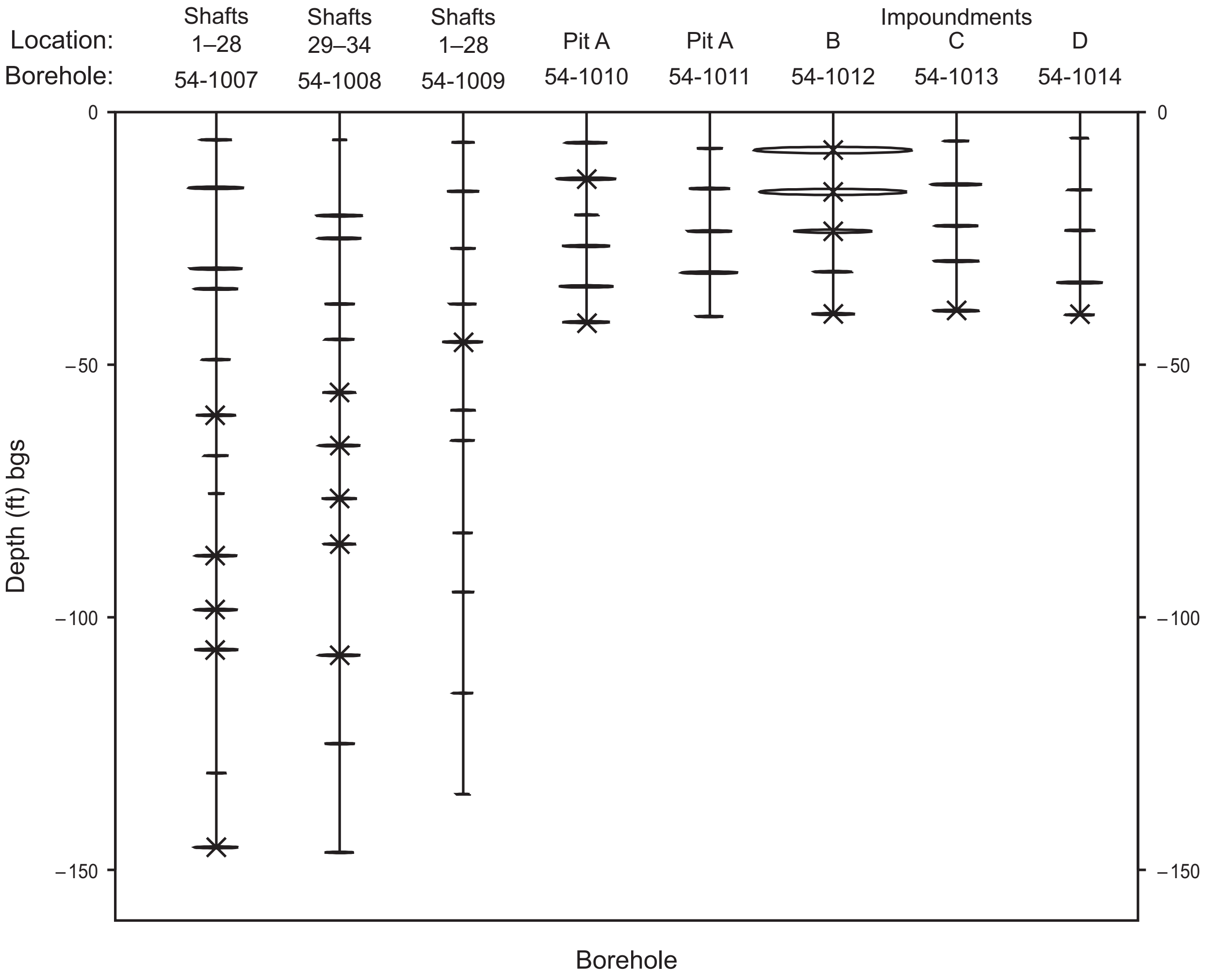


Figure 8. **Schematic of the hydrogeologic conceptual model for the Pajarito Plateau**



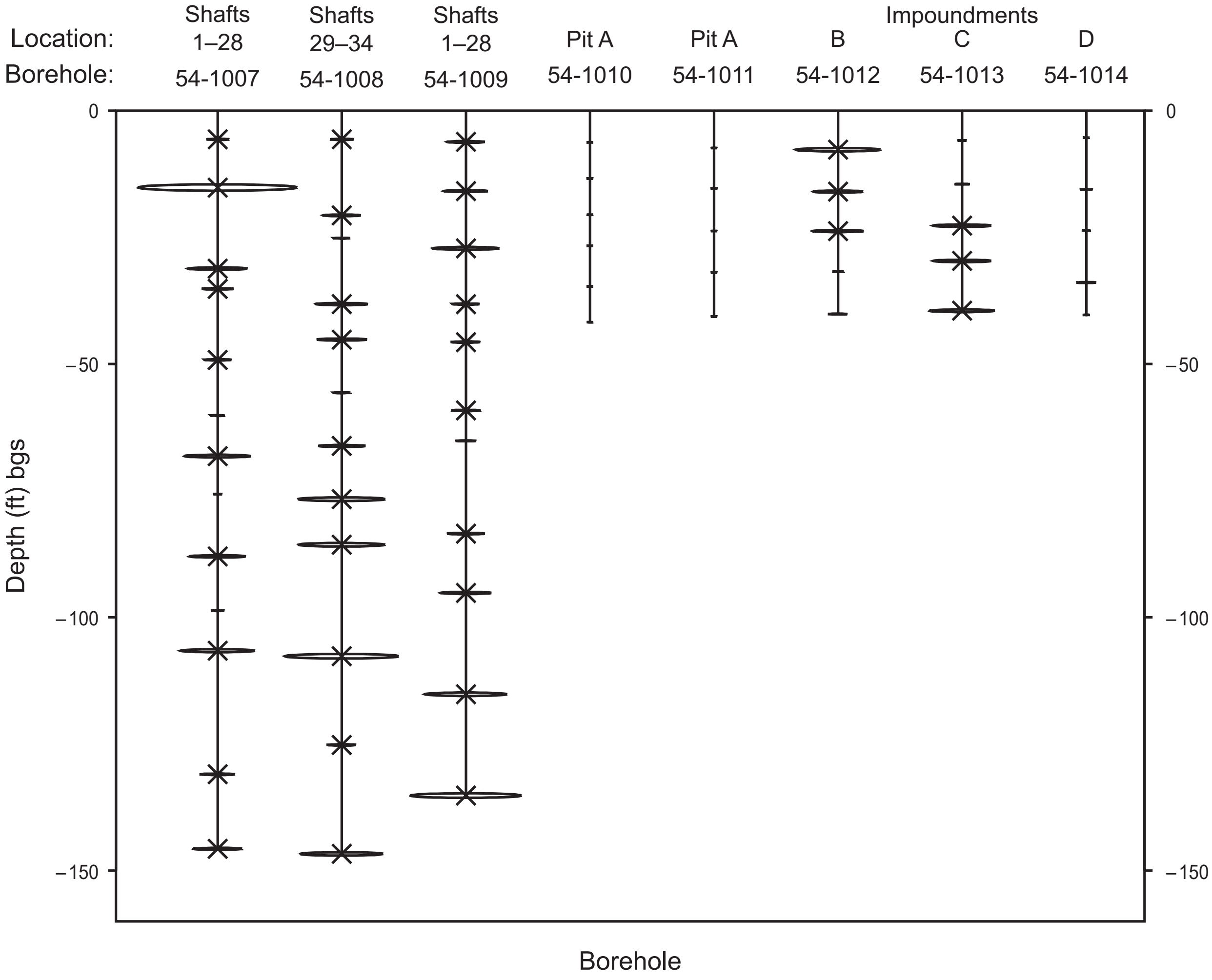
Source: GIS Lab m200714, REK, 061703_Rev. for F9, MDA L IWP, 082503, cf

Figure 9. Water table elevations at the Laboratory



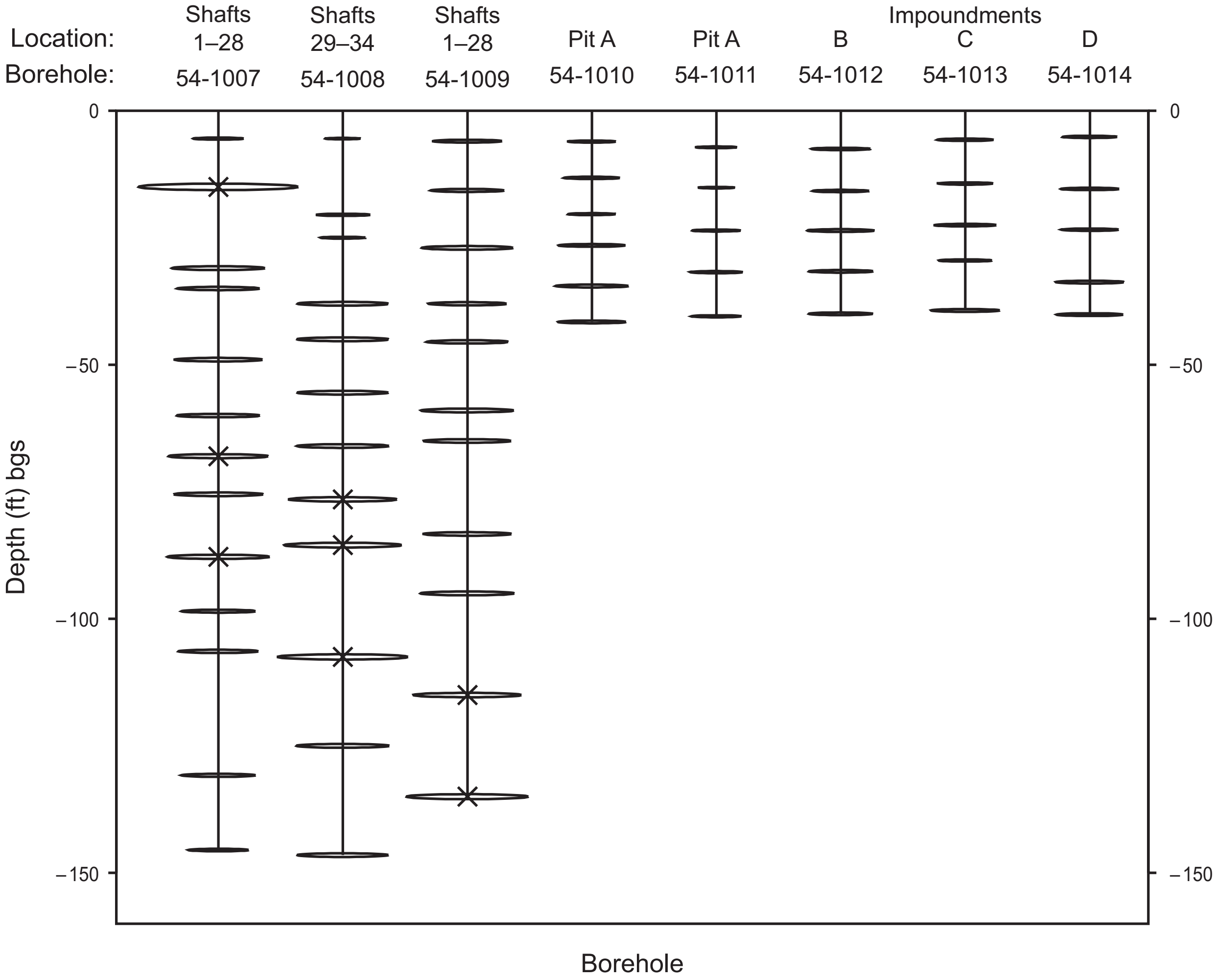
F6.1-16, TA-54 RFI RPT, 020100, PTM_Rev. for F12, MDA L IWP, 082203, cf

Figure 10. **Chromium concentrations (mg/kg) in Phase I RFI tuff samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) from the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (13 mg/kg).**



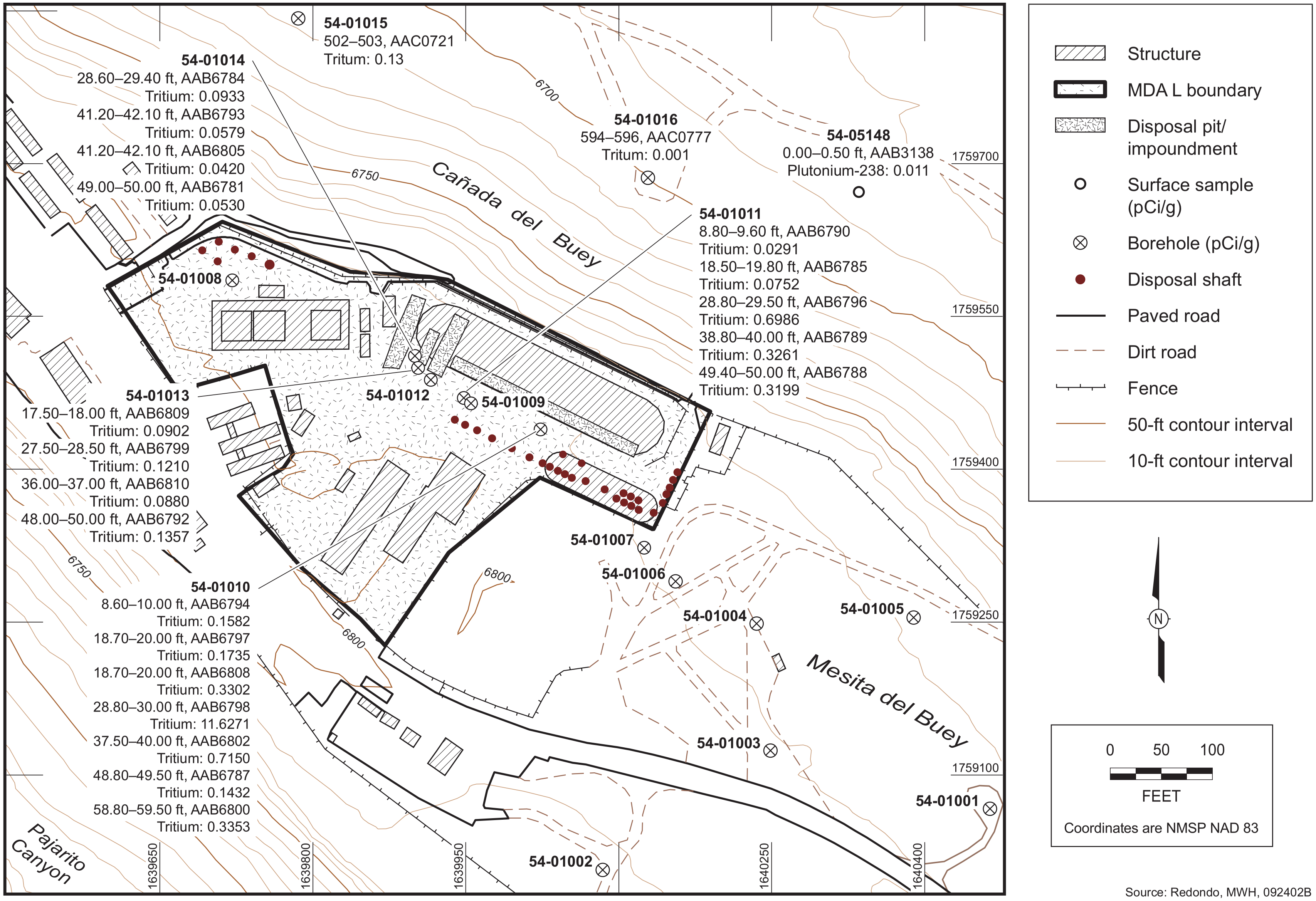
F6.1-17, TA-54 RFI RPT, 020100, PTM_Rev. for F12, MDA L IWP, 082203, cf

Figure 11. Copper concentrations (mg/kg) in Phase I RFI tuff samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) within the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (6.2 mg/kg).



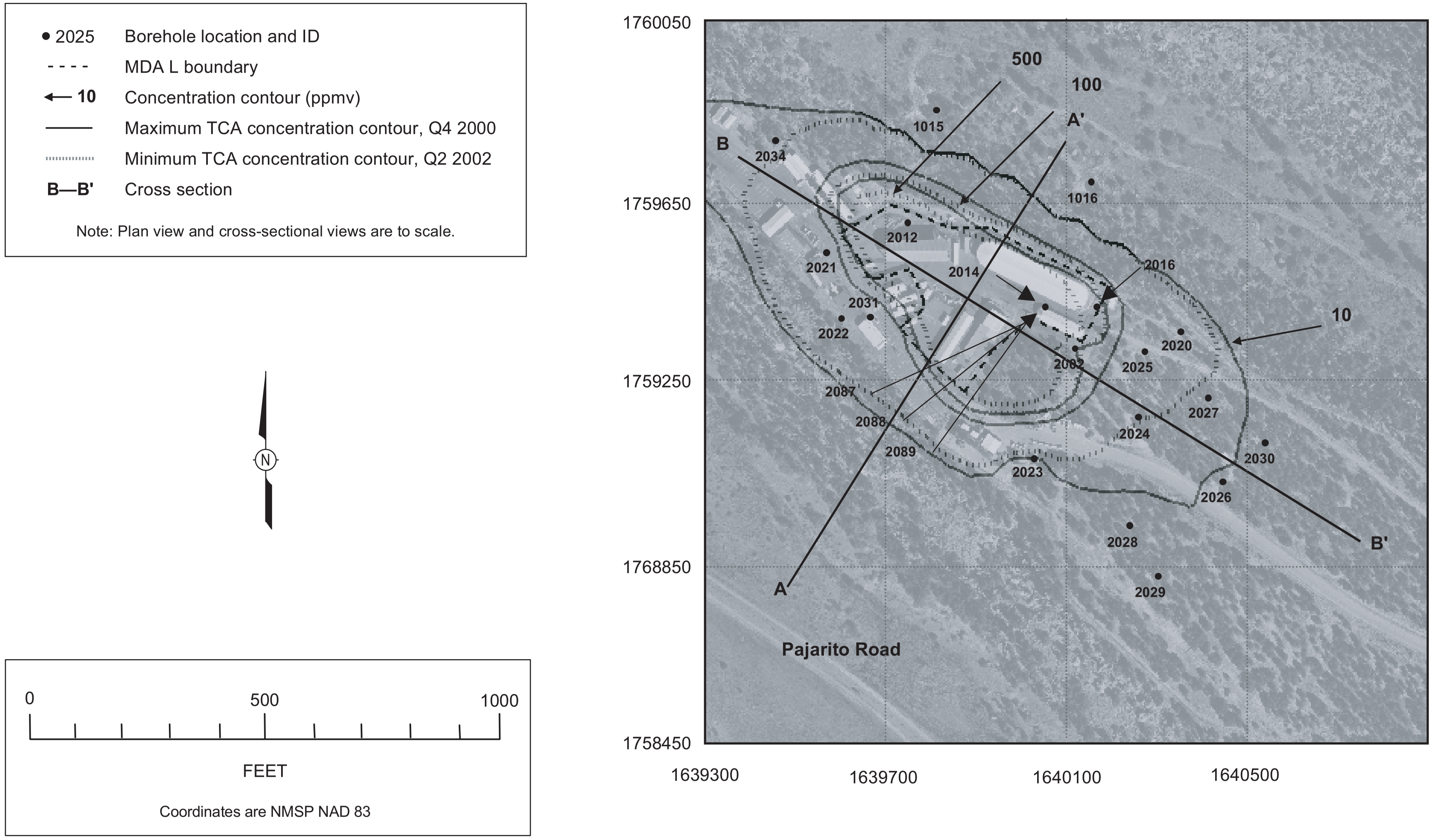
F6.1-18, TA-54 RFI RPT, 020100, PTM_Rev. for F12, MDA L IWP, 082503, cf

Figure 12. **Zinc concentrations (mg/kg) in Phase I RFI tuff samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) within the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (74 mg/kg).**



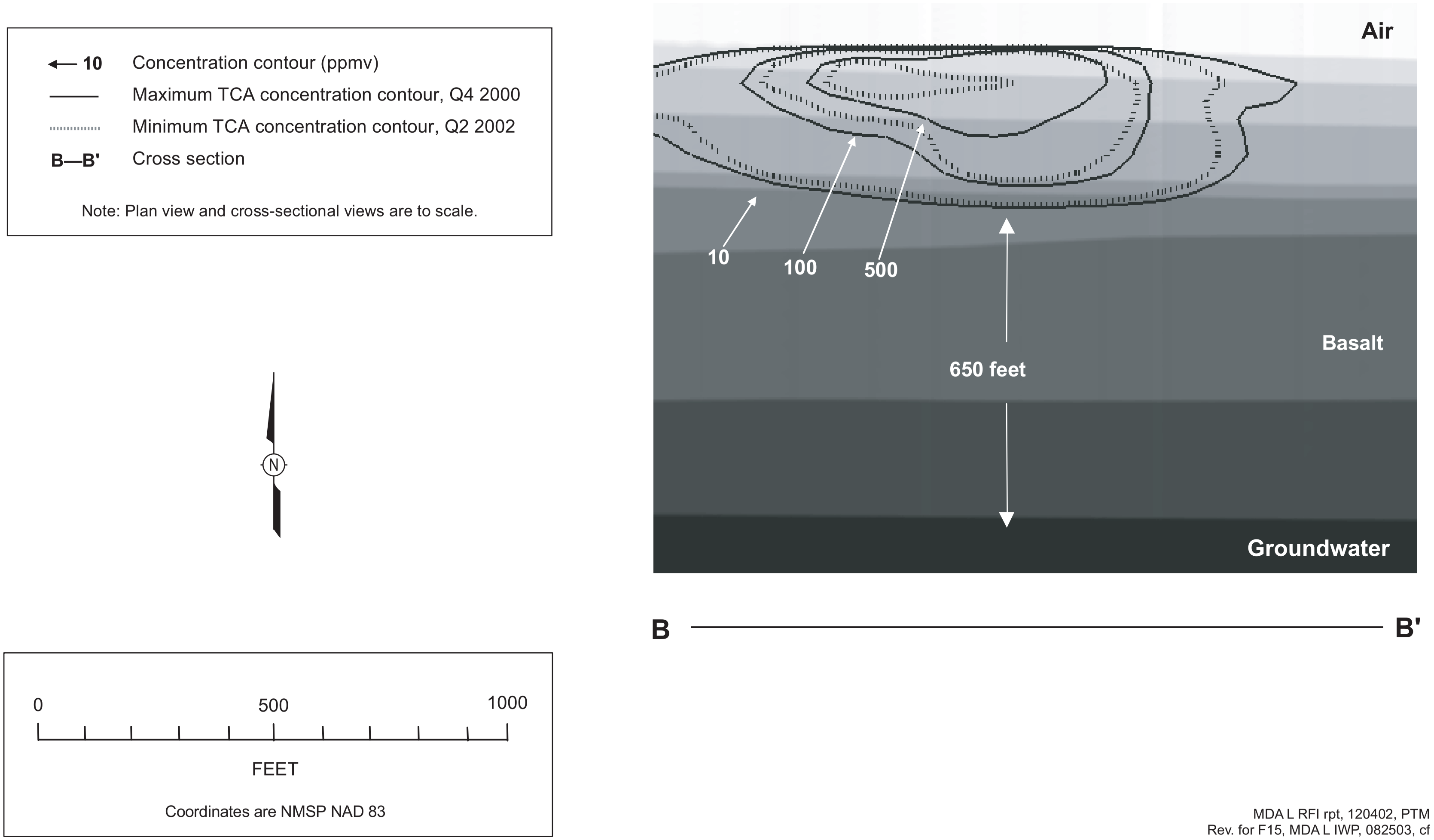
Source: Redondo, MWH, 092402B
MDA L RFI Rpt, 120302, PTM
Rev. for F13, MDA L IWP, 082503, cf

Figure 13. Radionuclide detections above background/fallout values at MDA L



MDA L RFI rpt / 120402 / PTM
Rev. for F14, MDA L IWP, 082503, cf

Figure 14. Aerial view of the TCA plume at MDA L. Both maximum and minimum lateral extent contours are presented for the B&K screening data.



MDA L RFI rpt, 120402, PTM
Rev. for F15, MDA L IWP, 082503, cf

Figure 15. North-south cross section (B–B') of the VOC plume, represented by TCA, at MDA L showing maximum and minimum vertical extent based on B&K screening

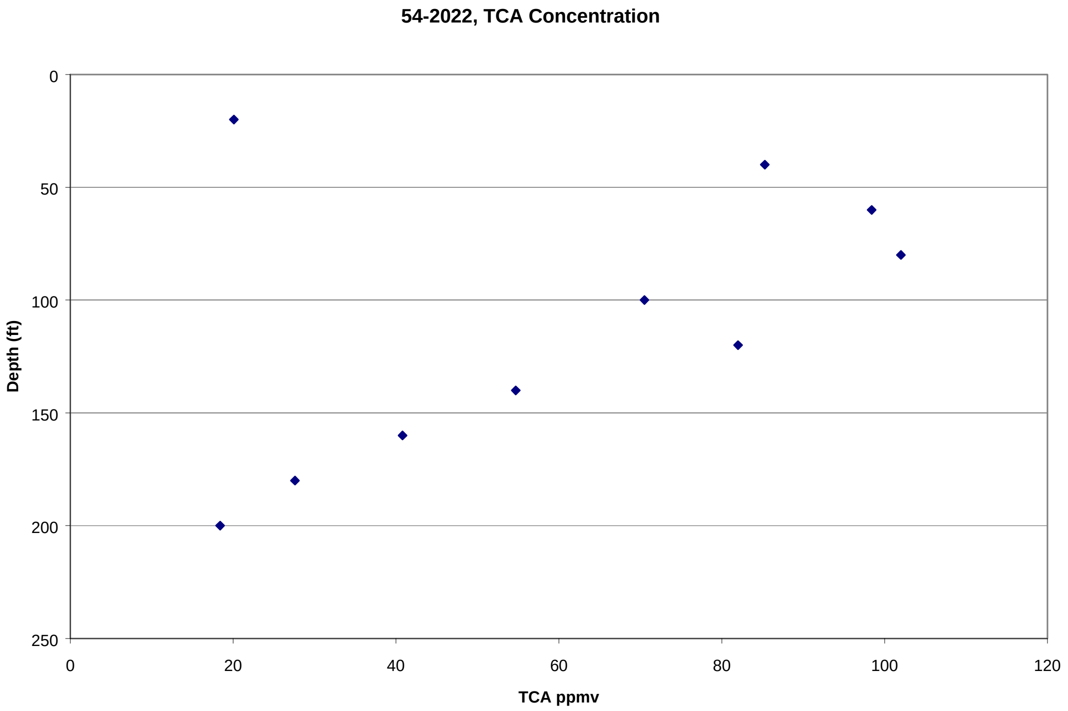


Figure 16. **Pore-gas monitoring borehole 54-02022—TCA concentration vs. depth. Note the characteristic increase in concentration to approximately 100 ft bgs at MDA L, followed by decreasing concentrations to the total depth of the borehole.**

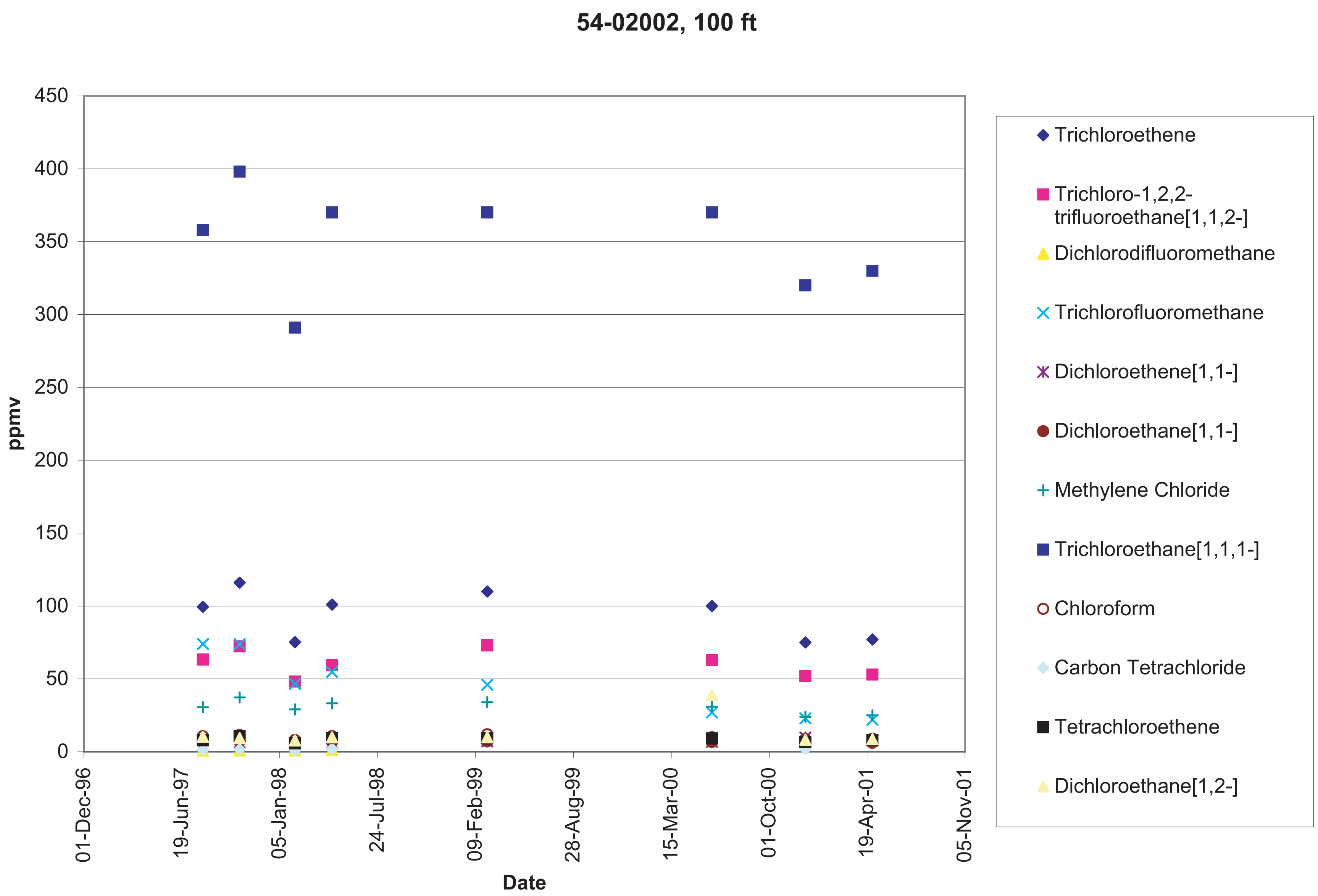


Figure 17. Pore-gas monitoring borehole 54-02002—100 ft bgs at MDA L: quarterly analytical results over time for the most frequently detected VOCs

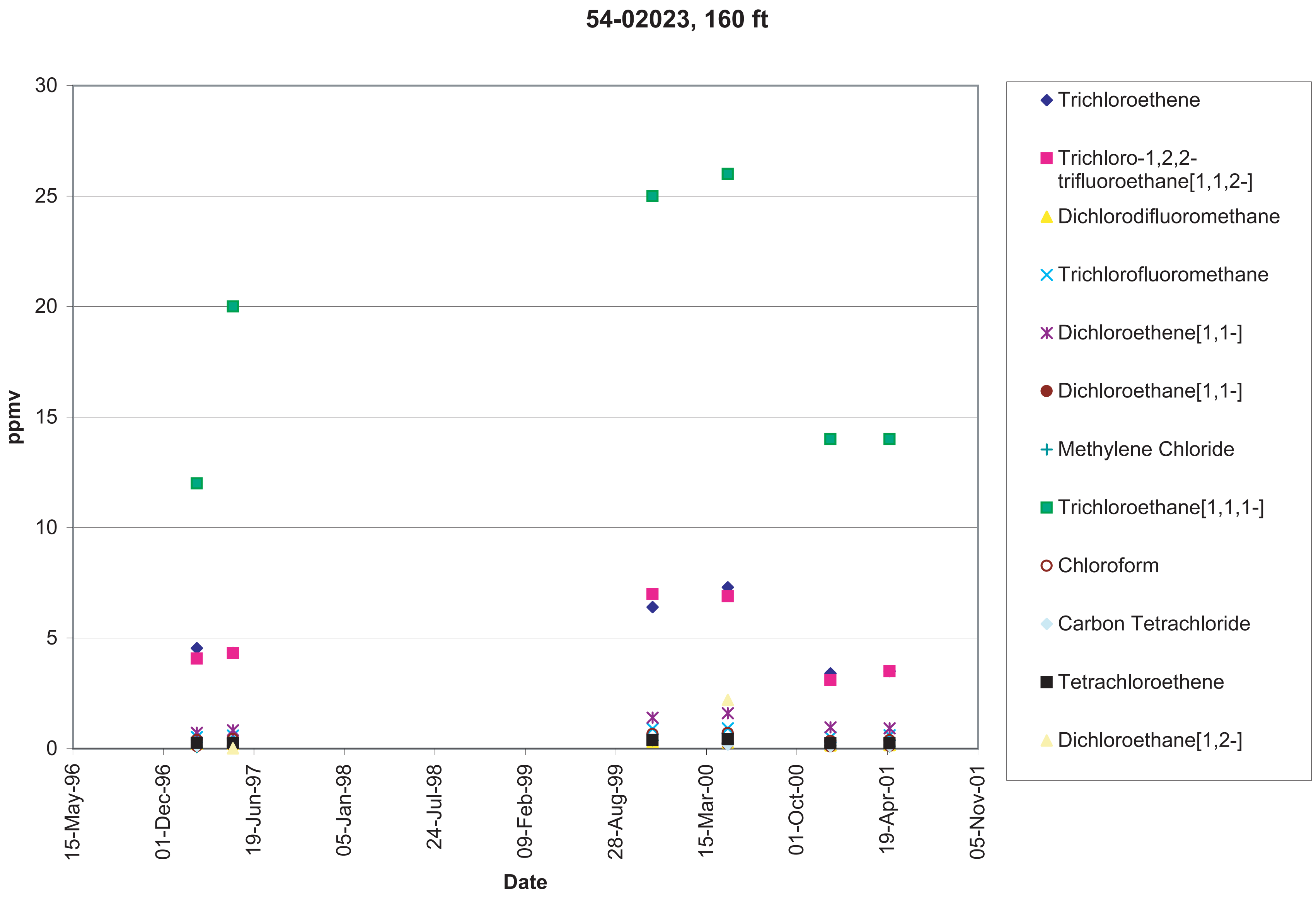


Figure 18. **Pore-gas monitoring borehole 54-02023—160 ft bgs at MDA L: quarterly analytical results over time for the most frequently detected VOCs**

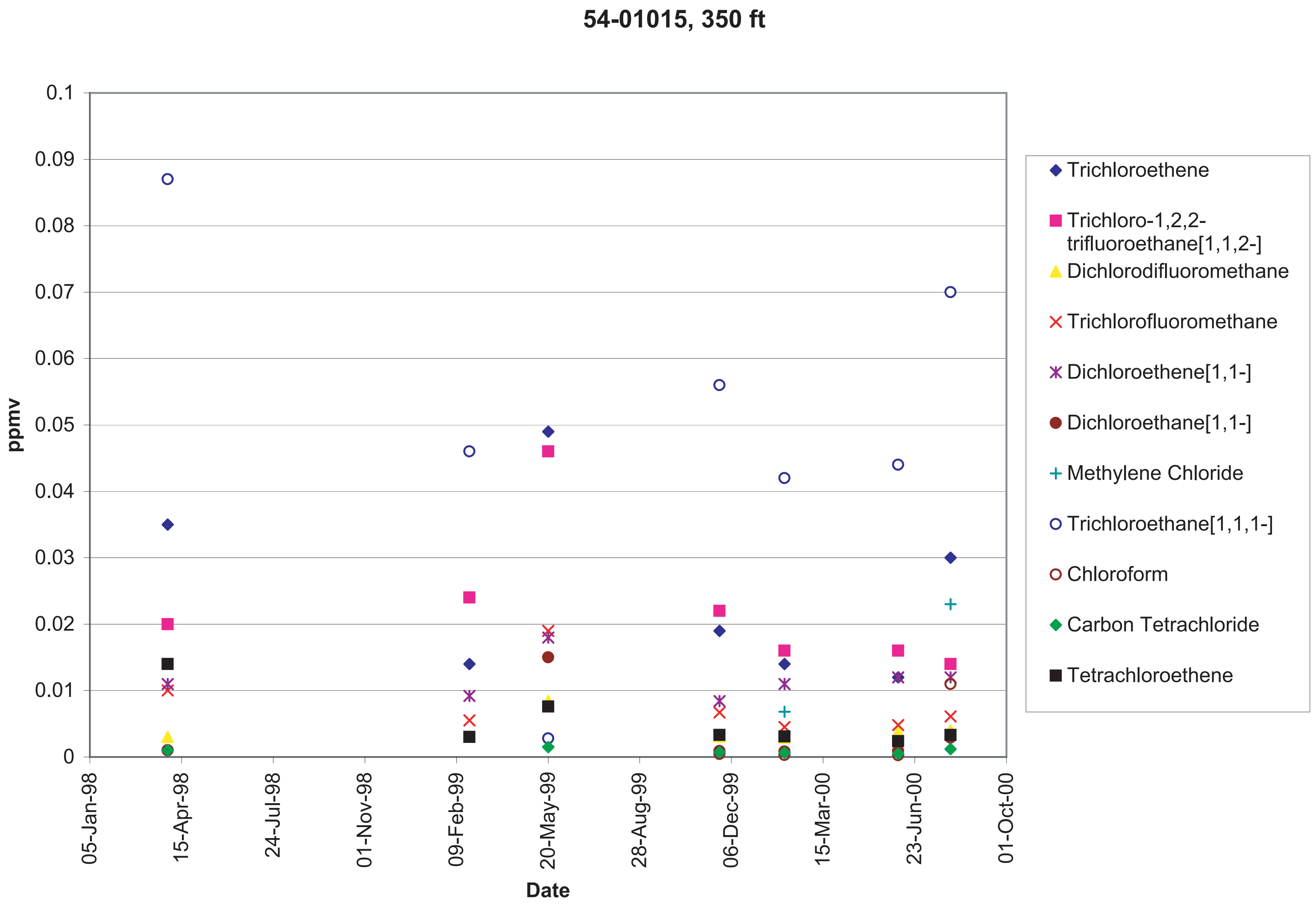
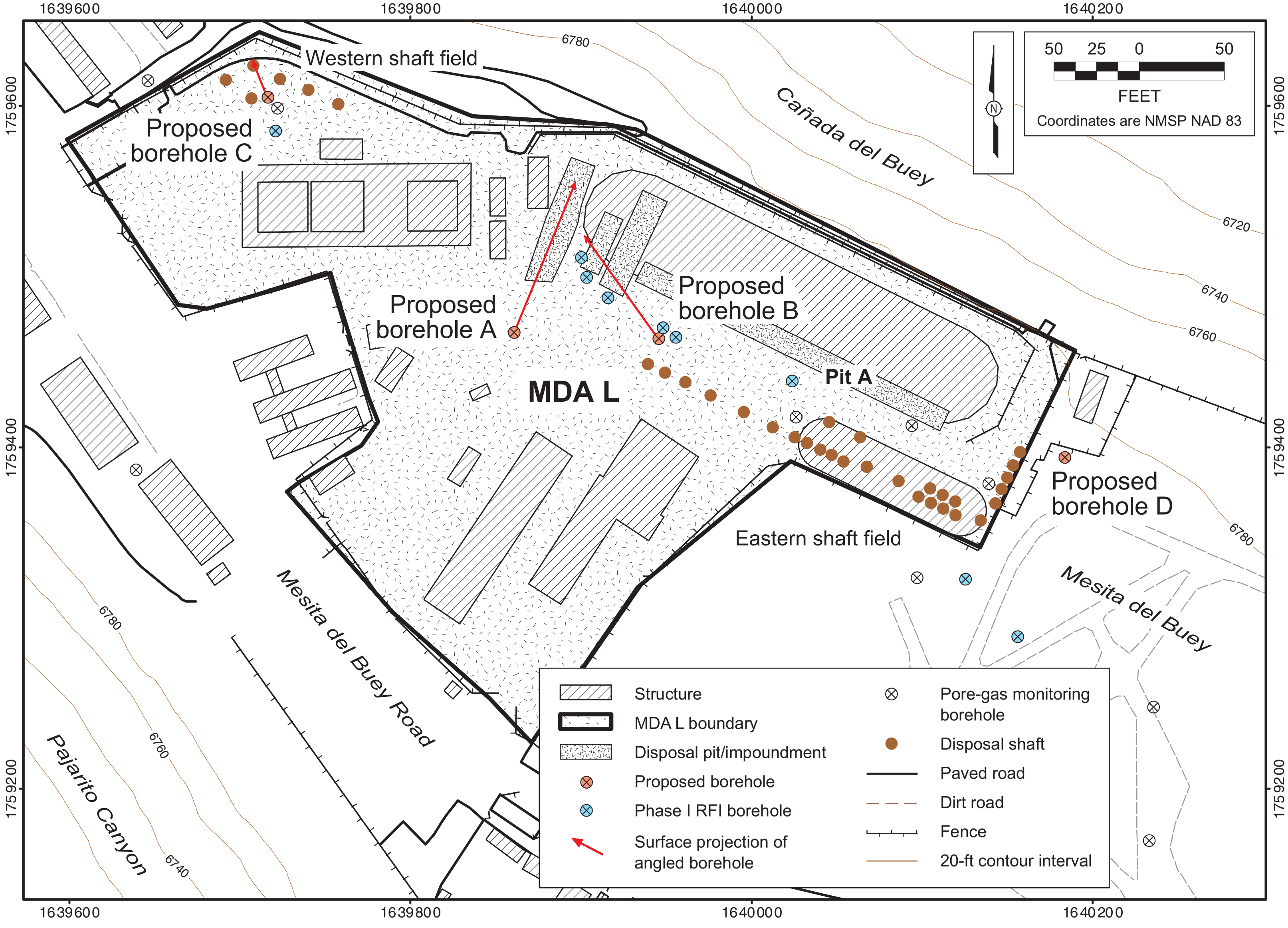


Figure 19. Pore-gas monitoring borehole 54-01015—400 ft bgs at MDA L: quarterly analytical results over time for most frequently detected VOCs



Source: RRES-RS map R03079, 082103, MO_Rev. for F20, MDA L IWP, 082503, cf

Figure 20. Locations of existing and proposed boreholes at MDA L

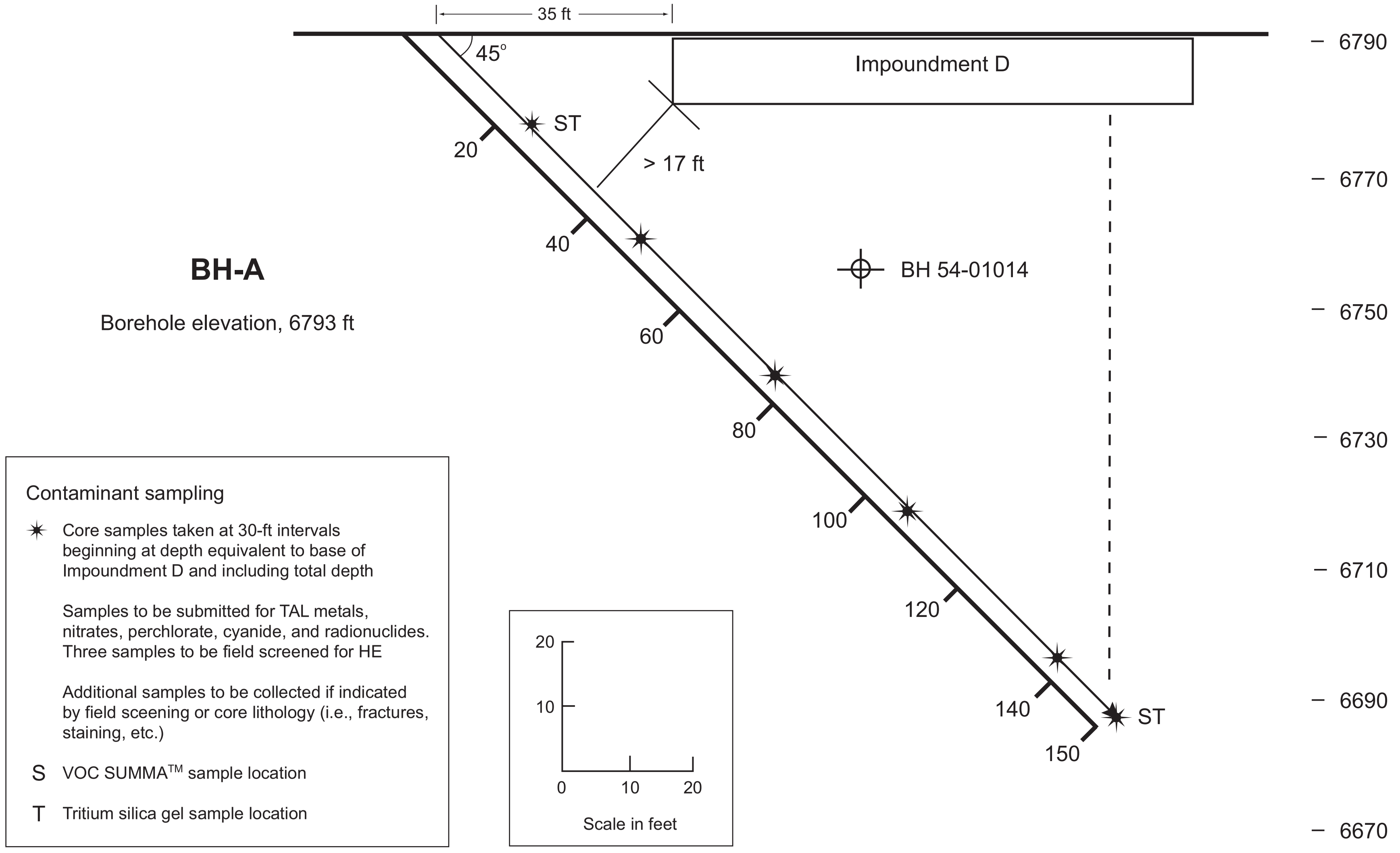
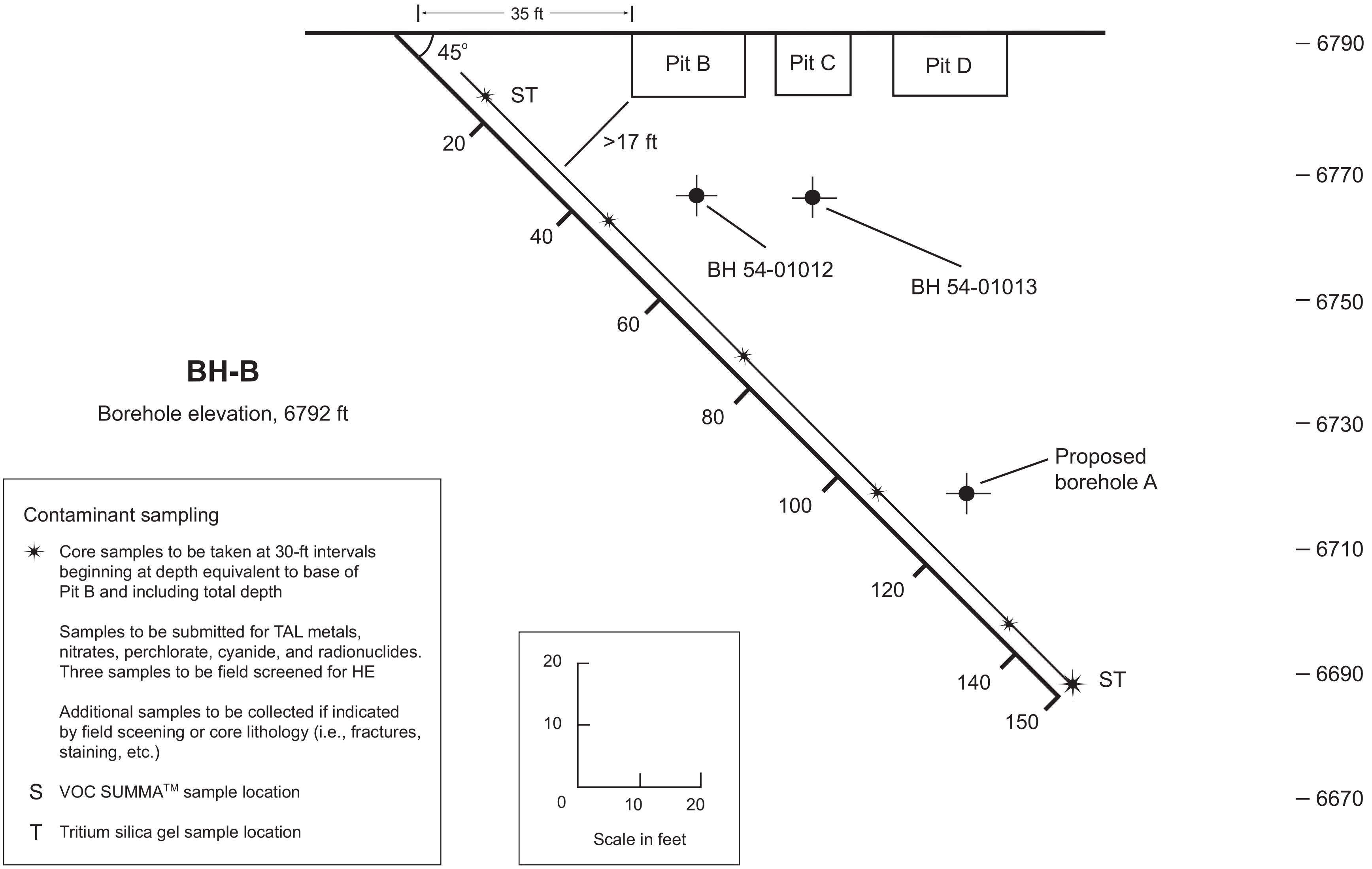


Figure 21. Profile of borehole A planned sample locations



Contaminant sampling

✶ Core samples to be taken at 30-ft intervals beginning at depth equivalent to base of Pit B and including total depth

Samples to be submitted for TAL metals, nitrates, perchlorate, cyanide, and radionuclides. Three samples to be field screened for HE

Additional samples to be collected if indicated by field sceening or core lithology (i.e., fractures, staining, etc.)

S VOC SUMMA™ sample location

T Tritium silica gel sample location

Figure 22. Profile of borehole B with planned sample locations

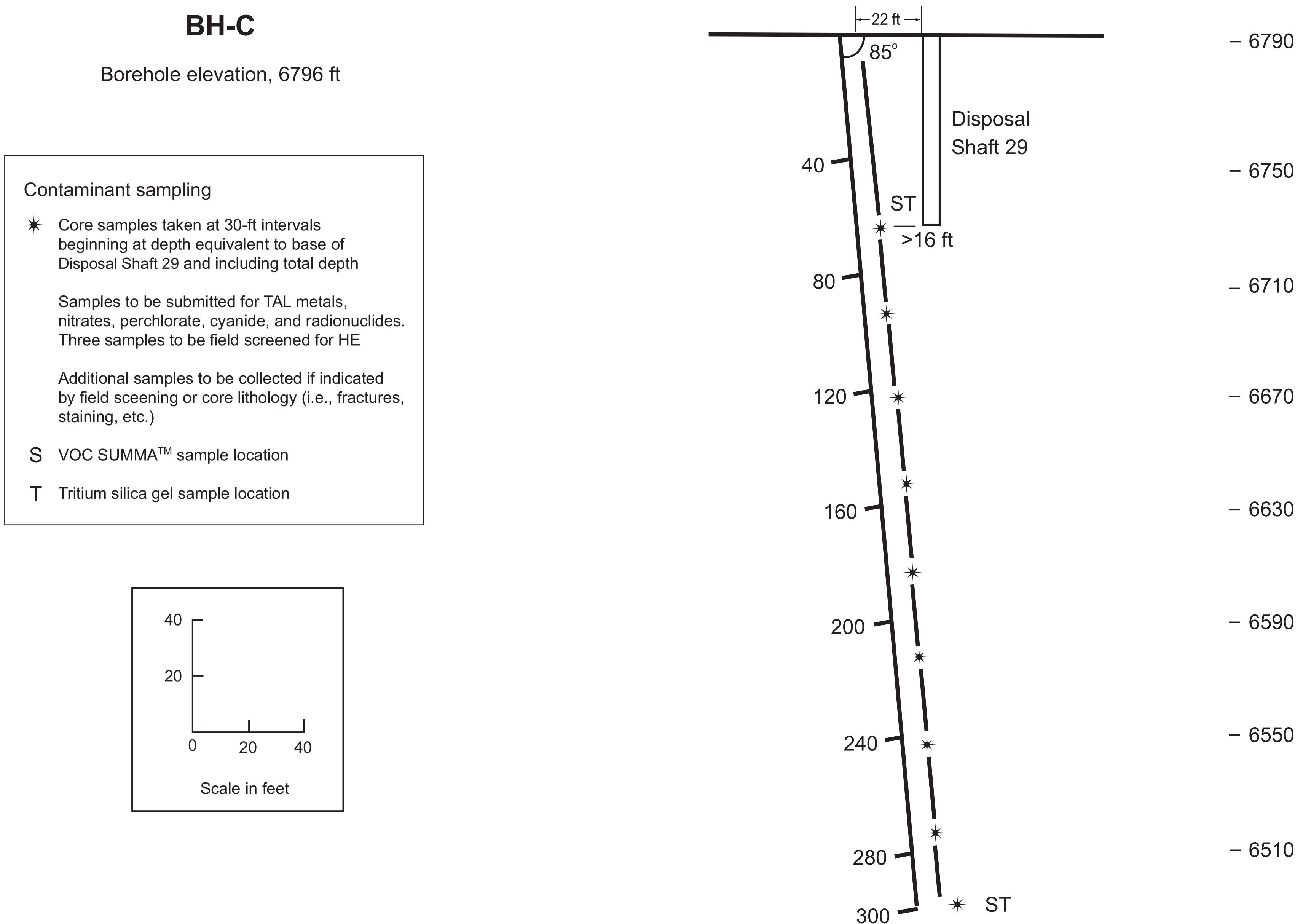
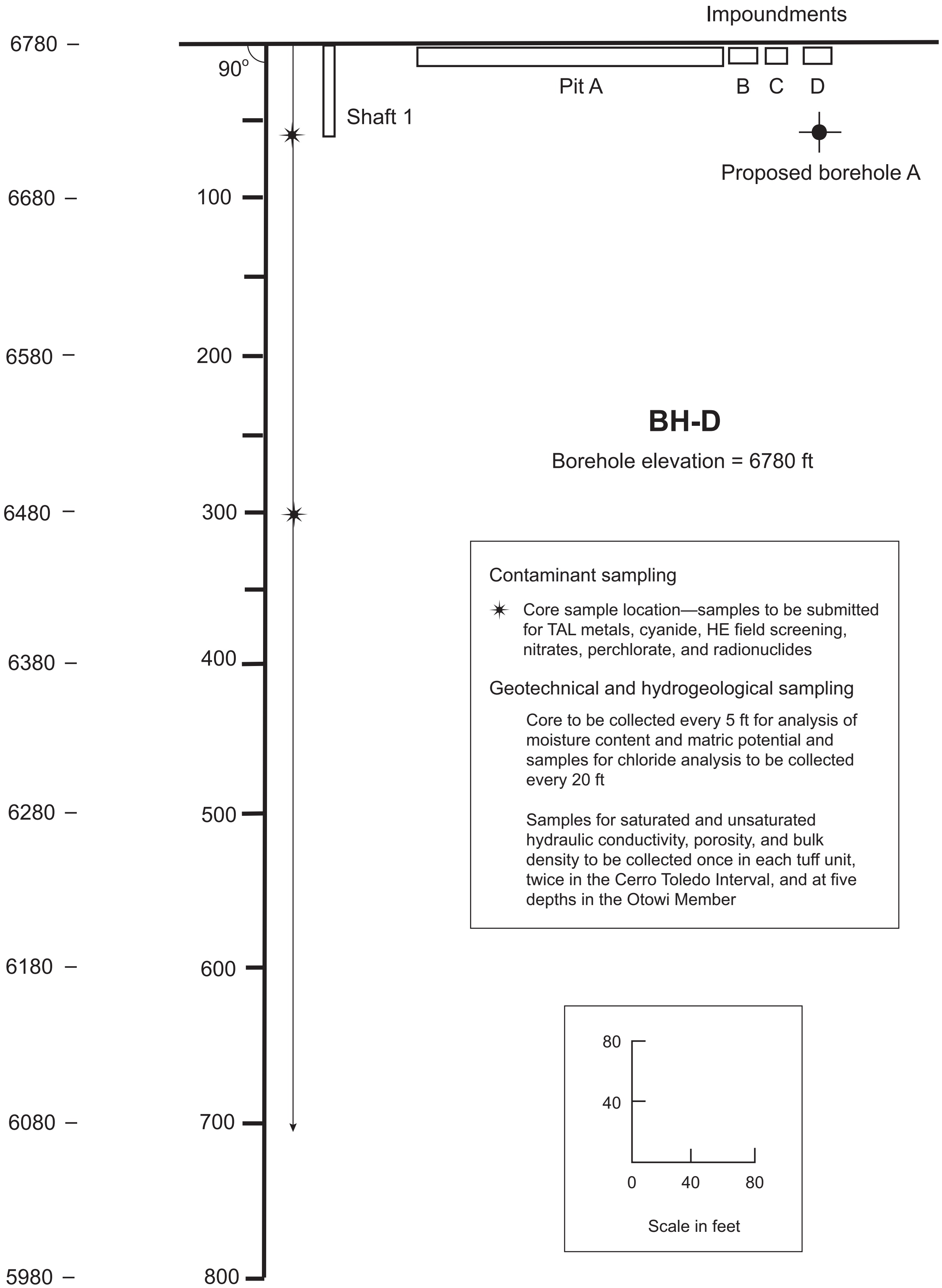


Figure 23. Profile of borehole C with planned sample locations



Contaminant sampling

✳ Core sample location—samples to be submitted for TAL metals, cyanide, HE field screening, nitrates, perchlorate, and radionuclides

Geotechnical and hydrogeological sampling

Core to be collected every 5 ft for analysis of moisture content and matric potential and samples for chloride analysis to be collected every 20 ft

Samples for saturated and unsaturated hydraulic conductivity, porosity, and bulk density to be collected once in each tuff unit, twice in the Cerro Toledo Interval, and at five depths in the Otowi Member

Figure 24. Profile of borehole D showing contaminant and geotechnical sample locations

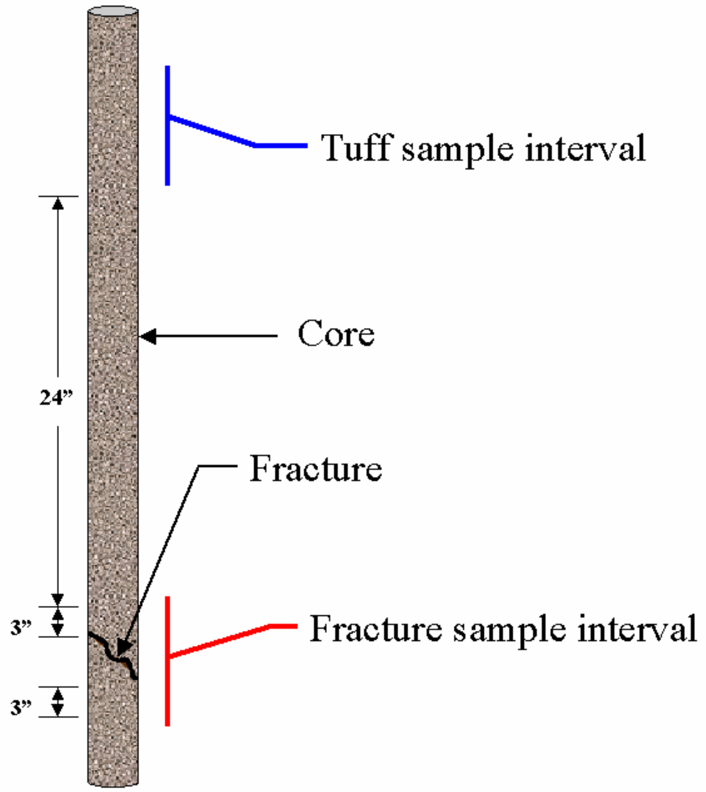
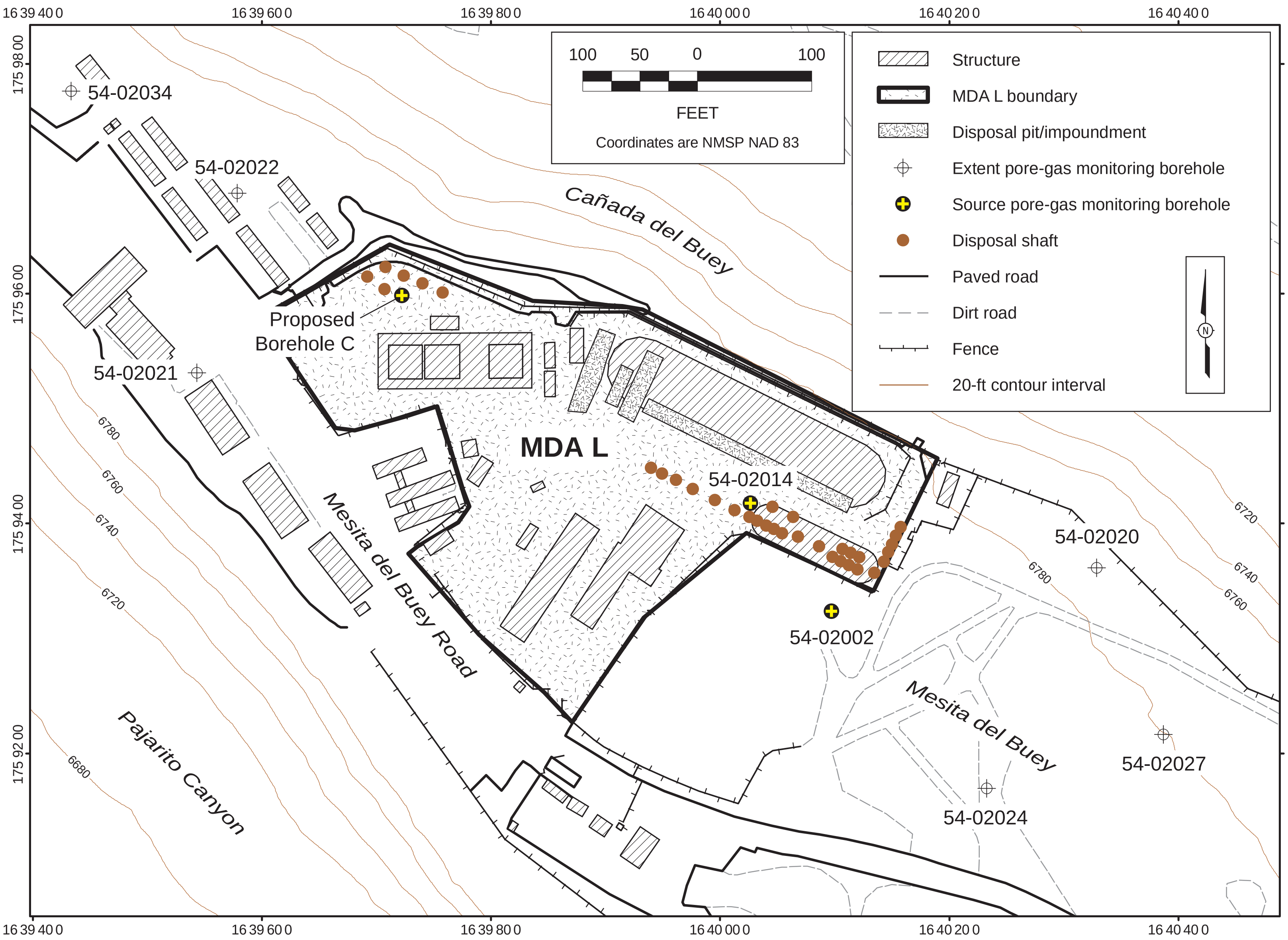


Figure 25. **Paired fracture sampling diagram**



Source: RRES-RS map R03077, 082203, MO_Rev. for F26, MDA L IWP, 082503, cf

Figure 26. Proposed pore-gas monitoring boreholes at MDA L

Table 1
Summary of Work Plan Specifications, Actual Fieldwork, and Rationale for Deviations

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
Sediment (drainages)	9	VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, herbicides, cyanide, gamma spectroscopy, gross alpha, beta, and gamma radiation	8 total: for gross radiation screening; Subset of 4 samples for offsite contract laboratory analysis	4 samples analyzed for pesticides/PCBs, herbicides, inorganic chemicals, gamma spec, Am-241, Sr-90, isotopic Pu, isotopic U, isotopic thorium, and tritium.	Eight samples were collected based on the geomorphic survey. All samples were field screened for alpha, beta, and gamma radiation to bias sample selection. One sample with the highest gross gamma level, the sample with the highest gross alpha and beta levels, and two other samples were sent to an offsite contract laboratory for analysis. (Glatzmaier 1994, 52015)
Core	126 (16 boreholes) See proposed drilling modifications (Glatzmaier 1994, 52015)	VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, cyanide, gross alpha and beta radiation, and gamma spectroscopy	89 total from 10 boreholes	VOCs, SVOCs, pesticides/ PCBs, herbicides, inorganic chemicals, cyanide, tritium, isotopic Pu, and isotopic U 77 – VOCs 55 – SVOCs 67 – TAL metals 62 – cyanide 11 – total uranium 48 – tritium 67 – pesticides/PCBs 38 – herbicides 5 – isotopic uranium and isotopic plutonium	Vertical boreholes 54-1007, 54-01008, and 54-01009 were also drilled adjacent to numerous shafts and Pit A to a TD of 150 ft. Thirty-eight core samples were collected at 10-ft intervals and submitted for offsite contract laboratory analysis of TAL metals, cyanide, pesticides/PCBs, herbicides, SVOCs, and VOCs. Five core samples from borehole 54-01009 were also submitted for offsite contract analysis of isotopic plutonium, isotopic uranium, and gamma spec. for Am-241 and Cs-137. Boreholes 54-01007, 54-01008, and 54-01009 were subsequently backfilled. Angle boreholes 54-01010 through 54-01014 were advanced beneath Pit A and Impoundments B, C, and D. The boreholes were backfilled and grouted closed. A total of 29 core samples were collected at 10-ft intervals and submitted to an off-site contract laboratory for analysis of TAL metals, pesticides/PCBs, SVOCs, VOCs, and tritium. Additional core samples submitted for off-site contract laboratory analyses included all 24 core samples from boreholes 54-01010, 54-01011, 54-01012, 54-01014 for cyanide; and 11 core samples

Table 1 (continued)

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
					from boreholes 54-01010, 54-01013, and 54-01014 for total uranium. Two deep angle boreholes, 54-01015 and 54-01016, were drilled from the adjacent canyon slope northeast of MDA L within Cañada del Buey to investigate the possible presence of vapor-phase contaminants at depth beneath MDA L. These boreholes were drilled to depths of 530 ft and 607 ft, respectively. The boreholes were completed as vapor monitoring boreholes. Boreholes 54-01017 and 54-01018 were advanced directly east of MDA L. Borehole 54-01017 was designed as the extraction well for the pilot vapor extraction test, and borehole 54-01018, located 20 ft south-southeast of borehole 54-01017, was used to monitor pore gas. Both boreholes are maintained for vapor monitoring and are capped at the ground surface.
			94 total from 6 boreholes 12 total from 1 borehole	Screened for VOCs Screened for VOCs and SVOCs	94 core samples were collected at 20-ft intervals from boreholes 54-01001 through 54-01006 and screened for VOCs and moisture. The 6 boreholes were instrumented for vapor monitoring. The RFI work plan specified locations for boreholes. Actual borehole locations were selected to maximize the area sampled and avoid obstacles such as buried utilities and waste.
Pore gas	99	VOCs	207	VOCs (EPA Method TO-14)	VOCs don't adsorb to the tuff matrix; gas phase analysis provides information about the nature and extent of VOCs in the subsurface. A summary of quarterly pore-gas monitoring results for pore-gas samples collected from 1985-2001 are provided in Appendix D.

Table 1 (continued)

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
VOC surface flux	136	VOCs	102 8	VOCs Tritium	Surface flux data can help identify lateral extent of subsurface VOC contamination. Surface flux locations were restricted by asphalt and site structures on the surface of MDA L.
Air (Ambient)	48	Total suspended particulates, VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, cyanide, and radionuclides	16	VOCs	ESH-17 air monitoring data from MDA L were reviewed for nature and extent of VOCs. (Jansen and Taylor 1996, 54959)
Air-Flow Velocity - Passive Vapor Extraction Test	n/a[b]	n/a	n/a	In 1997, airflow volume and VOC concentrations were measured at borehole 54-01006. In 1998, the tests were repeated using a one-way valve on borehole 54-01006 to allow only the exhalation of subsurface during periods of relatively high atmospheric pressure. During the 1998 study, vapor concentrations and pressure were measured at several subsurface ports in boreholes 54-01004, 54-01006, and 54-01018 and in atmospheric air.	None

[a] Based on proposed modifications to the RFI Work Plan for OU 1148 for drilling and core sampling at MDA L (Glatzmaier 1994, 52015)

[b] n/a = Not applicable.

Table 2
Proposed Borehole Locations and Analytical Suites for MDA L

Borehole	Borehole Type	Approximate Depth (ft)	Rationale	Core Sampling	Core Sample Analytical Suite	Pore-Gas Sampling
Borehole A: south of Impoundment D, advanced towards the northeast beneath the long-axis of the impoundment	Angle 45°	150	Determine the vertical extent of metal contamination.	6 samples; every 30 ft, beginning with the depth equivalent to the base of Impoundment D, and the last at the depth of the borehole.	TAL metals, nitrates, perchlorate, cyanide, and radionuclides. Three samples will be selected for HE field test kit screening.	VOCs and tritium sample at depth nearest adjacent disposal unit and bottom of borehole.
Borehole B: sited to the southeast of Impoundment B, and advanced toward the northwest, passing beneath Impoundments B, C, and D	Angle 45°	150	Determine the vertical extent of metal contamination.	6 samples; every 30 ft, beginning with the depth equivalent to the base of Impoundment B, and the last at the depth of the borehole.	TAL metals, nitrates, perchlorate, cyanide, and radionuclides. Three samples will be selected for HE field test kit screening.	VOCs and tritium sample at depth nearest adjacent disposal unit and bottom of borehole.
Borehole C: sited between shaft 30 and 34 and advanced northwest toward shaft 29	Angle 85°	300	Determine the vertical extent of metal contamination and long term pore-gas monitoring in the northwest shaft field.	9 samples; every 30 ft, beginning with the depth equivalent to the base of Disposal Shaft 29, and the last at the depth of the borehole.	TAL metals, nitrates, perchlorate, cyanide, and radionuclides. Three samples will be selected for HE field test kit screening.	VOCs and tritium subsurface sample at depth nearest adjacent disposal unit and bottom of borehole. Annual sampling for VOCs and tritium.
Borehole D: just outside eastern boundary of MDA L	Vertical	700	Investigate presence of intermediate/perched groundwater.	2 samples; one beginning at the depth of Shaft 1 and the second at 300 ft.	TAL metals, nitrates, perchlorate, and cyanide, radionuclides.	
				140 samples; every 5 ft	Moisture content and matric potential	
				70 samples; every 10 ft	Chloride analysis	
				Once in each tuff unit, twice in Cerro Toledo Interval, and at five depths in Otowi Member	Saturated and unsaturated hydraulic conductivity, porosity and bulk density.	

Table 3
Proposed Monitoring Boreholes for Long-Term Monitoring Network

Monitoring Well ID	Depths of Screened Ports (ft bgs)	Monitoring Purpose	Monitoring Frequency
54-2002	20, 40, 60, 80, 100, 120, 140, 157, 180, 200	Southeast source area, vertical extent	Annual
54-2014	13, 31, 46, 86	Southeast source area, vertical extent	Annual
Proposed borehole C	TBD*	Northwest source area, vertical extent	Annual
54-2021	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	Western extent of plume	Biannual
54-2022	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	Western extent of plume	Biannual
54-2034	20, 40, 60, 80, 100, 160, 200, 220, 260	Western extent of plume	Biannual
54-2020	20, 40, 60, 80, 95, 120, 140, 160, 180, 200	Eastern extent of plume	Biannual
54-2024	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	Eastern extent of plume	Biannual

*TBD = To be determined based on field data.

Appendix A

Acronyms, Glossary, and Metric Conversion Table

APPENDIX A ACRONYMS, GLOSSARY, AND METRIC CONVERSION TABLE

A-1.0 ACRONYMS

AA	atomic absorption
AB	authorization basis
AOC	area of concern
asl	above sea level
B&K	Brüel and Krajer
bgs	below ground surface
BV	background value
CFR	code of federal regulations
CLP	Contract Laboratory Program
CMS	corrective measure study
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
CST	Chemical Science and Technology (Laboratory Division)
DCF	dose conversion factor
DDD	dichlorodiphenyldichloroethane
DL	detection limit
DOE	US Department of Energy
DOE-LAAO	US Department of Energy—Los Alamos Area Office
dpm	disintegrations per minute
DQO	data quality objective
EDL	estimated detection limit
EP	extraction procedure
EPA	US Environmental Protection Agency
EQL	estimated quantitation limit
ER	Environmental Restoration (Project)
ESE	Environmental Science Engineering
ET	evapotranspiration
FIMAD	Facility for Information Management, Analysis and Display
FV	fallout value
FY	fiscal year
GCMS	gas chromatography/mass spectrometry
GFAA	graphite furnace atomic absorption

GIS	geographic information system
GPR	ground-penetrating radar
GPS	gel permeation chromatography
GPS	global-positioning system
HE	high explosive
HIR	historical investigation report
HSWA	Hazardous and Solid Waste Amendments of 1984
ICPAES	inductively coupled plasma atomic emission spectrometry
ICPMS	inductively coupled plasma/mass spectrometry
IWP	investigation work plan
KPA	kinetic phosphorescence analysis
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory (designation of the Laboratory before January 1, 1981)
LCS	laboratory control sample
MDA	material disposal area
MDL	method detection limit
MFP	mixed fission products
MRAL	mobile radiological analysis laboratory
msl	mean sea level
NCEA	National Center for Environmental Assessment
NFA	no further action
NIOSH VOST	National Institute of Occupational Safety and Health Volatile Organic Sample Training
NMED	New Mexico Environmental Department
NMEID	New Mexico Environmental Improvement Division (designation of NMED before January 1, 1991)
NMHWA	New Mexico Hazardous Waste Act
NOD	notice of deficiency
OU	operable unit
PAR	photoacoustic radiometer
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
ppbv	part per billion by volume
ppm	part per million
ppmv	part per million by volume

PQL	practical quantitation limit
PRS	potential release site
QA	quality assurance
QC	quality control
RALM	radionuclide analytical Laboratory method
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-trinitro-1,3,5-triazacyclohexane
RFI	RCRA facility investigation
RRES-RS	Risk Reduction and Environmental Stewardship–Remediation Services
SAP	sampling and analysis plan
SDGCMS	solvent desorption gas chromatography/mass spectrometry
SMO	Sample Management Office
SOP	standard operating procedure
SOW	statement of work
SVOC	semivolatile organic compound
SWMU	solid waste management unit
T&E	threatened and endangered
TA	technical area
TAL	target analyte list (EPA)
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TDGCMS	thermal desorption gas chromatography/mass spectrometry
TIC	tentatively identified compound
TNT	trinitrotoluene
TRU	transuranic
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
USGS	United States Geological Survey
UTL	upper tolerance limit
VOC	volatile organic compound

A-2.0 GLOSSARY

Background value (BV). The upper tolerance limits (UTLs) of background sample results, calculated as the upper 95% confidence limit for the 95th percentile. When a UTL cannot be calculated, either the detection limit or the maximum reported value is used as a BV; BVs are used as simple threshold numbers to identify potentially contaminated site sample results that are greater than background levels in that geological sample medium (or group of media). Most inorganic chemicals and radionuclides have BVs.

Baseline risk assessment (also known as risk assessment). A site-specific analysis of the potential adverse effects of hazardous substances that are released from a site in the absence of any control or mitigation actions. A baseline risk assessment consists of four steps: data collection and analysis, exposure assessment, toxicity assessment, and risk characterization.

Calibration. Process used to identify the relationship between the true (reference) analyte concentration or other variable and the response of a measurement instrument, chemical analysis method, or other measurement systems.

Chemical of potential concern (COPC). A chemical detected at a site that has the potential to adversely affect human *receptors* because of its concentration, distribution, and mechanism of toxicity. A COPC remains a concern until *exposure* pathways and receptors are evaluated in a site-specific human health risk assessment.

Chemical of potential ecological concern (COPEC). A chemical detected at a site that has the potential to adversely affect ecological *receptors* because of its concentration, distribution, and mechanism of toxicity.

Data validation. Systematic process that applies a defined set of performance-based criteria to a body of data and may result in qualification of the data. The data validation process is performed independently of the analytical laboratory that generates the data set and occurs before conclusions are drawn from the data. The process may comprise a standardized data review (routine data validation) and/or a problem-specific data review (focused data validation).

Department of Energy (DOE). Federal agency that sponsors energy research and regulates nuclear materials for weapons production.

Detection limit (DL). Minimum concentration that can be determined by a single measurement by an instrument; it implies a specified statistical confidence that the analytical concentration is greater than zero.

Dose. Quantity of radiation that is absorbed, per unit of mass, by the body or by any portion of the body.

Ecological screening level (ESL). An organism’s exposure-response threshold for a given chemical constituent. The concentration of a substance in a particular medium corresponds to a hazard quotient (HQ) of 1.0 for a given organism below which no risk is indicated.

Environmental Protection Agency (EPA). Federal agency responsible for enforcing environmental laws. While state regulatory agencies may be authorized to administer some of this responsibility, the EPA retains oversight authority to ensure protection of human health and the environment.

Groundwater. Water in a subsurface saturated zone; water beneath the regional water table.

Migration. The movement of inorganic and organic species through unsaturated or saturated materials.

Model. A mathematical approximation of a physical, biological, or social system.

National Pollutant Discharge Elimination System (NPDES). The national program for both issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits and imposing requirements under Sections 307, 318, 402, and 405 of the Clean Water Act.

Polychlorinated biphenyls (PCBs). Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances containing such substances. PCBs are colorless, odorless compounds that are chemically, electrically, and thermally stable and have proven to be toxic to both humans and animals.

Quality assurance (QA). All those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily in service.

Quality control (QC). (1) All those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. QC is the process through which actual quality performance is measured and compared with standards. (2) All methods and procedures used to obtain accurate and reliable results from environmental sampling and analysis. Includes rules for when, where, and how samples are taken; sample storage, preservation and transport; and the use of blanks, duplicates, and split samples during the analysis.

Radionuclide. A nuclide (species of atom) that exhibits radioactivity.

RCRA facility investigation (RFI). The investigation that determines if a *release* has occurred and the nature and extent of the contamination from such a release at a hazardous waste facility. The RFI is generally equivalent to the remedial investigation portion of the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) process.

Receptor. A person, plant, animal, or geographical location that is exposed to a chemical or physical agent released to the environment by human activities**.**

Regional aquifer. Geologic material(s) or unit(s) of regional extent whose saturated portion yields significant quantities of water to wells, contains the regional zone of saturation, and is characterized by the regional water table or potentiometric surface.

Release. Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous waste or hazardous constituents into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles that contain any hazardous wastes or hazardous constituents).

Resource Conservation and Recovery Act (RCRA). The Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976. (40 CFR 270.2)

Sample. A portion of a material (e.g., rock, soil, water, air), which, alone or in combination with other samples, is expected to be representative of the material or area from which it is taken. Samples are typically sent to a laboratory for analysis or inspection or are analyzed in the field. When referring to samples of environmental media, the term “field sample” may be used.

Screening action level (SAL). Medium-specific concentration level for a chemical derived using conservative criteria below which it is generally assumed that there is no potential for unacceptable *risk* to human health. The derivation of a SAL is based on conservative exposure and land-use assumptions. However, if an applicable regulatory standard exists that is less than the value derived by risk-based computations, it will be used for the SAL.

Screening assessment. A process designed to determine whether contamination detected in a particular medium at a site may present a potentially unacceptable human-health and /or ecological risk. The assessment utilizes screening levels that are either human-health or ecologically based concentrations derived by using chemical-specific toxicity information and standardized exposure assumptions below which no additional actions are generally warranted.

Sediment. (1) A mass of fragmented inorganic solid that comes from the weathering of rock and is carried or dropped by air, water, gravity, or ice; or a mass that is accumulated by any other natural agent and that forms in layers on the earth's surface such as sand, gravel, silt, mud, fill, or loess. (2) A solid material that is not in solution and either is distributed through the liquid or has settled out of the liquid.

Site conceptual model. A qualitative or quantitative description of sources of contamination, environmental transport pathways for contamination, and biota that may be impacted by contamination (called receptors) and whose relationships describe qualitatively or quantitatively the release of contamination from the sources, the movement of contamination along the pathways to the exposure points, and the uptake of contaminant by the receptors.

Standard operating procedure (SOP). A document that details the method for an operation, *analysi*s, or action with thoroughly prescribed techniques and steps, and is officially approved as the method for performing certain routine or repetitive tasks.

Target analyte. An element, chemical, or parameter, the concentration, mass, or magnitude of which is designed to be quantified by use of a particular test method.

Technical area (TA). The Laboratory established technical areas as administrative units for all its operations.

Topography. The physical configuration of the land surface in an area.

Tuff. A compacted deposit of volcanic ash and dust that contains rock and mineral fragments accumulated during an eruption.

US Department of Energy (DOE). Federal agency that sponsors energy research and regulates nuclear materials for weapons production. [Already listed under DOE]

US Environmental Protection Agency (EPA). Federal agency responsible for enforcing environmental laws. While state regulatory agencies may be authorized to administer some of this responsibility, the EPA retains oversight authority to ensure protection of human health and the environment.[Already listed above]

Vadose zone. The unsaturated zone. Portion of the subsurface above the water table in which pores are not fully saturated.

A-3.0 METRIC CONVERSION TABLE

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (l)	0.26	gallons (gal.)
milligrams per liter (mg/l)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

Appendix B

Historical Investigation Report

CONTENTS

List of Figures

List of Tables

APPENDIX B HISTORICAL INVESTIGATION REPORT

This historical investigation report (HIR) provides a summary of the field investigations and associated environmental data collected to date for material disposal area (MDA) L. This HIR provides supporting information for identifying data gaps and the proposed sampling design necessary to complete the MDA L investigation as presented in Section 4 of the investigation work plan (IWP).

B-1.0 MDA L DISPOSAL UNIT INFORMATION (OPERATIONAL HISTORY)

The Los Alamos National Laboratory (LANL or the Laboratory) used MDA L from the early 1960s until 1986 as the designated disposal area for nonradiological liquid chemical wastes, including containerized and uncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions and electroplating wastes, including precipitated heavy metals; and small batch quantities of treated lithium hydride. MDA L consists of an elongated pit (Pit A), three impoundments (Impoundments B, C, and D) and 34 shafts (Shafts 1 through 34) (Figure B-1). The pit, impoundments, and shafts were unlined. The dimensions, period of operation, and the capacity of the pit, impoundments, and shafts are listed in Tables B-1 through B-3. Laboratory drawings AB113 (LANL 1993, 76052) and ENG-C-45259 (DOE 1987, 25606) have been used to identify the locations of the pit, impoundments, and shafts at MDA L.

Pit A was excavated into native tuff, filled with waste to within three ft of the surface, and then decommissioned and covered with clean, crushed, consolidated tuff. Impoundments B, C, and D were excavated into native tuff and covered with clean, crushed, consolidated tuff after they were decommissioned. Thirty-four disposal shafts were dry-drilled directly into the subsurface tuff at MDA L. The shafts range in diameter from 3 ft to 8 ft and range in depth from 15 to 65 ft. Three feet of crushed tuff were placed in the bottom of each shaft to fill cracks and joints. When in use, the shafts were covered with a heavy steel cap, which could be opened or removed, depending on design, to place the wastes. When filled to within approximately 3 ft of the surface, the area below the steel plate was capped with a 3-ft concrete plug (Rogers 1977, 5707; 5708). When MDA L was decommissioned in 1986, the surface was paved with asphalt to accommodate waste management activities (permitted storage of hazardous and mixed waste).

B-1.1 Waste Inventory and Disposal History

Waste disposal records for MDA L are found in un-numbered disposal logbooks used to record information on the type, date, location, and volume of waste placed in MDA L (LANL 2003, 76036). Records prior to 1974 are incomplete, and many logbook entries contain only brief descriptions of wastes disposed at MDA L (i.e., waste types, volumes, and disposal locations are not always provided).

An estimate of the types and quantities of waste disposed of at MDA L was compiled in the operable unit (OU) 1148 data report (LANL 1992, 11729) and in the approved Resource Conservation and Recovery Act (RCRA) field investigation (RFI) work plan for OU 1148 (LANL 1992, 07669). Two waste inventory databases were developed based on original logbook entries for MDA L. The Source Term Database contains information on untreated waste, and the Batch Waste Source Term Database lists wastes that underwent batch treatment prior to disposal.

B-1.1.1 Source Term Database

The Source Term Database includes the following categories of information for untreated waste disposed at MDA L: date of disposal; waste volume or weight; number of cylinders or waste items disposed of; specific location of disposal (shaft, pit, or impoundment), if known; and a description of the untreated waste. Many of the entries do not include a specific location of disposal within MDA L. An example of potential volume discrepancies in this database occurs within the inventory of beryllium waste. One entry described as “chemicals and beryllium-contaminated wood” lists the volume of waste as five cubic ft. The actual quantity of beryllium or beryllium-contaminated wood is not accurately represented by this volume. The Source-Term Database is included in Appendix L. The assumptions used to create the database are listed on pages 3-1 and 3-2 of Appendix L.

B-1.1.2 Batch Waste Source Term Database

The Batch Waste Source Term Database includes the following categories of information for waste treated at MDA L: date of treatment; waste volume; source area where material originated; waste type (inorganic and organic); impoundment or pit location if known; treatment method; and the physical form of the waste. The records document only the wastes that were disposed of without treatment or following treatment in Pit A and Impoundment B. The Batch Waste Source Term Database is presented in Appendix L. The assumptions used to create the database are listed on pages 3-3 and 3-4 of Appendix L.

B-1.1.3 Uncertainties in the MDA L Inventory

There are no logbook entries for the waste disposed prior to 1974/1975, and there are no logbook entries for treatment in Impoundments C and D. It is possible that these impoundments were used for waste treatment and the residues were removed and placed elsewhere at MDA L, or the residues were left in situ and not accounted for in the logbooks. Operating dates for each disposal unit and a summary of the waste inventory compiled from disposal records and the databases for MDA L follows (LANL 1992, 07669).

Pit A (Late 1950s to December 1978)

Pit A received liquid chemical wastes, including containerized and uncontainerized liquid wastes, and functioned as an evaporation pit where bulk quantities of treated aqueous waste from throughout the Laboratory were discharged, pooled, and allowed to evaporate. Disposal records provided in Appendix L indicate that 5123 cubic ft of material were discharged to Pit A. After the aqueous phase evaporated, a salt layer remained on the floor of the disposal pit. When Pit A was decommissioned in 1978, it was covered with crushed tuff.

Impoundments B (January 1979 to June 1985) and C (July 1985 to December 1985)

Impoundments B and C were used for evaporating batch-treated salt solutions and electroplating wastes. Disposal records provided in Appendix L indicate that 2622 cubic ft of aqueous waste were discharged into Impoundment B, pooled, and allowed to evaporate. The four processes that contributed to the wastes disposed of in Impoundments B and C are the same as the aqueous waste treatment processes described previously for Pit A. Upon decommissioning, Impoundments B and C were covered with a minimum of 3 ft of crushed tuff.

Treated solutions resulting from the following four aqueous waste treatment processes contributed to the waste streams discharged into Pit A and Impoundments B and C (LANL 1992, 11729).

- Ammonium bifluoride waste was neutralized with calcium chloride and calcium hydroxide. The end product was an aqueous solution consisting of ammonium chloride, calcium fluoride, and water.

- Acids and caustics in quantities greater than 55 gal. were diluted to 15% or less and neutralized. Acid solutions were neutralized with sodium hydroxide; base solutions were neutralized with mineral acids. Heavy metals were precipitated and removed prior to disposal. Heavy metals precipitated from acid solutions were packaged in 15-gal. drums and disposed of in the same shaft(s) as the neutralized acid solutions, while heavy metals precipitated from caustic solutions were also packaged in 15-gal. drums and disposed of in the same shaft(s) as the neutralized caustic solutions (LANL 2003, 76078).
- Cyanide solutions were treated with calcium hypochlorite or calcium chloride and calcium hydroxide at technical area (TA) 50. The end products of both processes are cyanate, carbon dioxide, and nitrogen. The resulting aqueous solution was tested to ensure complete cyanide treatment. After treatment, the aqueous solution was discharged primarily to Pit A or to one of the evaporation impoundments (B, C, or D). Solids from the process were placed in metal drums, mixed with cement, and disposed of in shafts at MDA L.
- Chromium waste was treated with sodium hydroxide and one of two reducing agents: sulfur dioxide or sodium bisulfate. The end-products of this process were sodium sulfate and chromium hydroxide. The treated chromium waste was disposed of in the same shaft(s) as the neutralized acid solutions.

Impoundment D (1972 to 1984)

Impoundment D was used exclusively for treating small batch quantities of lithium hydride by reacting lithium hydride with water and allowing the neutralized liquid to evaporate. Based on the results of a safety review, this treatment process was discontinued in 1984 because of the reactivity of the lithium hydride, and disposal activities in Impoundment D ceased. Impoundment D was partially filled with crushed tuff in 1985 and completely filled in 1989. Between 1984 and 1989, six aboveground fiberglass used-oil storage tanks (area of concern [AOC] 54-021) were located within a soil-containment berm adjacent to Impoundment D. The tanks, which stored waste oil, were pumped out in 1985 and moved from MDA L to MDA G in 1989 to make room for new waste management facilities on the surface of MDA L. The tanks themselves were subsequently closed in 1990 under RCRA regulations and a closure report was submitted to the New Mexico Environment Department (NMED) in 1991. Any associated contaminated soil from the tanks will be addressed during closure of the RCRA-permitted surface treatment and storage units currently located on the surface of MDA L.

Disposal Shafts 1 through 34 (February 1975 to February 1985)

Disposal Shafts 1 through 34 were used for disposing of containerized and uncontainerized liquid chemical wastes and precipitated solids from the treatment of aqueous wastes. Before 1982, containerized liquids were disposed of without adding absorbents to the containers in which they were placed. Frequently, small containers were simply dropped into a shaft. Larger drums were lowered by crane and arranged in layers of one drum in a 3-ft- or 4-ft-diameter shaft, four to five drums in a 6-ft-diameter shaft, or 6 drums in an 8-ft-diameter shaft. The space around the drums was filled with crushed tuff, and a 6-in. layer of crushed tuff was placed between each layer of drums. Uncontainerized liquid wastes were also disposed of in the shafts.

Between 1982 and 1985, only containerized wastes (including liquids, precipitated heavy metals, and stabilized heavy metals) were disposed of in the shafts. Wastes were accumulated on the site and packaged in drums until sufficient quantities had accumulated for emplacing them in a shaft.

B-1.2 Previous Field Investigations

On May 7, 1985, the Laboratory received a compliance order from the New Mexico Environmental Improvement Division (NMEID, now NMED) that addressed numerous waste management issues at the Laboratory (NMEID 1985, 75885). The 1985 order specified the following six tasks that involved site investigation activities in and around MDA L:

- Task 1 required measuring the intrinsic permeability of the tuff,
- Task 2 required determining the soil-moisture characteristic curves,
- Task 3 required determining the unsaturated hydraulic conductivity of the Bandelier Tuff,
- Task 4 required analyzing the infiltration and redistribution of meteoric water into the tuff,
- Task 5 required characterizing the core and pore gas in the vadose zone, and
- Task 6 required analyzing the potential presence of perched water.

The results and outcomes of the above six tasks are described in a report entitled “Hydrogeologic Assessment of Technical Area 54, Areas G and L” (LANL 1987, 76068), which was submitted in 1987 to the NMEID in response to the 1985 compliance order/schedule.

Task 1: In 1986, five boreholes (three at MDA L and two at MDA G) were advanced to 125 ft below ground surface (bgs) to measure air permeability in units 2 and 1v of the Tshirege Member of the Bandelier Tuff. Field methods included air injection and vacuum testing of five boreholes. Water injection permeability tests conducted in one borehole validated the results of air tests. The intrinsic permeability of four core samples from each borehole was determined in the laboratory via the Klinkenberg Method and the Dynamic Method. Field methods yielded intrinsic permeability in the range of 10^{-8} to 10^{-9} cm^2 and laboratory methods yielded values of 10^{-9} cm^2.

Task 2: According to field and laboratory analyses, the moisture content of the core ranges from 2% to 4%, with isolated intervals ranging from 10% to 28%. Soil moisture characteristic curves were difficult to develop because the samples disaggregated under simulated low-capillary pressures; however, curves were developed for 20 samples. The analyses of these samples showed that high moisture retention values and low moisture content measurements result in vapor transport as the major mechanism of water transport.

Task 3: Five samples from each of four horizons were used to determine unsaturated hydraulic conductivity using both theoretical and laboratory methods. Theoretical methods yielded an average of 2.64×10^{-4} ft/day and measured values averaged 1.32×10^{-4} ft/day.

Task 4: Analysis of infiltration and redistribution of meteoric water into the core was conducted by neutron-moisture monitoring and measuring matric potential with thermocouple psychrometers. Neutron moisture monitoring and gravimetric moisture measurements indicated that the volumetric moisture content of the tuff below 10 ft is approximately 2% to 4%. In addition, analysis of daily moisture logs after autumn preciptitation indicated the depth of infiltration of meteoric water was approximately 10 ft. Moisture was not observed to move deeper than 10 ft and was assumed to be returned to the surface through evapotranspiration. Psychrometers indicate soil tensions range from slightly less than 1 bar to approximately 15 bars. Vertical hydraulic gradients, as determined by psychrometers, ranged from a downward gradient of 10.2 ft/ft to an upward gradient of 4.12 ft/ft.

Calculation of moisture flux rates through porous media using field-derived hydraulic gradients and laboratory-derived unsaturated hydraulic conductivities yielded mean flux rates of 0.036 and 0.211 ft/yr for MDAs L and G, respectively. However, because the moisture content used in calculating unsaturated hydraulic conductivity was greater than that observed in the field, the flux rates calculated were also higher than actual rates.

Task 5: In 1985, four boreholes were drilled at MDA L and two at MDA G; additionally, one background borehole was drilled on the western end of Mesita del Buey for core and pore-gas analyses of the Bandelier Tuff. Core samples collected from each 10-ft interval in all 7 boreholes were analyzed for extraction procedure (EP) toxicity and volatile organic compounds (VOCs). No EP toxic metals were detected in core samples beneath a depth of 20 ft. Part per million (ppm) concentrations of VOCs were detected in core samples from MDA L to depths of 100 ft (maximum depth sampled), and none was detected at MDA G.

A total of 23 sampling ports were installed in the 7 boreholes to collect pore-gas samples to 100-ft depths. Analysis of samples collected by pumping the pore gas through charcoal adsorption tubes showed that VOCs were detected in MDA L in ppm concentrations at all depths sampled and in the part per billion (ppb) range at all depths sampled at MDA G.

Task 6: Four test holes drilled in Cañada del Buey were converted to monitoring wells. Seven test holes were drilled in Pajarito Canyon, and three were converted to monitoring wells to investigate the alluvial, perched water systems potentially present in these canyons. The alluvium in Cañada del Buey was found to be confined to the canyon, and all test holes in the alluvium were dry. In Pajarito Canyon, the boreholes intersected a perched water system. The top of the perched water was about one to five ft below the surface of the alluvium, and the water level fluctuated significantly over short periods of time. It was concluded that perched water in Pajarito Canyon was confined to alluvium within the canyon and did not extend vertically or horizontally into the Bandelier Tuff, which forms Mesita del Buey. No perched water was found in Cañada del Buey. No perched bodies of water, which could be hydraulically connected to the regional aquifer, were found beneath MDAs G and L.

Between 1986 and 1990, the Laboratory voluntarily drilled and instrumented two additional boreholes at MDA G and 20 boreholes in and around MDA L to begin characterizing the nature and extent of the vapor-phase VOC plume. Analytical results from pore-gas samples collected between 1985 and 1990 were reported in “Analysis of the Pore-Gas Monitoring at Area L, TA-54” (Trent 1992, 11881) and “Review of Soil-Vapor Sampling Wells and Data from TA-54 Areas G and L” (LANL 1992, 11729).

A review of analytical data presented in these two reports for MDA L indicates

- releases from MDA L resulted in a subsurface vapor-phase VOC plume extending beneath the site and beyond the boundary of MDA L,
- 1,1,1-trichloroethane (TCA) is the primary constituent of the VOC plume,
- TCA is present to a depth of at least 200 ft below the surface of the mesa, and
- TCA concentrations vary across the plume.

A review of analytical results for pore-gas samples collected in 19 of the boreholes at MDA L between 1988 and 1992 is presented in a report entitled “Pilot Extraction Study Plan for the Organic Vapor Plume at MDA L” (LANL 1993, 22430). This report describes the VOC plume at MDA L as follows: “the principal vapor phase organic compounds, listed in descending order of concentration were TCA, trichloroethene (TCE), carbon tetrachloride, chloroform, tetrachloroethene (PCE), toluene, and benzene. Other contaminants that have been detected, but at much lower concentrations, include chlorobenzene, xylenes, and 1,2,4-trimethylbenzene. TCA was found in the greatest concentration, and it also exhibits the greatest lateral and vertical extent in the organic vapor plume. The measured concentrations of TCA are almost an order of magnitude greater than values measured for TCE, the contaminant of second highest concentration.”

B-2.0 PHASE I RFI FIELD INVESTIGATIONS

Phase I RFI fieldwork was conducted at MDA L from 1993 through 2002. The approved RFI work plan for OU 1148 specified sampling surface soil/sediment, subsurface tuff, surface flux, ambient air, and pore gas. Surface water, soil/sediment, core, and particulates from ambient air samples were to be analyzed for inorganic chemicals (target analyte list [TAL] metals and cyanide), organic chemicals (VOCs, semivolatile organic compounds [SVOCs], pesticides, polychlorinated biphenyls [PCBs]), and radionuclides (LANL 1992, 07669). The objectives of the Phase I RFI were to better define the source term and the nature of contaminants released from MDA L, to define the extent of the VOC plume and any other identified contaminant releases, to collect data to support and supplement existing data, and to collect data to be used in a risk assessment. Phase I RFI fieldwork conducted at MDA L included

- collecting and analyzing four surface drainage sediment samples,
- drilling seven vertical boreholes and 11 angled boreholes,
- collecting and analyzing 184 core samples,
- collecting and analyzing 207 subsurface pore-gas samples for VOCs,
- collecting and analyzing 102 surface flux samples plus nine duplicates for VOCs, and
- colleting and analyzing 102 ambient air samples for VOCs.

A summary of work plan specifications, the fieldwork performed, and the rationale for deviations from the work plan are provided in Table B-4.

B-2.1 Surface Investigation

B-2.1.1 Channel Sediment Sampling

Runoff from MDA L is concentrated into a single drainage channel that carries surface runoff to the north-northeast into Cañada del Buey (Figure B-2). This drainage includes multiple braided channels traversing a 50-ft- to 65-ft-wide area of a colluvial slope to the floor of a tributary of Cañada del Buey. The channels begin along the eastern fence of MDA L and diverge below the cliffs on the north side of Mesita del Buey.

In July 1994, eight locations from within the drainage were selected for sediment sampling to determine if contaminants had migrated from MDA L; the most likely depositional areas (e.g., low areas behind obstructions) for the channel were determined by an on-site geomorphic survey. These locations included areas with coarse sediment deposition on the upper slope and areas with finer sediment deposition on the lower slope. Sample depth ranged from 0 to 4 in. to 0 to 8 in. Eight sediment samples (along with a field duplicate sample and rinsate blank) were collected and field-screened for gross alpha, beta, and gamma radiation to bias sample selection. The sample with the highest gross alpha and gross beta, the sample with the highest gross gamma, and two other samples selected at random (four total) were submitted to an off-site contract laboratory for analysis of TAL metals, PCBs, pesticides, herbicides, gamma spectroscopy radionuclides, americium-241, tritium, isotopic thorium, strontium-90, isotopic uranium, and isotopic plutonium (LANL 1996, 54462.7). Table B-5 lists the sediment sample locations, sample IDs, and requested analyses.

B-2.1.2 Ambient-Air Sampling

During the summer of 1994, ambient air samples were collected in SUMMA™ canisters for VOC analysis on eight days at two sampling locations (locations 4 and 5 in Figure B-3) on the northern perimeter of MDA L (Mischler and Anderson 1994, 63525). Samples were also collected at a background location adjacent to Bandelier National Monument (location 3). Sampling dates included June 16, 17, 29, and 30; July 28; and August 1, 2, and 3, 1994. Duplicate samples were collected on three of the sampling days. The June samples were collected at the height of the dry season on the Pajarito Plateau, while the July and August samples were taken during the rainy season. Samples were collected over an 8-hr period beginning at 8:00 am. Meteorological data (i.e., ambient temperature and wind speed) were also recorded. Samples were analyzed by the US Environmental Protection Agency (EPA) Method TO-14. Ambient air data from these sampling events were used to evaluate potential air contamination from MDA L. A more detailed discussion of this sampling activity is presented in Mischler and Anderson (1994, 63525).

B-2.2 Surface Flux Measurements

B-2.2.1 Tritium Surface Flux (Chamber) Measurements

Tritium flux was measured using a flux chamber at five locations near MDA L during the summer of 1993 (locations T1, T2, C11, C29, and C30) and three locations during the summer of 1994 (locations S1, S2, and S3). Tritium flux chamber locations are shown in Figure B-4 and results are presented in Table B-6 (Eklund 1995, 56033). The flux chamber sampling apparatus consisted of a 1300 cm^2 Plexiglas flux chamber pressed about 1 in. into the soil through which a sweep gas was fed at a constant rate. Air was pulled through the chamber with a pump at a rate slightly less than the sweep gas rate to avoid dilution with ambient air. Tritium samples were collected on primary and secondary gel tubes.

B-2.2.2 VOC Surface Flux (EMFLUX®) Measurements

VOC surface flux was measured across MDA L in two surveys conducted in August 1993 and August 1994. The purpose of the surveys was to identify the nature and extent of potential subsurface VOC contamination. EMFLUX® collectors, consisting of an adsorbent cartridge suspended on a stake beneath a protective shell for a 72-hr period, were used in the survey. Details of the investigation are reported in Quadrel Services reports (Quadrel 1993, 63868). Trujillo et al. (1998, 58242) issued a report summarizing the results of the surface flux VOC measurement investigations.

In the first survey in August 1993, 70 sample locations were identified and an additional 32 locations were selected in the August 1994 survey. The majority of the 1993 sample locations were on the mesa top at MDA L, while most of the 1994 sample locations were in the slopes and drainages on the sides of the mesa. The EMFLUX® surface flux measurement locations are shown in Figure B-5. Four field duplicate samples also were collected during the first survey, and three field duplicates were collected during the second survey.

B-2.3 Subsurface Investigations

B-2.3.1 Core Sampling

From September 9, 1993, to May 8, 1995, 7 vertical boreholes and 11 angled boreholes were advanced at MDA L during the Phase I RFI. Detailed borehole logs, including lithologies and a diagram showing pore-gas sampling port construction for the monitoring borehole are presented in Appendix H. Borehole locations and trajectories are shown on Figure B-6. The RFI boreholes are described by depth, declination, and adjacent disposal unit in Table B-7. Table B-7 lists similar information for the pre-RFI boreholes. The exterior and ends of each core barrel and each 5-ft. interval of core were screened for VOCs using a photoionization detector (PID). Each 5-ft interval of core was inspected for fractures or stains, and the results were noted in borehole logs (Appendix H).

During the Phase I RFI at MDA L, 89 core samples were collected from 10 boreholes and submitted to an off-site contract laboratory for analysis. Depth intervals for sample collection and analytical suites varied by borehole and are described below. A total of 18 boreholes were drilled during the Phase I RFI; however, core samples were not collected from boreholes 54-01017 and 54-01018. Core samples collected from boreholes 54-01001 through 54-01006 were collected for screening only. Both screening and off-site contract laboratory core samples were submitted from borehole 54-01009. Borehole 54-01017 was designed as the extraction well for the pilot vapor extraction test, and borehole 54-01018 was drilled as an additional pore-gas monitoring borehole located 20 ft from borehole 54-01017. Table B-8 lists the core sample locations, sample IDs, depths, media sampled, and requested analyses.

In 1993, boreholes 54-01001 through 54-01006 were drilled immediately east of MDA L (Figure 6). These two vertical and four angled boreholes were drilled to depths ranging between 291 and 340 ft bgs using an 8-in.-diameter hollow-stem auger and a continuous-coring technique. These six boreholes were instrumented with vapor-monitoring systems using SEAMist™ positive-pressure borehole liners. A total of 94 core samples were collected at 20-ft intervals from boreholes 54-01001 through 54-01006 and submitted to an on-site mobile chemical laboratory for VOCs.

Vertical boreholes 54-01007, 54-01008, and 54-01009 were also drilled in 1993 adjacent to numerous shafts and Pit A. Twenty-six core samples were collected at 10-ft intervals and submitted for off-site contract laboratory for analysis of TAL metals, cyanide, pesticides/PCBs, herbicides, SVOCs, and VOCs. Five core samples from borehole 54-01009 were also submitted to an off-site contract laboratory for isotopic plutonium and isotopic uranium analysis. Twelve samples from 54-01009 were submitted to an on-site mobile chemical laboratory for VOC and SVOC analysis. Boreholes 54-01007, 54-01008, and 54-01009 were subsequently backfilled.

In 1994, angled boreholes 54-01010 through 54-01014 were advanced using an 8-in.-diameter hollow-stem auger and a continuous-coring technique beneath Pit A and Impoundments B, C, and D at MDA L (Figure B-6). In 1996, the surface casings were removed, and each borehole was backfilled and grouted closed, ensuring that the borehole did not provide a conduit for surface runoff to enter the subsurface. A total of 29 core samples were collected at 10-ft intervals and submitted to an off-site contract laboratory for analysis of TAL metals, pesticides/PCBs, SVOCs, VOCs, and tritium. Additional core samples submitted for off-site contract laboratory analyses included all 24 core samples from boreholes 54-01010, 54-01011, 54-01012, and 54-01014 for cyanide; and 11 core samples from boreholes 54-01010, 54-01013, and 54-01014 for total uranium.

In 1994 and 1995, two deep-angled boreholes, designated as 54-01015 and 54-01016, were drilled from the adjacent canyon slope northeast of MDA L (Figure B-6) within Cañada del Buey to investigate the possible presence of vapor-phase contaminants at depth beneath MDA L. These boreholes were drilled to depths of 530 ft and 607 ft bgs, respectively, below MDA L using air-rotary installation of 8-in.-diameter STRATEX® casing to the bottom of each borehole. The boreholes were selectively cored for approximately 10 ft within every 40-ft interval below a depth of 260 ft bgs. From discontinuous core, 22 samples were collected at 50-ft intervals and analyzed at an off-site contract laboratory for VOCs and tritium. Following the installation of a Solinst multiport vapor and lysimeter-coupled systems in each borehole, the STRATEX® casing was withdrawn while annular well completion materials were emplaced to complete the vapor monitoring borehole. Both boreholes are maintained as vapor-monitoring wells.

In 1995, boreholes 54-01017 and 54-01018 were advanced east of MDA L (Figure B-6). Borehole 54-01017 was designed as the extraction well for the pilot vapor extraction test, and borehole 54-01018, located 20 ft south-southeast of borehole 54-01017, was used to monitor pore gas during extractor tests. Borehole 54-01017 was drilled to a depth of 159 ft bgs using an 8-in.-diameter hollow-stem auger and reamed to a 10-in. diameter. The top 75 ft of borehole 54-01017 is cased with 10-in.-diameter steel casing and is open below the casing to a depth of 150 ft. Borehole 54-01018 was drilled to a depth of 328 ft bgs using an 8-in.-diameter hollow-stem auger and a continuous-coring technique. The top 30 ft of borehole 54-01018 is cased 8-in.-diameter steel. No core samples were collected from boreholes 54-01017 and 54-01018 for screening or analysis during the Phase I RFI. Both boreholes are capped at the ground surface.

Results of geologic logging were recorded in the borehole logs (Appendix H). Saturation was not encountered in any of the Phase I RFI boreholes at MDA L; however, intervals of cuttings and core with elevated moisture content were encountered in RFI boreholes 54-01015 and 54-01016 drilled in 1994 and 1995. Borehole logs provided in Appendix H document that elevated moisture was observed in the form of moist to wet cuttings and core at depths of 390 ft bgs (Puye Formation paleosol), 511 ft bgs (basalt), and 540 ft bgs (basalt) in borehole 54-01015. Similarly, the borehole log for borehole 54-01016 shows that elevated moisture was observed in cuttings and core at a depth of 254 ft bgs (Cerro Toledo interval) and at multiple depths within the basalt (362, 429, 430, 461, 533, 556, 577, and 592 ft bgs) beneath MDA L. Instruments to collect both pore vapor and water were installed where moist-to-wet conditions were found at two depths (350.8 and 525 ft bgs) in borehole 54-01015 and at four depths (188.3, 318.8, 480.8, and 600.7 ft bgs) in borehole 54-01016. During quarterly pore-gas monitoring conducted from 1996 through 1999, sampling of the water ports to target zones of potential perched zones was attempted; however, no water was recovered.

B-2.3.2 Borehole Airflow Velocity (Passive VOC Extraction)

In 1997 and 1998, the former Environmental Restoration Project (now called Risk Reduction and Environmental Stewardship–Remediation Services [RRES-RS]) evaluated the effectiveness of passive vapor extraction of subsurface vapor-phase VOCs at MDA L as specified in Appendix A of the approved RFI work plan for OU 1148 (LANL 1992, 07669). Passive vapor extraction uses natural changes in atmospheric barometric pressure as a pump to exhaust VOCs through the open boreholes. The volume of air flowing out of a borehole and the concentration of VOCs in this air are used to calculate the annual emission rate of VOCs from a borehole.

In 1997, airflow volume and VOC concentrations were measured with a Brüel and Kjaer (B&K) Multigas Analyzer, Model 1302 at borehole 54-01006 and reported in Neeper and Kisiel (1998, 63999). In 1998, the tests were repeated using a one-way valve on borehole 54-01006 to allow only the exhalation of subsurface air during periods of relatively high atmospheric pressure. During the 1998 study, vapor concentrations and pressure were measured at several subsurface ports in boreholes 54-01004, 54-01006, and 54-01018 and in atmospheric air. The 1998 results are presented in Kisiel and Mason (1998, 63526). These data were not used for evaluating the nature and extent of contamination at MDA L.

B-2.3.3 Pore-Gas Sampling

Subsurface pore gas sampling at MDA L is required by Section C.5 of Module VIII of the Laboratory's Hazardous Waste Facility Permit, "Unsaturated Zone Monitoring" (EPA 1990, 1585; EPA 1994, 44146). The approved sampling and analysis plan (Davis 1993, 38812) requiring collecting pore-gas samples from 12 of 28 available boreholes at MDAs G (4) and L (24) on a quarterly basis is described in the Laboratory's response (Glatzmaier 1993, 30987) to an EPA notice of deficiency ([NOD] Driscoll 1992, 3849.3). Of the 12 boreholes, 10 boreholes are to be selected every quarter from the available 24 pore-gas monitoring boreholes located at MDA L (Figure B-6).

The depths of pore-gas sampling ports in the 24 operational boreholes currently sampled at MDA L are listed in Table B-9. Detailed borehole logs, including lithologies for boreholes 54-01015 and 54-01016, are presented in Appendix H. Pore-gas monitoring methods have changed over the years in response to more sensitive detection capabilities. A summary of pore-gas sampling from 1995 through 2001 is included in Appendix G.

The pilot extraction study plan, as originally described in the approved RFI work plan for OU 1148 (LANL 1992, 07669), was modified in 1996 (LANL 1996, 55574) to include the installation of two angled boreholes instead of two vertical boreholes to allow for data collection beneath multiple disposal units and from deep geologic formations. The angled boreholes (54-01015 and 54-01016) were drilled into the basalt underlying the Bandelier Tuff between November 1994 and March 1995. The two angled boreholes were advanced from Cañada del Buey to vertical depths of 400 and 600 ft, respectively, below the surface of MDA L. Borehole 54-01015 was drilled to intersect the region below the closed disposal shafts located in the western part of MDA L. Borehole 54-01016 was drilled to intersect the region below the closed pit, impoundments, and shafts located in the eastern part of MDA L (Figure B-6).

Since 1997, pore-gas sampling has been aided and directed using soil-gas screening with a B&K Multigas Analyzer, Model 1302. The gas analyzer is capable of measuring up to five analytes and is used to screen for TCA, TCE, PCE, Freon 11 and Freon 13. These five analytes are used for screening because they are the most prominent VOCs in the MDA L vapor plume. The gas analyzer is integrated into a gas-sampling train that allows for subsurface soil-gas purging, screening, and SUMMA™ canister sampling. Soil-gas ports are purged until subsurface carbon dioxide levels have stabilized to representative soil-gas levels prior to screening and sampling. All sampling ports in all boreholes are screened using the B&K.

Until fiscal year (FY) 2000, the pore-gas procedure called for screening of well ports using the B&K, followed by SUMMA™ sampling at the highest concentration port of selected wells. This procedure provided a good data set for a limited number of ports in a limited number of boreholes. To address data gaps associated with nature and extent of contamination, the procedure was modified in FY 2000 at the request of NMED. All ports in all wells are still screened using the B&K to provide data regarding changes in the concentrations of VOCs in the plume; however, the screening results are not used to direct SUMMA™ sampling. Instead, ports are sampled with SUMMA™ canisters as needed to evaluate changes in the plume stability based on a defined quarterly sampling schedule presented in the July through September quarterly report (LANL 2002, 73712).

B-3.0 REVIEW OF PHASE I RFI FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS

B-3.1 Data Review

The Phase I RFI data set for MDA L includes analytical data from four surface channel sediment samples, 184 core samples collected from 16 boreholes, 8 surface tritium flux samples, 102 surface VOC EMFLUX® survey samples, as well as 7 field duplicates, 16 ambient air samples, and 207 subsurface pore-gas samples. All data used quantitatively to identify chemicals of potential concern (COPCs) at MDA L were subjected to RRES-RS quality assurance and quality control (QA/QC) procedures. The data review process for identifying COPCs begins with a comparison of site data with

- naturally occurring background concentrations for inorganic chemicals,
- naturally occurring background or fallout concentrations for radionuclides, and
- analytical estimated quantitation limits (EQLs) for organic chemicals.

Organic chemical data are evaluated based on detection status only. Background comparisons and a variety of statistical and graphical methods are used to compare site inorganic chemical and radionuclide data with Laboratory-wide background data (LANL 1998, 59730). For background comparisons, the first step is to compare the site data with a background value (BV), which is a calculated value that represents the background data set (upper tolerance limit [95, 95] or the 95% upper confidence bound on the 95th quantile).

If a site-specific datum exceeds its BV, additional evaluation of the datum may be performed by comparing the range of values in the site data set for that chemical to the range of values for that chemical in the background data set. Graphical analyses (e.g., box plots) may be used, or if adequate data are available, statistical tests that evaluate differences in distribution may be used. Nonparametric tests commonly used to assess data distributions include the Gehan, quantile, and slippage tests. Together these tests assess complete shifts in distributions, shifts of a subset of the data, and the potential for site data to be greater than the background data set. Observed significance levels (p-values) are obtained; these values indicate whether a difference exists between the data sets. A p-value of less than 0.05 indicates a difference between the distributions (i.e., the site data are different from the background data) exists, while a p-value greater than 0.05 indicates the distributions (i.e., site and background data) are similar. The results of these statistical analyses for MDA L are discussed in Appendix E.

Graphical analyses of the data sets provide a visual representation of the data and allow a visual comparison among concentration distributions. The observed differences may include an overall shift in concentration or, when centers are nearly equal, a difference between the upper tails of the two distributions. The plots may either be used alone to describe the relationship of the two distributions or may be used in conjunction with the statistical tests described above. Box plots and borehole profiles were used to assess the Phase I RFI inorganic chemical and radionuclide data from MDA L (Appendix E).

Only data that are relevant for identifying COPCs are included in this section; these data include measurements that are above applicable thresholds or whose detection limits (DLs) are greater than an applicable threshold. Tables D-8 through D-15 in Appendix D include the data for all analytes (detected and undetected).

B-3.1.1 Channel Sediment Samples

Channel sediments at MDA L are derived from the mesa-top materials, the tuff on the sides of the mesa, and colluvium and soils on the mesa slopes (LANL 1996, 54462). The samples were described in the field summary report as soil samples and in the channel sediment report as silt, sand, and gravel mixtures. Sample concentrations were compared with the Laboratory sediment background data set (LANL 1998, 59730), which was derived from sediment samples collected in Indio, Ancho, Los Alamos, Pueblo, and Guaje Canyons. Because these deposits are young alluvium in or near stream channels (LANL 1998, 59730), the Laboratory background data set for sediments might represent a different matrix than the channel sediment samples collected at MDA L.

Channel sediment samples collected at MDA L were analyzed for TAL metals, pesticides/PCBs, herbicides, gamma spectroscopy, isotopic plutonium, isotopic uranium, isotopic thorium, strontium-90, and tritium. Table B-5 includes the surface channel sediment samples collected during the Phase I RFI and the requested analyses for each sample.

Inorganic Chemical Comparison with Background

No inorganic chemicals were detected at concentrations above the sediment BVs in any of the channel sediment samples (Table B-10). Although cadmium, selenium, and silver were not detected, the DLs for these inorganic chemicals exceeded their respective BVs. The sediment BVs for cadmium, selenium, and silver were based on nominal DLs. The sample DLs were reported at approximately twice the BV or less. These metals data are evaluated further in Appendix E. Figures E-1 and E-2 in Appendix E provide more details on the inorganic chemical comparisons. There were no QA/QC issues associated with the channel sediment inorganic chemical results at MDA L. Overall, the sediment inorganic chemical data for MDA L were of good quality and suitable for data assessment. Table D-8 in Appendix D presents the complete data set.

Radionuclide Comparison with BVs and Fallout Values

Except for tritium, there were no QA/QC issues associated with the radionuclide results for samples collected at MDA L. Tritium results were qualified J (estimated) because the results from a blind QC sample fell outside sample recovery limits. Overall, the sediment radionuclide data for MDA L are of good quality and suitable for data assessments. Table D-9 in Appendix D provides the complete data set.

Detected concentrations of radionuclides were compared with the sediment BV or the sediment fallout values (FVs), depending on whether the radionuclide is naturally occurring or a fallout radionuclide (LANL 1998, 59730). Americium-241, cesium-137, cobalt-60, tritium, plutonium-238, plutonium-239, and strontium-90 were compared with sediment FVs. Isotopes of uranium and thorium, which are naturally occurring radionuclides, were compared with sediment BVs (Table B-11).

The channel sediment report (LANL 1996, 54462) listed americium-241, polonium-210, technetium-99, and yttrium-90 as COPCs because no BVs and FVs for those radionuclides were available at that time. Currently, americium-241 has a sediment BV of 0.04 pCi/g, which is greater than the detected concentrations in the channel sediment (Table B-11). Polonium-210 and yttrium-90 both have short half-lives (approximately 138 days and 60 hours, respectively), so they are no longer present in the channel sediment and are, therefore, not evaluated in this HIR.

A detected concentration for plutonium-238 (0.011 pCi/g) exceeded the associated sediment BV of 0.006 pCi/g (Table B-11). Figure B-7 shows the sample location and detected plutonium-238 concentration. No other radionuclides were detected above their respective BVs or FVs. Table E-2 in Appendix E discusses the radionuclide background comparisons in more detail. Plutonium-238 is retained as a COPC in channel sediments at MDA L.

Evaluation of Organic Chemicals

There are no QA/QC issues associated with the analytical data, and the data are of good quality and suitable for data assessment. Table D-10 in Appendix D provides the complete data set.

Methoxychlor was detected in three samples at concentrations of 0.027 mg/kg (location 54-05148), 0.028 mg/kg (location 54-05143), and 0.063 mg/kg (location 54-05145) (Figure B-8). The concentrations detected are approximately one to three times the EQL (0.02 mg/kg). No other organic chemicals were detected in the sediment samples. Table E-3 in Appendix E provides more details on the organic chemical analyses. Methoxychlor was retained as a COPC in channel sediments at MDA L.

B-3.1.2 Subsurface Core Samples

A total of 96 subsurface core samples were collected from 10 boreholes at MDA L (Figure B-6). These samples were analyzed for TAL metals and cyanide, pesticides/PCBs, herbicides, VOCs, SVOCs, and radionuclides. Not every sample was analyzed for every constituent, as described below. Core samples from six boreholes (54-01001 through 54-01006) were drilled to investigate the vapor plume east of MDA L; 94 core samples from these boreholes were screened only for VOCs and moisture by an on-site mobile chemical laboratory. Two deep characterization boreholes (54-01015 and 54-01016) were drilled at an angle to investigate the potential presence of vapor-phase contaminants at depth below MDA L; the core samples from these boreholes were analyzed for moisture, VOCs, and tritium. The remaining eight boreholes (54-01007 through 54-01014) were drilled in the vicinity of the disposal units (i.e., pit, impoundments, and shafts) and were analyzed for all constituents, except herbicides in core samples from boreholes 54-01010 through 54-01014. Core samples were not collected from two additional boreholes drilled in 1995. Borehole 54-01017 was designed as the extraction well for the pilot vapor extraction test, and borehole 54-01018 was an additional pore-gas monitoring borehole. Table B-8 summarizes the subsurface core samples collected during the Phase I RFI and the requested analyses for each sample.

Inorganic Chemical Comparison with Background

Subsurface core sample data for inorganic chemicals (Table B-8) were obtained from the eight boreholes (54-01007 through 54-01014) in the vicinity of the disposal shafts, impoundments, and pit at MDA L (Figure B-6). Five (out of 67) mercury and cyanide analyses were rejected because the holding times had been exceeded, and four out of 67 arsenic and selenium results were rejected because of low analyte recovery from a QC sample. The low recovery indicates potentially unacceptable accuracy in the results for arsenic and selenium. Many results for the inorganic chemicals were qualified J (estimated) because of evidence of variable efficiencies of extraction from the soil matrix or very low reported concentrations relative to DLs. J-qualified data are usable for decision making but carry higher analytical uncertainty than unqualified data. Overall, except for the rejected data, the data are of good quality and are sufficient for data assessment.

Analytical results for the samples collected from Qbt 2 were compared with BVs for Qbts 2, 3, and 4, and samples from Qbt 1v and Qbt 1g were compared with BVs for those units (LANL 1998, 59730). Table B-12 provides a summary of the frequency of detected inorganic chemicals above background. Figure B-9 shows the locations and concentrations of inorganic chemicals detected above BVs in subsurface tuff at MDA L. Analytical results were plotted by depth in each borehole to identify patterns potentially associated with a release and migration through a fractured medium (Appendix E, Table E-4, Figures E-3 and E-4). Table D-11 in Appendix D provides the complete data set.

The data review indicates that barium, chromium, cobalt, copper, manganese, nickel, uranium, and zinc are elevated compared with Laboratory BVs and are retained as COPCs in subsurface tuff at MDA L.

Radionuclide Comparison with BVs or FVs

Core samples from seven boreholes (54-01010 through 54-01016) were analyzed for tritium, and five core samples from borehole 54-01009 were analyzed for isotopic plutonium and isotopic uranium (Table B-8). The analytical result from one of 48 core samples analyzed for tritium was rejected because of a laboratory error. A number of the analytical results are J qualified (estimated) because laboratory QC indicators identified more variability in the analytical results than normally expected. With the exception of one (of 48) rejected sample, the radionuclide results from subsurface tuff at MDA L are of good quality and sufficient for data assessment. Naturally occurring uranium isotopes were compared to Laboratory sitewide BVs from the appropriate tuff strata (LANL 1998, 59730). Fallout radionuclides (plutonium-238, plutonium-239, and tritium) were evaluated on the basis of detection status (i.e., if a fallout radionuclide is detected, it is evaluated further).

Data indicate that tritium was detected in 22 of 48 core samples and at several depths in boreholes 54-01010, 54 -01011, 54-01013, and 54-01015. The concentrations ranged from nondetect to 11.6 pCi/g[1] (196 pCi/mL) in borehole 54-01010. Uranium-234 and -238 were detected at low concentrations less than or equal to the BVs of 0.14 pCi/g and 1.93 pCi/g, respectively. Therefore, tritium is the only radionuclide identified as a COPC in the core samples. Table B-13 summarizes the frequency of detected radionuclides above BVs for the subsurface core samples. Table B-14 presents the detected tritium concentrations by subsurface sample. Figure B-7 presents the sample locations and results for the radionuclides detected above BV/FV concentrations in sediment and tuff.

Evaluation of Organic Chemicals

A total of 96 core samples collected from 10 boreholes were analyzed for VOCs. Sixty-seven core samples collected from the eight boreholes drilled in the vicinity of the disposal shafts and pits (54-01007 through 54-01014) were also analyzed for SVOCs, pesticides, and PCBs. Thirty-eight core samples collected from three boreholes (54-01007 through 54-01009) in closest proximity to the disposal shafts were also analyzed for herbicides.

Forty VOC results were qualified as not detected (U) because the results were less than 5 or 10 times the concentrations detected in the method blank. Six results were qualified as estimated (J or UJ) because the surrogate recoveries associated with these analytes were low. Eleven results were qualified as estimated (J) for acetone and 2-butanone because the results were less than the practical quantitation limit (PQL) but greater than the method detection limit (MDL). Two results were qualified as estimated (J) because the holding time was exceeded. Overall, the data are of good quality and sufficient for data assessments.

Six SVOC results were qualified as estimated (J or UJ) because the holding time had been exceeded. Two results were qualified as estimated (J) because the results were less than the PQL, but greater than the MDL. Three results were rejected (R) and could not be used for data assessment because the surrogate recoveries associated with the analytes were low (10%). Overall, except for the rejected data, the data are of good quality and are sufficient for data assessment.

Herbicides were not detected in any of the subsurface core samples from MDA L. Fifteen VOCs were detected in core, most at trace concentrations (i.e., less than or slightly above the EQLs). Concentrations greater than EQLs were detected at boreholes beneath Pit A (54-01010 and 54-01011), between Pit A and Shafts 1 through 28 (54-01009), and at the east end of the array of Shafts 1 through 28 (54-01007 [Figure B-10]).

---

[1] The accuracy of the tritium values is questionable. Tritium in core is measured by EPA Method 906.0, which is performed on the water extracted from the core sample. At gravimetric moisture content less than 10%, a 3-in. length of 2-in.-diameter core will yield less water than the minimum required volume of 5 mL. To reach the necessary volume, de-ionized water is added to the extracted water. The reported activity and uncertainty are corrected for the dilution. Therefore, any moisture loss from a core sample prior to analysis at low moisture contents may substantially increase the uncertainty of the measurement. Moreover, the EPA method requires that the core material be ground to a fine mesh before the water is extracted, such that significant moisture loss is inevitable. Given these issues, RRES-RS concluded that tritium contamination is best characterized in low moisture content at MDA environments by using sorbent materials to extract and retain in situ subsurface water samples from pore gas. Disposal of tritium per se is not recorded in the disposal logbooks; however, chemicals containing hydrogen disposed of at MDA L could have contained tritium. Vacuum pump oils would be a likely source. The activity of tritium is low, indicating tritium-contaminated material may have gone into MDA L and not sent to MDA G as radioactive material.

Two pesticides, Aroclor-1260, and three SVOCs were detected in one to four samples at several sampling depths in tuff. Aroclor-1260 was reported in one sample from borehole 54-01010 at a concentration (0.313 mg/kg) about 70 times greater than the sample EQL (0.0044 mg/kg). Methoxychlor was detected above the EQL in one sample in borehole 54-01010 (0.0756 mg/kg versus the EQL of 0.0226 mg/kg), and the pesticide dichlorodiphyldichloroethane (DDD) was detected in two samples at concentrations marginally above to approximately three times the EQL (0.0044 mg/kg) in borehole 54-01011. In borehole 54-01009, bis(2-ethylhexyl)phthalate was detected at one sampling depth beneath Pit A at a concentration of 0.8 mg/kg compared to its EQL of 0.6 mg/kg. Di-n-butyl phthalate was reported at concentrations one to three times its EQL (0.44 mg/kg) at three nonconsecutive sampling depths. Pentachlorophenol was detected at concentrations three to ten times the EQL (1.2 mg/kg) at two sampling depths below Impoundment B (Figure B-10).

In summary, several organic chemicals were reported in the subsurface media near Pit A and Shafts 1 through 28. The organic chemicals were detected primarily at concentrations near or below the EQLs at only a few depths. Although some VOCs were detected in the core samples at concentrations approximating EQL values, these measurements were unreliable because VOCs do not adsorb to tuff. Therefore, the nature and extent of the VOC plume at MDA L was better defined using the pore-gas sampling results (see below) than the core results. The sporadic nature of the detections of SVOCs, Aroclor-1260, and pesticides does not indicate a release and has not been evaluated further.

The frequency and range of concentrations for the detected organic chemicals is given in Table B-15. Figure B-10 presents the sample locations for the detected organic chemicals. Table D-14 in Appendix D presents the complete data set.

B-3.1.3 Pore-Gas Samples

VOC Flux Measurements (EMFLUX®)

Twenty VOCs were detected in 102 EMFLUX® samples collected in 1993 and 1994 (Trujillo et al. 1998, 58242). Flux measurements were taken only in areas not covered by asphalt, which include perimeter and hillside locations. The detected VOCs include acetone, benzene, bromobenzene, 2-butanone, carbon tetrachloride, chlorobenzene, chloroform, chloromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloropropane, ethylbenzene, n-propylbenzene, PCE, toluene, TCA, TCE, Freon 113, and xylene. Fewer VOCs were detected in the 1994 samples from the hillsides and were limited to acetone, chlorobenzene, chloroform, 1,1-dichloroethane, 1,1-dichloroethene, methylene chloride, PCE, toluene, TCA, TCE, Freon 113, and xylene. The highest surface flux measurements were found in samples collected in 1993 from the mesa top for TCA, PCE, and TCE. Freon 113 and acetone were also detected in many samples at relatively low levels compared to the three main VOCs: TCA, TCE, and PCE. The 1994 EMFLUX® data from the hillsides indicate much lower surface flux than those measured on top of the mesa in 1993; the most prevalent VOCs in the 1994 data were also TCA, PCE, and TCE. The compound 1,1-dichloroethene was also detected at a relatively high frequency in the 1994 samples on the north slope of the mesa. Freon 113 was detected frequently in the 1994 data set, although at low levels in samples collected on the southern slope of the mesa.

A plot showing the TCA surface flux results at MDA L is provided in Figure B-11. Flux measurements with values less than or equal to 3.1 ng/m^2/min are represented as a small triangle. These are very near the detection limit of the method.

VOCs in Pore Gas

Pore-gas monitoring methodologies have evolved over time. Appendix G provides a history of the monitoring methodologies, including the current monitoring program. In general, the methods and resulting data quality have improved steadily. For this HIR, the pore-gas monitoring data collected prior to and during 1996 are used only semi-quantitatively to assess the history of MDA L's subsurface vapor-phase VOC plume. The data collected from 1997 to the present have been subjected to rigorous QA/QC, both in field collection and in laboratory analysis. During each round of quarterly sampling, an equipment blank is collected to identify whether laboratory contamination has affected analytical results, a field duplicate is collected to determine if the analytical instrument is within precision limits, and a performance evaluation sample of calibration gases is collected to determine if calibration gases used for the B&K instrument are at the concentration listed on the gas cylinder.

The pore-gas monitoring data for MDA L indicate TCA is the primary VOC, followed consistently in abundance by TCE. The complete pore-gas data set is included in Appendix D, Table D-11. The frequency of detection and range of concentrations for sampling from 1997 through 2001 are presented in Table B-16. VOCs are retained as COPCs in subsurface pore gas at MDA L.

Table B-17 presents the maximum detected concentration for each VOC from the fourth quarter FY 1999 SUMMA™ canister sampling results, and the location of that sample (borehole and port depth). This data set is representative of the results from the sampling protocol in place prior to FY 2000 when the purpose of sampling was to determine the nature and extent of the VOC plume. Table B-18 provides similar information from the first quarter FY 2002 SUMMA™ canister sampling results, which are representative of the post-2000 pore-gas sampling protocol where the purpose of the sampling is to determine trends in plume concentration in the source area and at the boundaries of the plume.

Analysis of the pore-gas monitoring data indicates vapors from the two shaft fields (1 through 28 and 29 through 34) are compositionally different, indicating two unique sources. The two sources consist largely of TCA, but the relative concentrations of lesser compounds are different. The two source areas are referred to as the northwest source area and the southeast source area.

Tritium Surface Flux Chamber Measurements

The 1993 and 1994 tritium flux chamber data indicate that vapor-phase tritium contamination in ambient air is widespread near MDA L (Eklund 1995, 56033). However, these locations (Figure B-4) are not in close proximity to any known subsurface tritium sources. The tritium fluxes calculated from these samples are provided in Table B-6. Tritium is identified as a COPC in ambient air.

B-3.1.4 Ambient Air

Measured concentrations of selected aromatic and halogenated hydrocarbons at ambient air sampling locations 4 and 5 (Figure B-3) are shown in Tables B-19 and B-20. Only organic chemicals that were consistently detected in four or more samples are presented. The data set collected at the Bandelier National Monument for the analytes listed in these tables is shown in Table B-21. VOCs are identified as COPCs in ambient air.

B-3.1.5 Summary of COPCs at MDA L

Table B-22 summarizes the results of the data review and lists all COPCs at MDA L for channel sediments, ambient air, subsurface tuff, and pore-gas samples. For each COPC, or group of COPCs, the table identifies the analytes retained and the ones eliminated from further consideration in the HIR, and the rationale for the decision.

B-4.0 DATA INTERPRETATION AND IDENTIFICATION OF DATA GAPS

Information presented in Sections B-1.0, B-2.0, and B-3.0 is summarized and interpreted in this section to describe the current understanding of the nature and extent of environmental contamination at MDA L. Based on this interpretation, data gaps related to the nature and extent of environmental contamination at MDA L are identified. The information provided here is summarized in Section 4.1 of the IWP where it forms the basis for the proposed sampling activities in Section 4.2 of the IWP.

B-4.1 Nature and Extent of Contamination in Channel Sediments

Inorganic chemicals: No inorganic chemicals were detected above sediment BVs in the drainage channel at MDA L (Figures B-2, E-1, and E-2). However, the analytical detection limits for cadmium, selenium, and silver exceeded the sediment BVs (Table B-10; LANL 1998, 59730), and these inorganic chemicals are retained as COPCs. The analytical DLs were approximately twice the BVs, and there are no known historical surface releases of metals at MDA L.

Radionuclides: Plutonium-238 was the only radionuclide detected above BV/FV concentrations in the four channel sediment samples collected downgradient from MDA L (Table B-11). Although the detected concentration (0.011 pCi/g) is above the sediment FV of 0.006 pCi/g, there is no historical documentation of a surface release at MDA L.

Organic chemicals: Methoxychlor was detected in three of four sediment samples (locations 54-05143, 54-05145, and 54-05148) with a maximum concentration of 0.063 mg/kg (Figure B-8), which is approximately three times the EQL of 0.02 mg/kg. Similar to results of the MDA H RFI, the presence of methoxychlor is attributed to routine application of this pesticide at operating areas throughout TA-54 and not the result of past waste disposal practices (LANL 2002, 73270).

Data Gaps Related to Channel Sediments

Since Phase I RFI data showed that plutonium-238 and methoxychlor were detected in low concentrations, a supplemental channel sediment will be sampled at the interface of the alluvial sediments and bedrock to collect data where all the sediments accumulated over the years.

B-4.2 Nature and Extent of Contamination in Air

The data from ambient air samples near MDA L indicate that TCA and TCE are being emitted from the vadose zone plume. Other VOCs detected in MDA L ambient air samples but not detected in flux measurements include dichlorofluoromethane, chloromethane, n-hexane, trichlorofluoromethane, methylene chloride, benzene, toluene, and xylene.

Data Gaps Related to Air

An evaluation of the tritium and VOC Phase I RFI data for air at MDA L does not indicate any data gaps are present relative to identifying the nature and extent of contamination. Facility waste operations monitor the personnel who have been involved in ongoing waste management activities. These data are sufficient to assess for risk in a future report.

B-4.3 Nature and Extent of Contamination in Subsurface Core

Inorganic chemicals: Barium, chromium, cobalt, copper, manganese, nickel, uranium, and zinc were detected at concentrations above BVs in one or more borehole(s) in two out of three consecutive sampling depths (Figures B-12, B-13, and B-14 and E-4 through E-8). The data indicate that a release from subsurface waste disposal units occurred (Figure B-10). The nature and extent of the release is reviewed in the following subsections by the specific impoundments, pit, and shafts.

Impoundments B, C, and D: Boreholes 54-01012, 54-01013, and 54-01014 were drilled to angle beneath the three impoundments, respectively (Figure B-6). Concentrations of chromium and copper were detected above their respective BVs at three consecutive sampling depths in core samples beneath Impoundment B. Beneath Impoundment C, concentrations of copper were above BVs at three consecutive sampling depths, and nickel concentrations exceeded BV at two out of three consecutive sampling depths. Based on these results, it was concluded that copper and chromium have been released from Impoundment B, and copper and nickel have been released from Impoundment C. In borehole 54-01014, uranium was the only inorganic chemical detected at several consecutive sampling depths. Samples collected from the unit 2/unit 1v interface contain uranium concentrations that are slightly above the unit 2 BV (2.40 mg/kg) but below the unit 1v background value (6.22 mg/kg; see Appendix K). The pattern indicates that a release of uranium from Impoundment D to the surrounding subsurface tuff may have occurred. The vertical extent of inorganic chemical contamination is not completely bounded beneath the impoundments.

Pit A: Boreholes 54-01010 and 54-01011 were drilled at an angle to pass beneath the eastern and western portions of Pit A, respectively (Figure B-6). In borehole 54-01011, barium was detected in one sample (138 mg/kg at 29.5 ft bgs) at approximately twice the BV (LANL 1998, 59730). In borehole 54-01010, cadmium, mercury, and uranium were detected above their respective BVs (LANL 1998, 59730) in one sample each, and chromium was detected above BV in two samples separated by four sampling depths (Figure B-9). The results from the boreholes angled beneath Pit A show evidence of a release, but the vertical extent of the release is defined beneath Pit A.

Shafts 1 through 28: This shaft field is located on the east end of MDA L and was evaluated by core samples collected from boreholes 54-01007 and 54-01009. The pattern of inorganic chemical concentrations detected in these boreholes indicates that a release has occurred. The primary component of the release was copper, with smaller contributions from chromium, barium, and zinc. Nickel was also detected above the BV (LANL 1998, 59730) in the lower tuff strata (units 1v and 1g).

Copper, chromium, barium, and zinc were detected in borehole 54-01007 at concentrations above their respective BV values at 146 ft (LANL 1998, 59730) (Figure E-7, B-12, B-13, and B-14). Copper concentrations were greater than BV in 10 of 13 core samples, often by more than a factor of 10. Chromium concentrations were greater than BV (LANL 1998, 59730) in 5 of 13 samples but did not exceed BV by more than a factor of two. Copper and chromium remained elevated at the deepest sampling location (146 ft). Barium and zinc concentrations were more than twice their respective BVs in a single core sample and at concentrations marginally above their BVs at two and four sampling depths (some consecutive depths), respectively. Concentrations of barium and zinc decreased to less than their respective BVs at the deeper sampling intervals. Distributions of copper, barium, and zinc in samples taken from borehole 54-01009 were similar to those noted for borehole 54-01007. Based on this analysis, the vertical extent of copper, chromium, and zinc has not been established.

Shafts 29 through 34: This shaft field is located on the west end of MDA L and was evaluated using data from borehole 54-01008 (Figures B-12, B-13, and B-14), a vertical 150-ft borehole located about 20 ft to the southeast of Shafts 29 through 34. Inorganic chemicals detected at concentrations above BVs included copper, zinc, and chromium. Copper concentrations exceeded the BV in a majority of the samples (10 out of 12); concentrations detected were more than 10 times the BV. Zinc and chromium were detected at three or more consecutive sampling depths at concentrations that exceeded their BVs by a factor of 2 or less. Manganese and cobalt concentrations above their BVs were reported at two consecutive sampling depths: manganese was marginally above its BV, and one cobalt concentration was more than twice the BV. Results from core samples collected in borehole 54-01008 indicated the release of inorganic chemicals from Shafts 29 to 34. The vertical extent of this release is not established.

Radionuclides: Core samples from seven boreholes were analyzed for tritium. Five shallow boreholes (up to 60 ft bgs) were angled beneath Pit A and Impoundments B, C, and D (Figure B-6). Two deep, angled boreholes (54-01015 and 54-01016) were drilled beneath Shafts 1 through 34 and Pit A (Figure B-6). The tritium data samples results from the shallow boreholes beneath Pit A ranged from 0.03 pCi/g to 11.6 pCi/g, and concentrations decreased with depth. Tritium was detected at low concentrations in two samples collected from the deep, angled boreholes; at 0.13 pCi/g at approximately 524 ft in borehole 54-01015; and at 0.001 pCi/g at approximately 593 ft in borehole 54-01016. These results indicate a tritium release from MDA L and indicate that the vertical extent of the tritium contamination is bounded. However, there are insufficient data to define the lateral extent of tritium contamination.

Organic chemicals: Twenty-two organic chemicals were detected in 127 core samples collected at MDA L, most at trace concentrations (i.e., less than or slightly above the EQLs). The higher concentrations (i.e., concentrations greater than EQLs) were detected in the boreholes beneath Pit A (boreholes 54-01010 and 54-01011), between Pit A and Shaft 28 (borehole 54-01009), and at the east end of the array of Shafts 1 through 7 (borehole 54-01007 [Figure B-6]).

Two pesticides, Aroclor-1260, and three SVOCs were detected in one to four samples at several sampling depths in tuff. Aroclor-1260 was reported in borehole 54-01010 at a concentration (0.313 mg/kg) at a depth of 30 ft and was not detected in deeper samples. Methoxychlor was detected above the EQL in a single sample collected at a depth of 59.5 ft in borehole 54-01010 at a concentration of 0.0756 mg/kg. The pesticide DDD was detected in two samples in borehole 54-01011; DDD was not detected in deeper samples from borehole 54-01011. In borehole 54-01010, bis(2-ethylhexyl)phthalate was detected in a single sample at a depth of 30 ft beneath Pit A but was not detected in deeper samples. Di-n-butyl phthalate was detected at four nonconsecutive sampling depths but was not detected at the bottom of the borehole. Pentachlorophenol was detected at concentrations (13.0 mg/kg and 3.3 mg/kg) at two sampling depths below Impoundment B and decreased with depth.

In summary, several organic chemicals were reported in the subsurface tuff near Pit A and Shafts 1 through 28. The SVOCs, pesticides, and Aroclor-1260 either decreased with depth or were detected at low concentration at the bottom of the borehole, with no detects at shallower depths in the borehole. VOCs were detected in the core samples at concentrations approximating EQL values; however, these measurements cannot be used to define the extent because VOCs do not adsorb readily to tuff and are transported mainly as vapor phase in the subsurface of MDA L. Therefore, the nature and extent of the VOC plume at MDA L is better defined using pore-gas sampling results (see below) than the core sample results. The nature and extent of the other organic chemicals detected do not indicate a release, have the extent defined, and are not evaluated further.

Data Gaps Related to Subsurface Core

Phase I RFI core data for inorganic chemicals and tritium indicate releases to subsurface tuff have occurred beneath Impoundments B, C and D and the two shaft fields, respectively. The number and locations of Phase I RFI samples of core are inadequate to support conclusions regarding the nature and extent of contamination beneath the impoundments and shaft fields.

In addition to the analytical suites required for Phase I RFI core samples, additional suites may be appropriate given the nature of the disposed waste at MDA L. Nitrates and perchlorate, which are very soluble and susceptible to migration with infiltrating surface water, were not analyzed in the Phase I RFI core samples. Nitrates are associated with fertilizers and are 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 L, analysis of nitrates and perchlorate in core samples at MDA L is appropriate, and the absence of data for these chemicals is a data gap. Some high explosive (HE) compounds are also relatively soluble in water and subject to transport from the disposed waste. However, the presence of HE in appreciable quantities in the disposed waste is unlikely because it has always been Laboratory policy to “flash”' (burn) HE-contaminated material prior to disposal. However, inventory records for MDA L are incomplete, and with the absence of HE data for the Phase I RFI is a data gap.

Information on the hydrogeologic properties and other physical characteristics of the vadose zone at MDA L is minimal and is therefore identified as a data gap for completion of the future corrective measure study (CMS) for MDA L. During the Phase I RFI, information on the moisture content of core was collected only from a depth of approximately 271 ft bgs. Other relevant hydrogeologic information, as well as information on the water content of core at greater depths in the vadose zone, is presently inferred from data obtained elsewhere at TA-54. 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 an evaluation, usually performed using numerical models to simulate field conditions, provides support for conclusions regarding the current nature and extent of contamination. It will also be used in evaluating potential corrective measures to estimate 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 L. Some strata, specifically units of the Tshirege Member of the Bandelier Tuff, also contain fractures that can act as conduits for 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 information on 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 L.

B-4.4 Nature and Extent of Contamination in Subsurface Pore-Gas and VOC and Tritium Surface Flux

Pore-gas analytical results indicate that the highest concentrations of vapor-phase VOCs exist in close proximity to the two source areas: the northwest source area and the southeast source area. Concentrations of vapor-phase VOCs decrease in all directions from the two source areas. TCA has consistently been the most prevalent VOC detected in pore-gas samples and is the best indicator of the extent of the plume.

The field-screening data obtained using the B&K multigas analyzer correlate well with the analytical laboratory SUMMA™ canister data for the four compounds screened for (TCA, TCE, PCE, and Freon 113) in the ppm concentration range. Figures B-15 and B-16 show the correlation of B&K screening results to EPA Method TO-14 analytical results (SUMMA™ canister samples) for TCA and TCE, respectively. The linear regression for SUMMA™ canister samples versus TCA indicates that the B&K reads to within approximately 70% of the EPA Method TO-14 analytical results with a correlation coefficient (r^2) of 0.87. For TCE, the B&K reads to within approximately 60% of the EPA Method TO-14 analytical results with an r^2 = 0.9. In summary, B&K screening is a good indicator of actual pore-gas concentrations in the ppm range and can be used to help define the extent of VOC contamination in the ppm concentration range.

Figure B-17 shows contours of TCA concentration at MDA L based on quarterly B&K screening data collected from FY 2000 through the first quarter of FY 2002. The figure shows projected 10, 100, and 500 parts per million by volume (ppmv) TCA contours, assuming a horizontal plane through the mesa at an elevation of 6736 ft. is equal to a depth of 100 ft bgs. Figure B-17 also shows the location of monitoring boreholes. Figure B-18 presents a cross section of the mesa, showing 10, 100, and 500 ppmv TCA contours based on quarterly B&K screening data collected since FY 1999. Figure B-19 shows a representative two-dimensional plot of the TCA concentration versus depth. Figure B-20 shows the extent of the TCA plume, in relation to White Rock and nearby domestic production wells.

Figures B-17 and B-18 show the lateral and vertical extent by the 10-ppmv concentration contour. Outside this contour, concentrations decrease noticeably to below the quantification capability of the B&K; analytical results for samples collected from this region show TCA concentrations in the part per billion by volume (ppbv) range. Since 1999, the long-axis plume aerial extent, defined by the 10 ppmv contour, has fluctuated between 700 and 1000 ft. The short axis extent has not fluctuated significantly because of the physical constraint of the mesa walls. Vertically, the maximum extent of the 10 ppmv TCA contour is approximately 300 ft below the mesa top (pore-gas samples are monitored to a depth of 607 ft bgs). The extent has not fluctuated significantly since 1999. The 10 ppmv TCA contour is approximately 650 ft above the regional aquifer. Concentrations increase to a depth of approximately 85 ft below the MDA L surface, followed by decreasing concentrations through the total depth of the plume.

A discussion of historical and current pore-gas sampling methodologies is provided in Appendix G. Sampling and analytical methods have greatly improved since the late 1990s, resulting in consistent, good quality data, from both the analytical chemistry and B&K screening. This allows some evaluation of trends within the plume. The B&K results indicate a stable plume (Figures B-21, B-22, and B-23). Figure B-20 shows the areal extent of the VOC plume with respect to surrounding facilities and the town of White Rock; the outer edge of the plume is approximately two miles from the town of White Rock. The SUMMA™ canister analytical results presented in Figures B-21, B-22, and B-23 show the organic chemicals present in the highest concentrations. Figure B-21 shows data from vapor-monitoring borehole 54-02002, which is representative of the source areas. Figure B-22 depicts data from vapor-monitoring borehole 54-02023, which is representative of a medium-to-low concentration zone of the plume. Figure B-23 shows data from vapor-monitoring borehole 54-01015, which is representative of the plume at a greater depth. As shown in the figures, the top 11 detected VOC concentrations have remained relatively constant over time or have decreased slightly. Therefore, it is concluded that the plume is in a near steady state.

Stauffer et al. (2002, 69794) modeled the plume evolution using a three-dimensional finite element program. The full report is provided in Appendix I, and an in-depth review of the report along with studies of passive and active venting is provided in Appendix J. The model assumed vapor diffusion emanating from two source areas located at the two shaft fields at MDA L. The model was calibrated using the quarterly pore-gas monitoring data. The resulting modeled plume closely matches the shape, concentration gradients, and extent of the plume as measured. Also, the model predicts that the plume should be at or near steady state. This modeling supports the conclusion that the VOC plume exists predominantly in the vapor phase, that the VOCs move by diffusion, and that the plume is stable. Stauffer et al. (2002, 69794) also predicted plume evolution over a 50-yr period. If the assumed source remains constant, the plume does not change appreciably during the simulation period, which further verifies the stability of the plume. If a constant source were not assumed, the plume would gradually decrease in size and concentration over time.

The following statements can be made with respect to the nature and extent of the VOC vapor plume at MDA L based on pore-gas data:

- VOCs are transported from the source areas primarily in the vapor phase;
- TCA is the dominant contaminant, followed by TCE;
- the ratio of the major plume contaminants (TCA, TCE, and Freon 113) is 1:0.3:0.2;
- vertically, the plume extends between ground surface and the top of the basalt (approximately 300 ft bgs);
- laterally, the plume extends along the mesa about 1000 ft from the center of Area L, and perpendicular across the mesa (approximately 450 ft from the center of Area L);
- the plume is changing very little in area or contaminant concentrations over time (1999 to the present);
- the 11 VOCs detected most frequently have remained consistent over time, and the concentrations of these VOCs have remained relatively constant or have decreased slightly over time; and
- vapor diffusion modeling fits the measured geographic distribution of TCA concentration.

Based on this data set, the nature and extent of the VOC plume has been defined, and the current monitoring network adequately encompasses the plume to evaluate changes over time.

Results of the surface VOC flux study conducted in 1994 show the surface expression or “fingerprint” of the subsurface plume (Quadrel 1994, 63869; Figure B-11). The study was limited to non-asphalt covered locations; therefore, the VOC flux data only exists for the perimeter of MDA L. The flux study does show that the magnitude of surface flux is greatest near MDA L and decreases noticeably with distance from the sources. The lateral extent of the VOC plume as defined by the surface flux data closely matches the lateral extent defined by subsurface pore-gas measurements. The primary VOCs reported within the area closest to the source areas (the disposal shafts) were TCA, PCE, TCE, Freon 113, and acetone, which accounted for 33%, 30%, 27%, 6%, and 2% of the emissions, respectively.

Tritium flux data collected at MDA L indicate tritium transported in the vapor phase is diffusing from the subsurface into the atmosphere; however, the sample locations are not in close proximity to any known subsurface tritium sources. Tritium is a COPC. Because of the small number of samples and their poor geographic distribution, no determination can be made about the lateral extent of tritium contamination in the subsurface.

Data Gaps Related to Subsurface Pore Gas

The concentrations and spatial extent of VOC vapors in subsurface tuff have been identified; however, continued monitoring is required to track plume stability, migration, or the potential for a release from the source area. One additional pore-gas monitoring borehole is required for long-term monitoring of the western shaft fields. The extent of tritium is a data gap.

B-5.0 REFERENCES

The following list includes all references cited in this document. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of actual documents at the RRES-RS Records Processing Facility.

Davis, A., December 14, 1993. “RFI Work Plan for OU 1148, Approval Los Alamos National Laboratory NM0890010515,” Memorandum to J. Vozella, DOE, Region VI, from A. Davis, EPA, Region VI, Los Alamos, New Mexico. (Davis 1993, 38812)

DOE (US Department of Energy) February 1987. Engineering Drawing ENG-C-45259, number LA-ZU-B-C4, prepared by Black and Veatch for the Department of Energy, Los Alamos Area Office, Los Alamos, New Mexico. (LASL 1987, 25606)

Driscoll, B., November 30, 1992. “Overall Comments Regarding Notice of Deficiency,” Memorandum from B. Driscoll, EPA, to C. Rofer, Los Alamos National Laboratory, Los Alamos, New Mexico. (Driscoll 1992, 3849.3)

Eklund, B., March 15, 1995. "Measurement of Emission Fluxes from Technical Area 54, Areas G and L, Final Report," prepared under DOE Subcontract No. 63545L0014-31 by Radian Corporation, Austin, Texas. (Eklund 1995, 56033)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 1585)

EPA (US Environmental Protection Agency), April 19, 1994. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, new requirements issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 19, 1994, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1994, 44146)

Glatzmaier, T. June 1994. “Proposed Modification to the Resource Conservation and Recover Act (RCRA) Facility Investigation (RFI) for Operable Unit (OU) 1148,”Los Alamos National Laboratory letter (EM/ER:94-A199) to T. Taylor, DOE-LAAO, from T. Glatzmaier, EM, Los Alamos, New Mexico. (Glatzmaier 1994, 52015)

Glatzmaier, T., November 12, 1993. “Final Notice of Deficiency (NOD) Response for Operable Unit (OU) 1148,” Los Alamos National Laboratory letter (EM-13:93-A232) to T. Taylor, DOE, from T. Glatzmaier, EM-13, Los Alamos, New Mexico. (Glatzmaier 1993, 30987)

Jansen, J., and T. Taylor, July 17, 1996. “Modification to Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1148, Field Unit 5, MDA G,” Los Alamos National Laboratory Letter (EM/ER:96-234) to B. Garcia, NMED from J. Jansen, LANL (ER/EM) and T. Taylor, DOE, Los Alamos, New Mexico. (Jansen and Taylor 1996, 54959)

Kisiel, K., and N. Mason, October 1998. “Passive Vapor Extraction Test with a One-Way Valve at Borehole 54-1006, MDA L, TA-54,” Science & Engineering Associates report SEASF-TR-98-215, Santa Fe, New Mexico. (Kisiel and Mason 1998, 63526)

LANL (Los Alamos National Laboratory), 1987. “Hydrogeologic Assessment of Technical Area 54, Areas G and L, Los Alamos National Laboratory,” Docket Number NMHWA 001007, Los Alamos, New Mexico. (LANL 1987, 76068)

LANL (Los Alamos National Laboratory), May 1992. "RFI Work Plan for Operable Unit 1148," Los Alamos National Laboratory document LA-UR-92-855, Los Alamos, New Mexico. (LANL 1992, 07669)

LANL (Los Alamos National Laboratory), September 1992. “Operable Unit 1148 Data Report,” Los Alamos, New Mexico. (LANL 1992, 11729)

LANL (Los Alamos National Laboratory), 1993. Engineering Drawing AB-113, number C1, prepared by Johnson Controls for Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 1987, 76052)

LANL (Los Alamos National Laboratory), July 1993. “Pilot Extraction Study Plan for the Organic Vapor Plume at MDA L,” Los Alamos, New Mexico. (LANL 1993, 22430)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for Channel Sediment Pathways from MDAs G, H, J, and L, TA-54,” Los Alamos National Laboratory document LA-UR-96-110, Los Alamos, New Mexico. (LANL 1996, 54462)

LANL (Los Alamos National Laboratory), December 1996. "Installation Work Plan for Environmental Restoration Program," Revision 6, Los Alamos National Laboratory document LA-UR-96-4629, Los Alamos, New Mexico. (LANL 1996, 55574)

LANL (Los Alamos National Laboratory), September 22, 1998. “Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 59730)

LANL (Los Alamos National Laboratory, October 2002. “Addendum to the RFI Report for Material Disposal Area H (Solid Waste Management Unit 54-004) at Technical Area 54,” Los Alamos National Laboratory document LA-UR-02-3397, Los Alamos, New Mexico. (LANL 2002, 73270)

LANL (Los Alamos National Laboratory), November 2002. “Quarterly Technical Report: July–September 2002,” Los Alamos National Laboratory document LA-UR-02-6976, Los Alamos, New Mexico. (LANL 2002, 73712)

LANL (Los Alamos National Laboratory), August 2003. TA-54, Area G, Los Alamos National Laboratory Logbooks from January 1966 to January 1996, RRES Record Package 661, Los Alamos New Mexico. (LANL 2003, 76036)

LANL (Los Alamos National Laboratory), August 5, 2003. Personal communication between P. Bertino, J. Hopkins, K. Kisiel, and J. Mascarenas, Risk Reduction and Environmental Stewardship Remediation Services Project Oral Communication Record, Los Alamos, New Mexico. (LANL 2003, 76078)

Mischler, S., and E. Anderson, March 15, 1994. “Ambient Monitoring of Volatile Organic Compounds at Los Alamos National Laboratory in Technical Area 54, Areas G & L,” prepared under DOE Subcontract No. 63545L0014-31 by Radian Corporation, Austin, Texas. (Mischler and Anderson 1994, 63525)

Neeper, D., and K. Kisiel, May 5, 1998. “Passive Vapor Extraction Test at TA-54, Well 54-1006 During 1997,” Science and Engineering Associates report SEA-SF-TR-98-195, Santa Fe, New Mexico. (Neeper and Kisiel 1998, 63999)

NMEID (New Mexico Environmental Improvement Division), May 1985. In the Matter of LANL EPA ID #NM0890010515, Docket Number NMHWA 001007, Compliance Order/Schedule. (NMEID 1985, 75885)

Quadrel (Quadrel Services, Inc.), September 1993. “EMFLUX® Soil-Gas Survey of Technical Area 54 (MDA G) Los Alamos National Laboratory,” Quadrel Report Number QS1135, Maryland Spectral Services, Inc., Forest Hill, Maryland. (Quadrel 1993, 63868)

Quadrel (Quadrel Services, Inc.), September 1994. “EMFLUX® Soil-Gas Survey of Technical Area 54, Los Alamos National Laboratory,” Quadrel Report Number QS1190, Maryland Spectral Services, Inc., Forest Hill, Maryland. (Quadrel 1993, 63869)

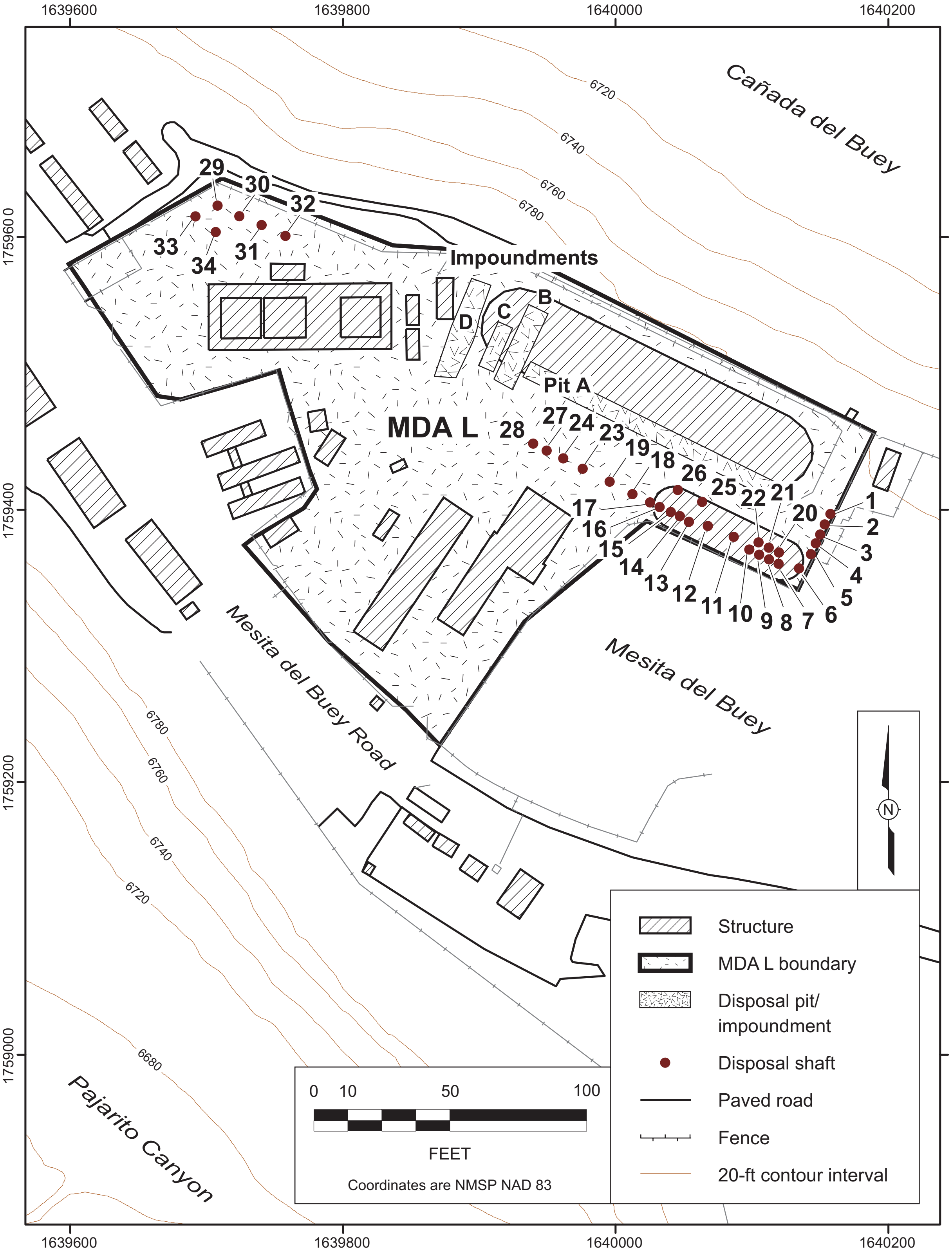
Rogers, M. A., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory report LA-6848-MS, Volume I, Los Alamos, New Mexico. (Rogers 1977, 5707)

Rogers, M., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory report LA-6848-MS, Volume II, Los Alamos, New Mexico. (Rogers 1977, 5708)

Stauffer, P. H., K. H. Birdsell, M. Witowski, T. Cherry, and J. Hopkins, March 2000. “Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions,” Los Alamos National Laboratory document LA-UR-00-2080, Los Alamos, New Mexico. (Stauffer et al. 2000, 69794)

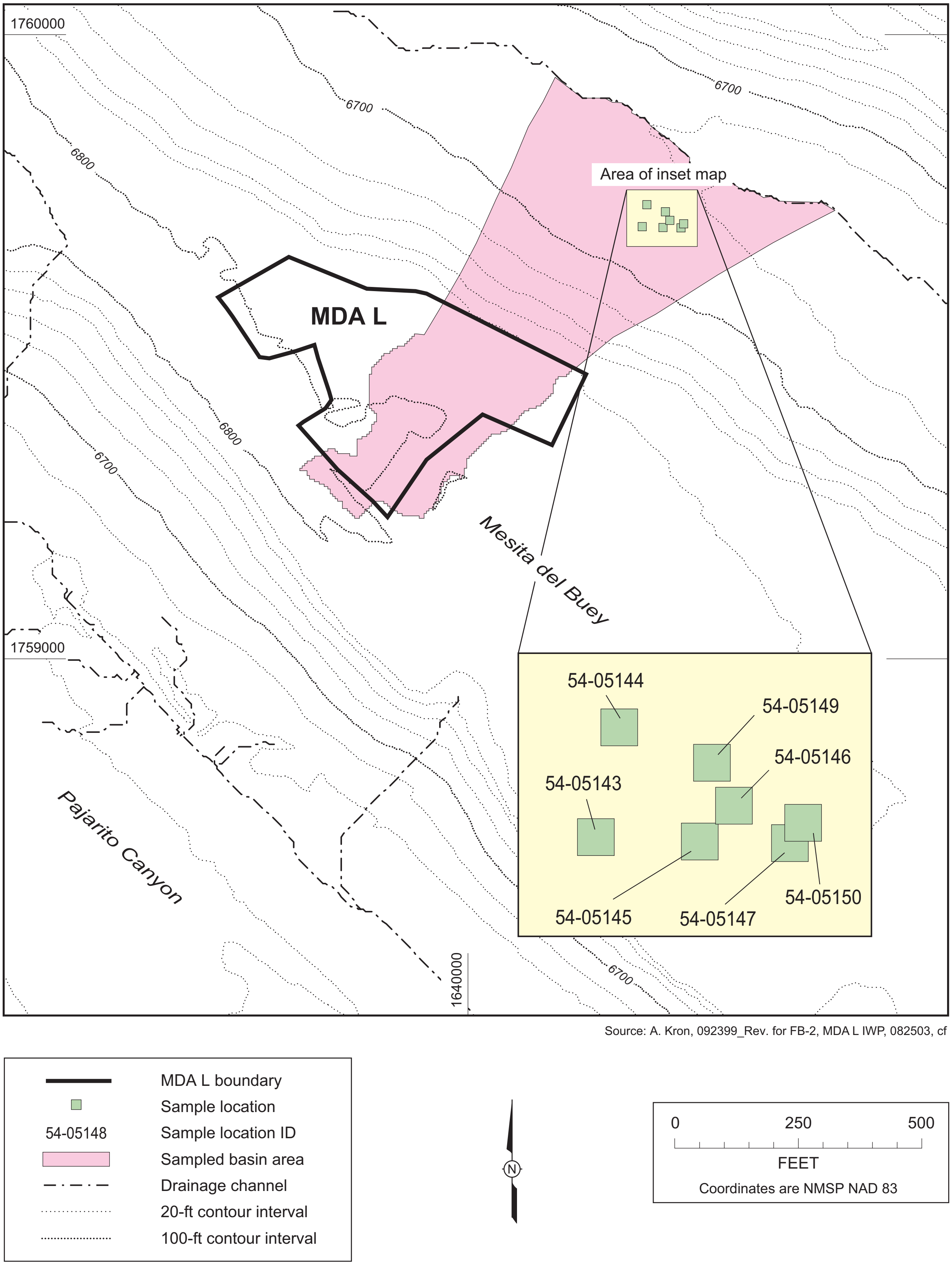
Trent, B., May 15, 1992. “Analysis of the Pore Gas Monitoring at Area L, TA-54 Los Alamos National Laboratory,” Los Alamos National Laboratory report, Los Alamos, New Mexico. (Trent 1992, 11881)

Trujillo, V., R. Gilkeson, M. Morgenstern, and D. Krier, June 1998. “Measurement of Surface Flux Rates for Volatile Organic Compounds at Technical Area 54,” Los Alamos National Laboratory report LA-13329, Los Alamos, New Mexico. (Trujillo et al. 1998, 58242)



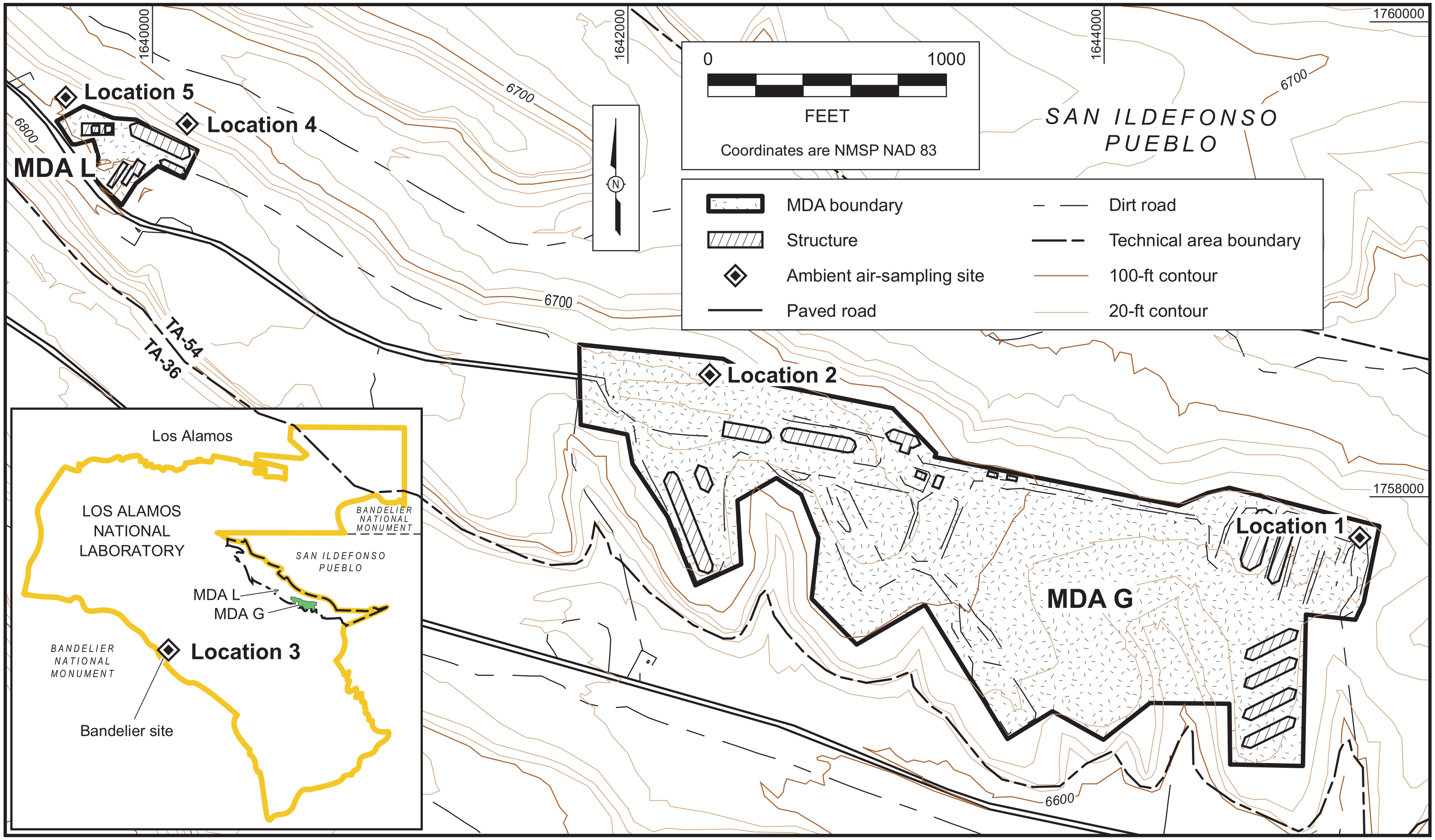
Source: RRES-RS map R03074, 082003, MO Rev. for FB-1, MDA L IWP, 082503, cf

Figure B-1. Locations of subsurface disposal units at MDA L (PRS 54-006)



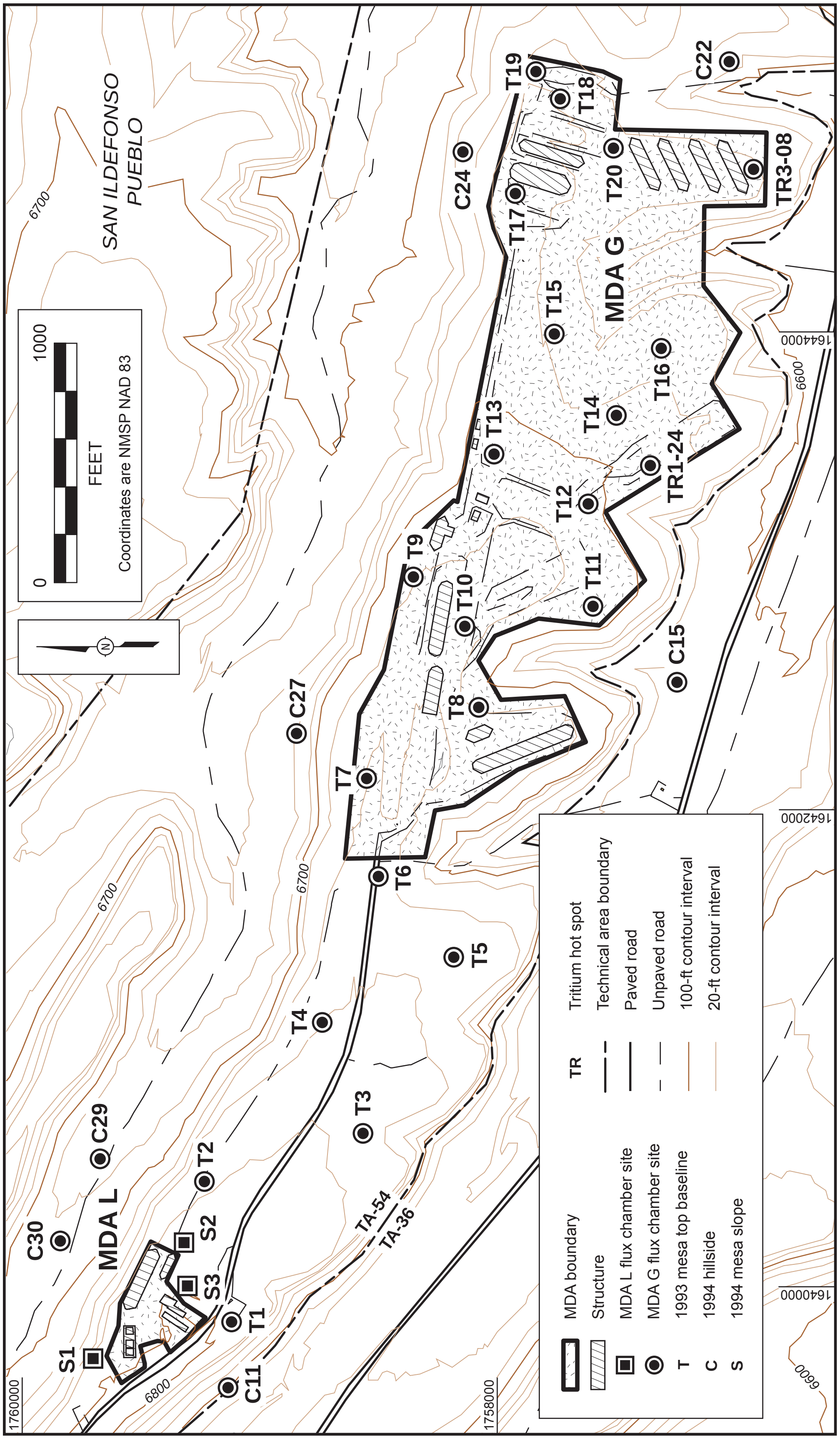
Source: A. Kron, 092399_Rev. for FB-2, MDA L IWP, 082503, cf

Figure B-2. **Phase I RFI sediment sample locations at MDA L**



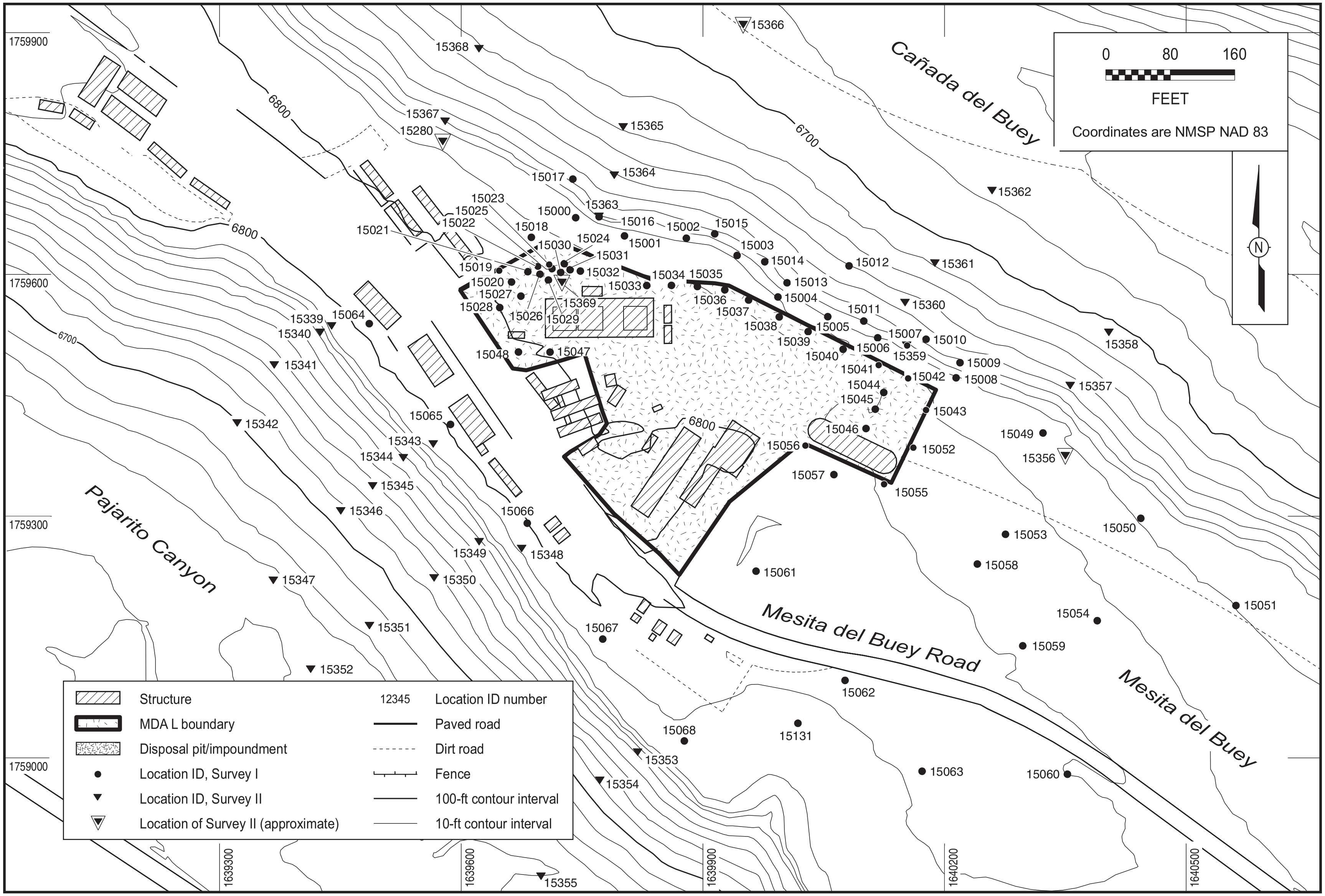
Source: FIMAD map G107980, 072999_MDA L RFI r, 120302, PTM_Rev. for FB-3, MDA L IWP, 082603, cf

Figure B-3. Ambient air VOC sample locations at MDAs G and L



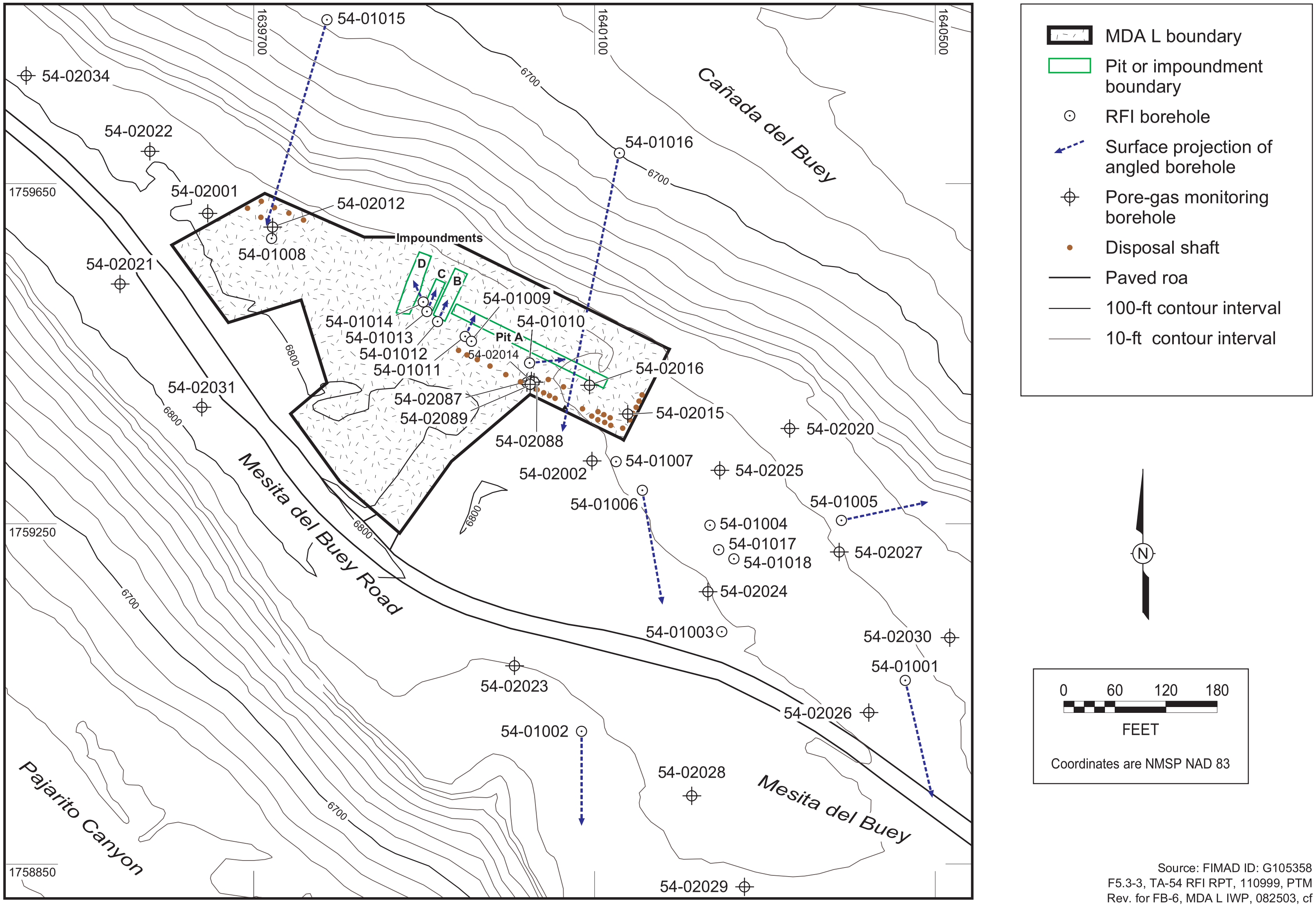
Source: FIMAD map G107980, 072999
MDA L RFI rpt, 120302, PTM_Rev. for FB-4, MDA L IWP, 082803, cf

Figure B-4. Locations of VOC and tritium flux chamber samples at MDAs L and G



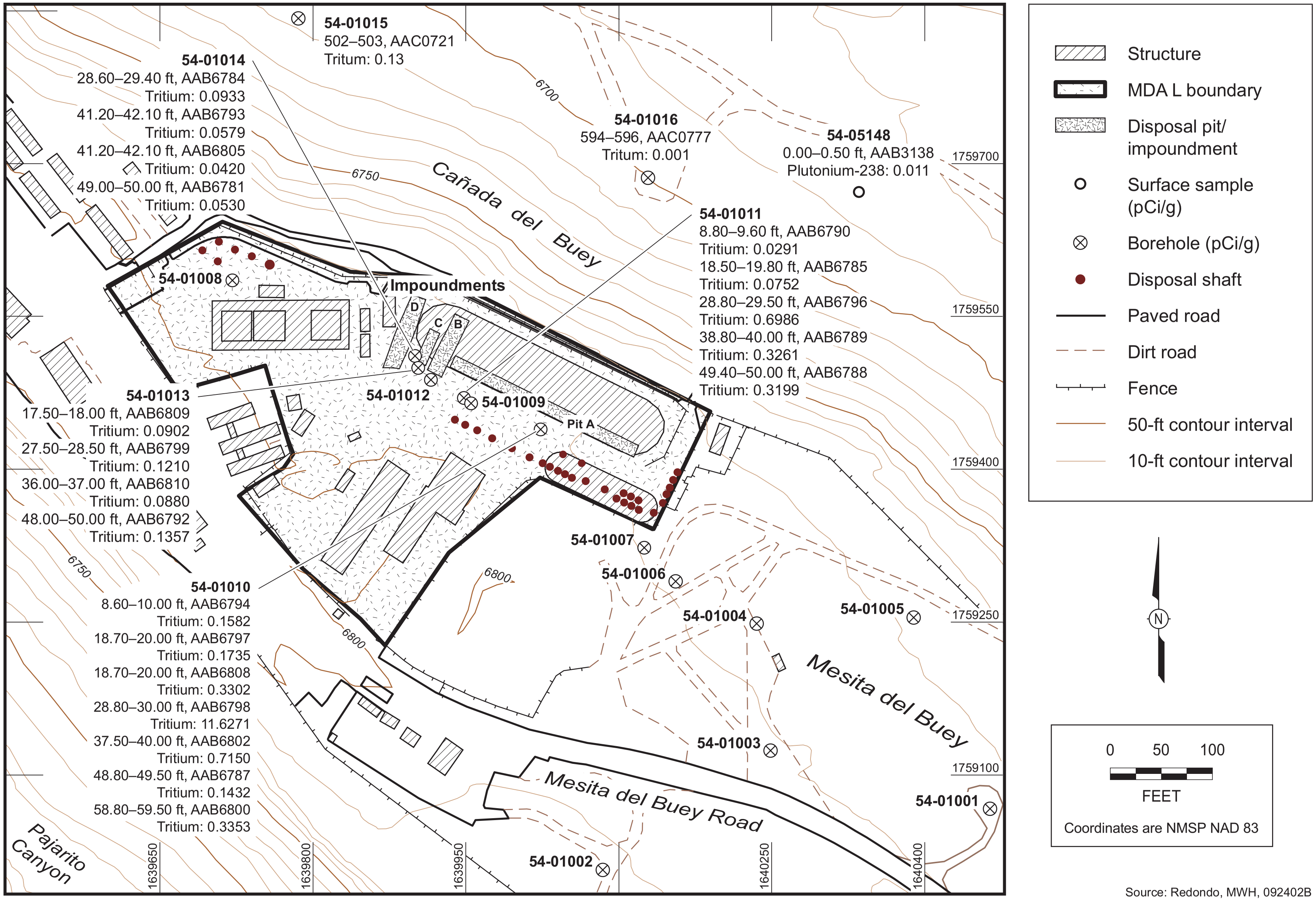
Source: FIMAD map G104040, 011396
F5.3-2, TA-54 RFI Rpt., 11299, PTM
Rev. for FB-5, MDA L IWP, 082803, cf

Figure B-5. EMFLUX® sample locations at MDA L



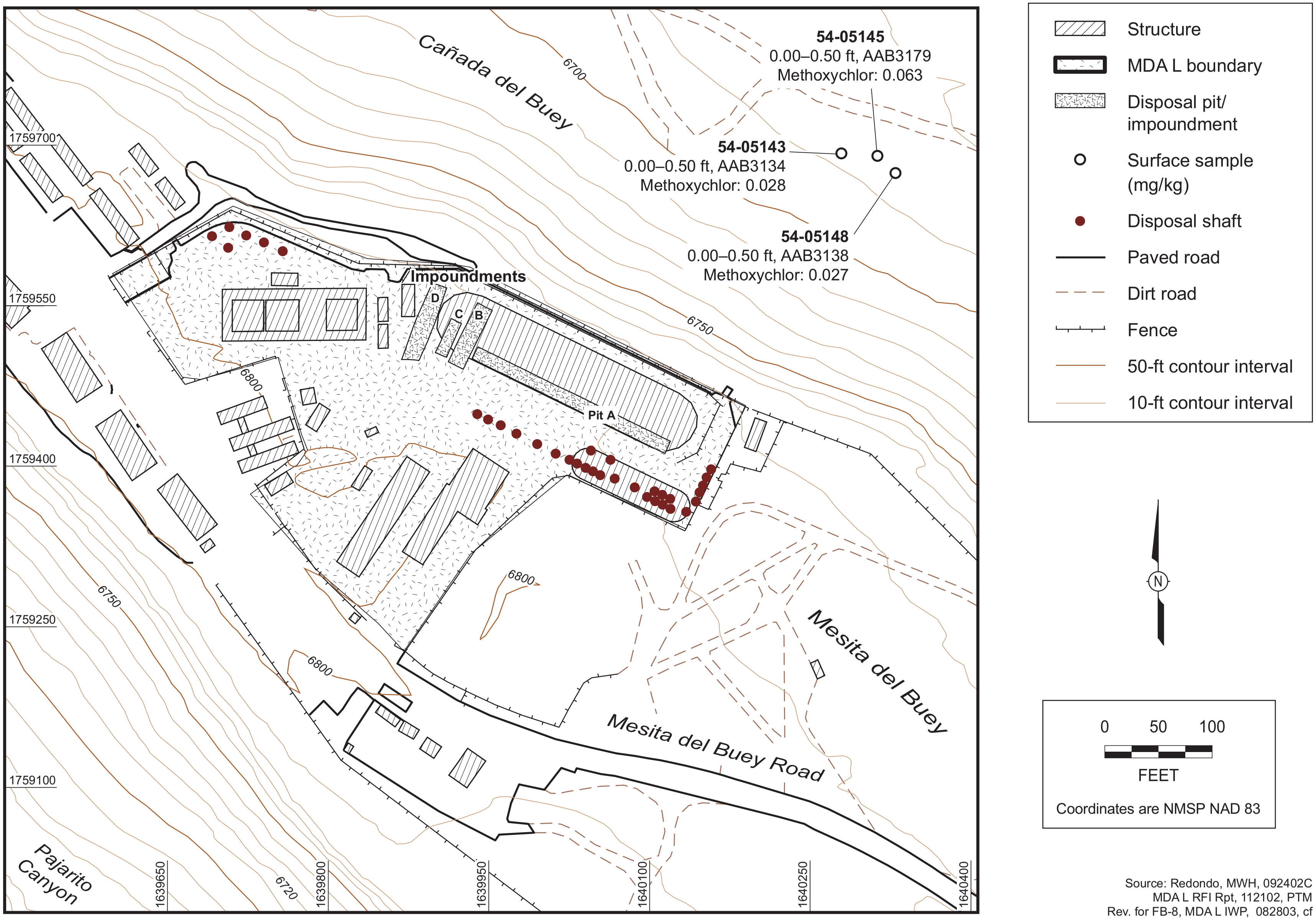
Source: FIMAD ID: G105358
F5.3-3, TA-54 RFI RPT, 110999, PTM
Rev. for FB-6, MDA L IWP, 082503, cf

Figure B-6. Locations of Phase I RFI boreholes at MDA L



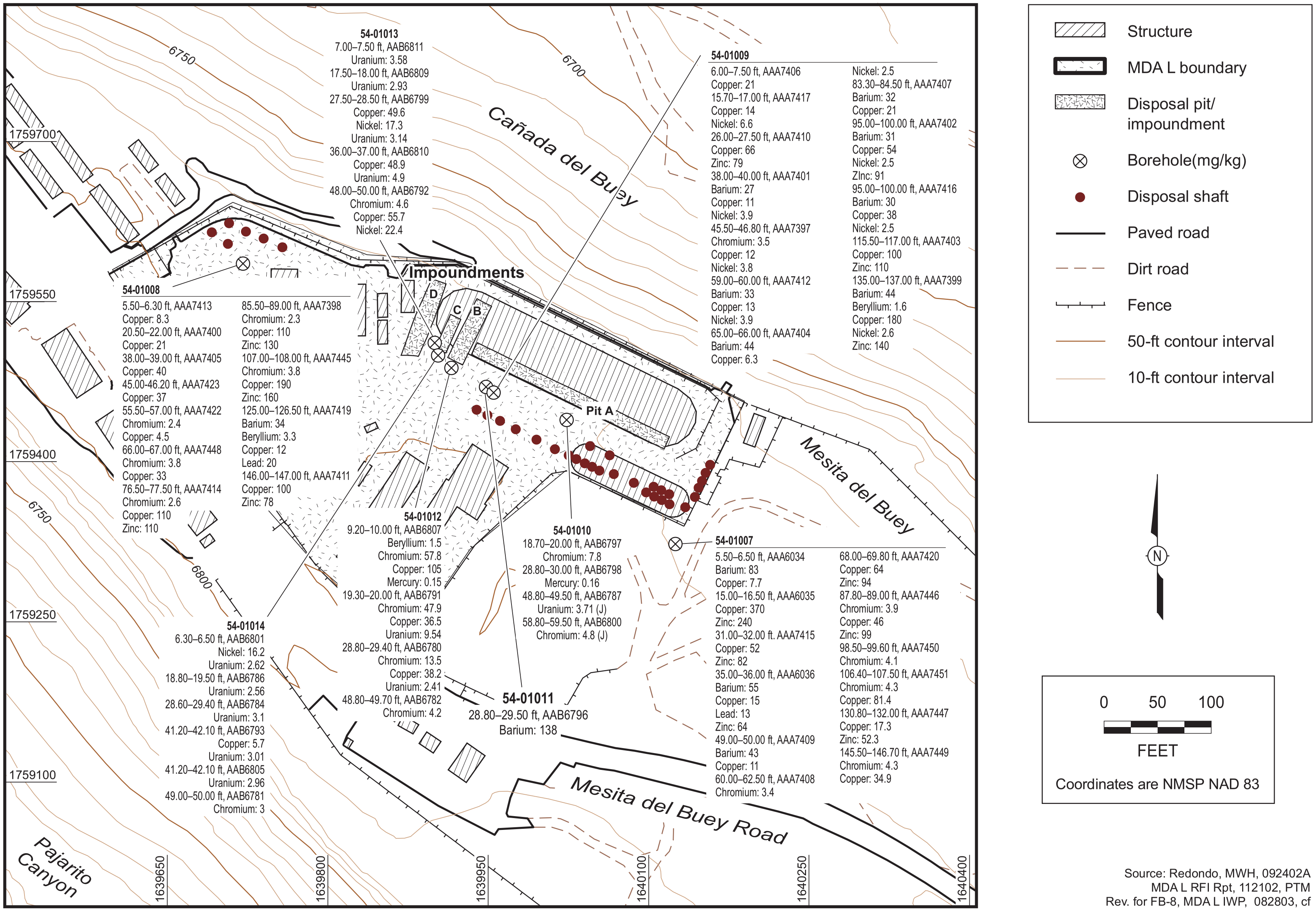
Source: Redondo, MWH, 092402B
MDA L RFI Rpt, 120302, PTM
Rev. for FB-7, MDA L IWP, 082803, cf

Figure B-7. Radionuclide detections above background/fallout values at MDA L



Source: Redondo, MWH, 092402C
MDA L RFI Rpt, 112102, PTM
Rev. for FB-8, MDA L IWP, 082803, cf

Figure B-8. Organic chemicals detected in channel sediments at MDA L



54-01013
7.00–7.50 ft, AAB6811
Uranium: 3.58
17.50–18.00 ft, AAB6809
Uranium: 2.93
27.50–28.50 ft, AAB6799
Copper: 49.6
Nickel: 17.3
Uranium: 3.14
36.00–37.00 ft, AAB6810
Copper: 48.9
Uranium: 4.9
48.00–50.00 ft, AAB6792
Chromium: 4.6
Copper: 55.7
Nickel: 22.4

54-01009
6.00–7.50 ft, AAA7406
Copper: 21
15.70–17.00 ft, AAA7417
Copper: 14
Nickel: 6.6
26.00–27.50 ft, AAA7410
Copper: 66
Zinc: 79
38.00–40.00 ft, AAA7401
Barium: 27
Copper: 11
Nickel: 3.9
45.50–46.80 ft, AAA7397
Chromium: 3.5
Copper: 12
Nickel: 3.8
59.00–60.00 ft, AAA7412
Barium: 33
Copper: 13
Nickel: 3.9
65.00–66.00 ft, AAA7404
Barium: 44
Copper: 6.3
Nickel: 2.5
83.30–84.50 ft, AAA7407
Barium: 32
Copper: 21
95.00–100.00 ft, AAA7402
Barium: 31
Copper: 54
Nickel: 2.5
ZInc: 91
95.00–100.00 ft, AAA7416
Barium: 30
Copper: 38
Nickel: 2.5
115.50–117.00 ft, AAA7403
Copper: 100
Zinc: 110
135.00–137.00 ft, AAA7399
Barium: 44
Beryllium: 1.6
Copper: 180
Nickel: 2.6
Zinc: 140

54-01008
5.50–6.30 ft, AAA7413
Copper: 8.3
20.50–22.00 ft, AAA7400
Copper: 21
38.00–39.00 ft, AAA7405
Copper: 40
45.00-46.20 ft, AAA7423
Copper: 37
55.50–57.00 ft, AAA7422
Chromium: 2.4
Copper: 4.5
66.00–67.00 ft, AAA7448
Chromium: 3.8
Copper: 33
76.50–77.50 ft, AAA7414
Chromium: 2.6
Copper: 110
Zinc: 110
85.50–89.00 ft, AAA7398
Chromium: 2.3
Copper: 110
Zinc: 130
107.00–108.00 ft, AAA7445
Chromium: 3.8
Copper: 190
Zinc: 160
125.00–126.50 ft, AAA7419
Barium: 34
Beryllium: 3.3
Copper: 12
Lead: 20
146.00–147.00 ft, AAA7411
Copper: 100
Zinc: 78

54-01012
9.20–10.00 ft, AAB6807
Beryllium: 1.5
Chromium: 57.8
Copper: 105
Mercury: 0.15
19.30–20.00 ft, AAB6791
Chromium: 47.9
Copper: 36.5
Uranium: 9.54
28.80–29.40 ft, AAB6780
Chromium: 13.5
Copper: 38.2
Uranium: 2.41
48.80–49.70 ft, AAB6782
Chromium: 4.2

54-01010
18.70–20.00 ft, AAB6797
Chromium: 7.8
28.80–30.00 ft, AAB6798
Mercury: 0.16
48.80–49.50 ft, AAB6787
Uranium: 3.71 (J)
58.80–59.50 ft, AAB6800
Chromium: 4.8 (J)

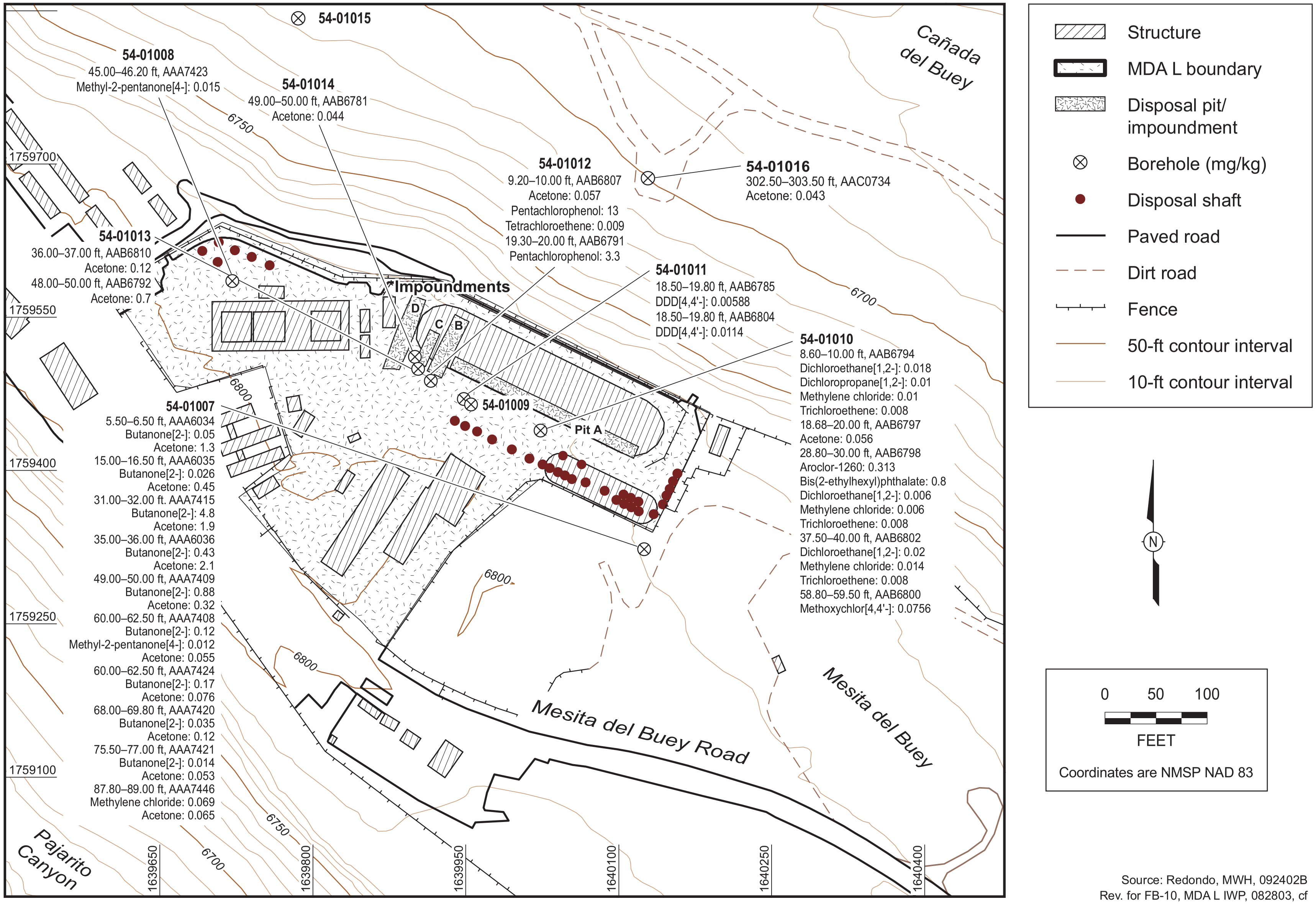
54-01007
5.50–6.50 ft, AAA6034
Barium: 83
Copper: 7.7
15.00–16.50 ft, AAA6035
Copper: 370
Zinc: 240
31.00–32.00 ft. AAA7415
Copper: 52
Zinc: 82
35.00–36.00 ft, AAA6036
Barium: 55
Copper: 15
Lead: 13
Zinc: 64
49.00–50.00 ft, AAA7409
Barium: 43
Copper: 11
60.00–62.50 ft, AAA7408
Chromium: 3.4
68.00–69.80 ft, AAA7420
Copper: 64
Zinc: 94
87.80–89.00 ft, AAA7446
Chromium: 3.9
Copper: 46
Zinc: 99
98.50–99.60 ft, AAA7450
Chromium: 4.1
106.40–107.50 ft, AAA7451
Chromium: 4.3
Copper: 81.4
130.80–132.00 ft, AAA7447
Copper: 17.3
Zinc: 52.3
145.50–146.70 ft, AAA7449
Chromium: 4.3
Copper: 34.9

54-01014
6.30–6.50 ft, AAB6801
Nickel: 16.2
Uranium: 2.62
18.80–19.50 ft, AAB6786
Uranium: 2.56
28.60–29.40 ft, AAB6784
Uranium: 3.1
41.20–42.10 ft, AAB6793
Copper: 5.7
Uranium: 3.01
41.20–42.10 ft, AAB6805
Uranium: 2.96
49.00–50.00 ft, AAB6781
Chromium: 3

54-01011
28.80–29.50 ft, AAB6796
Barium: 138

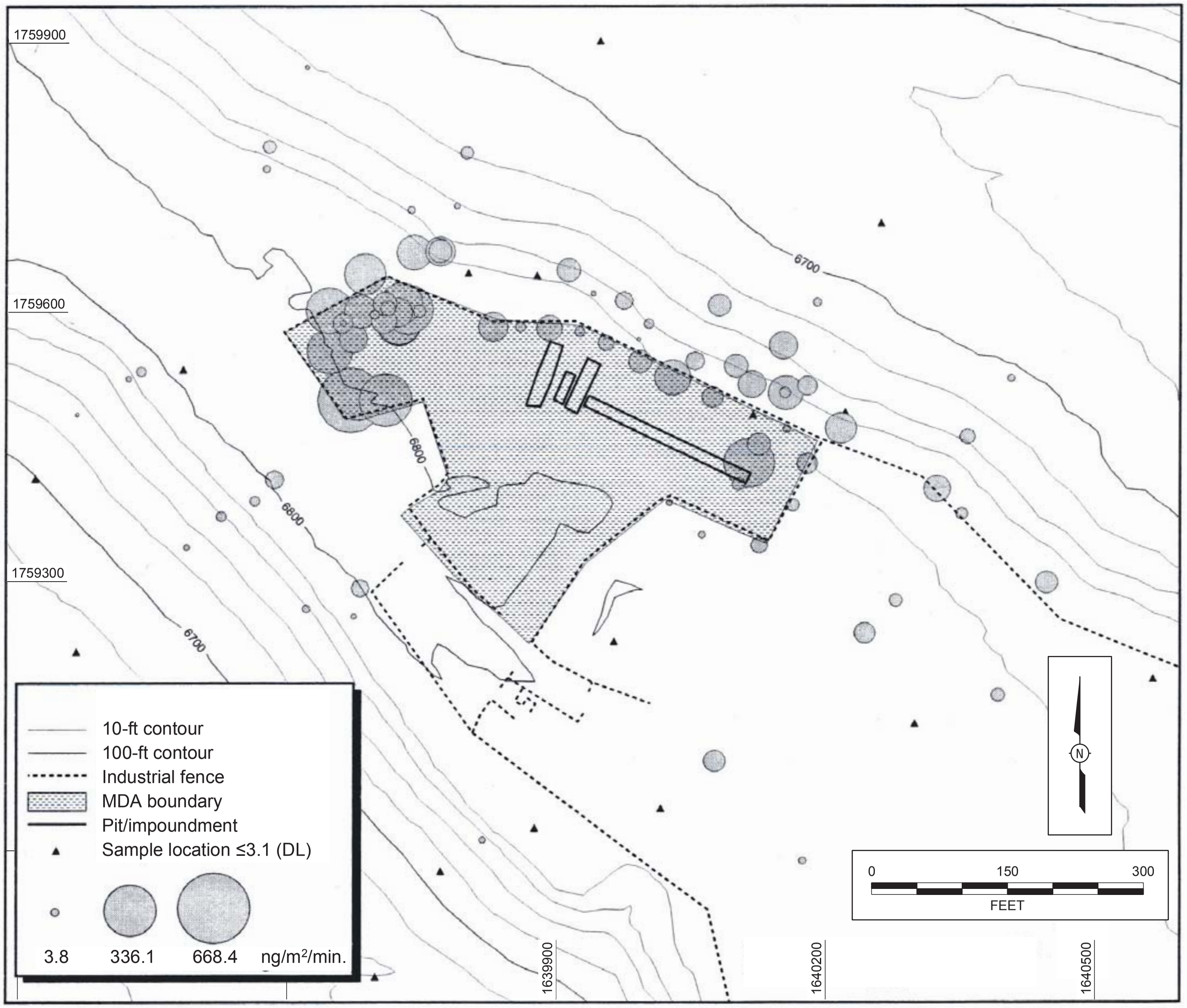
Source: Redondo, MWH, 092402A
MDA L RFI Rpt, 112102, PTM
Rev. for FB-8, MDA L IWP, 082803, cf

Figure B-9. Inorganic chemicals detected above background values in the subsurface tuff at MDA L



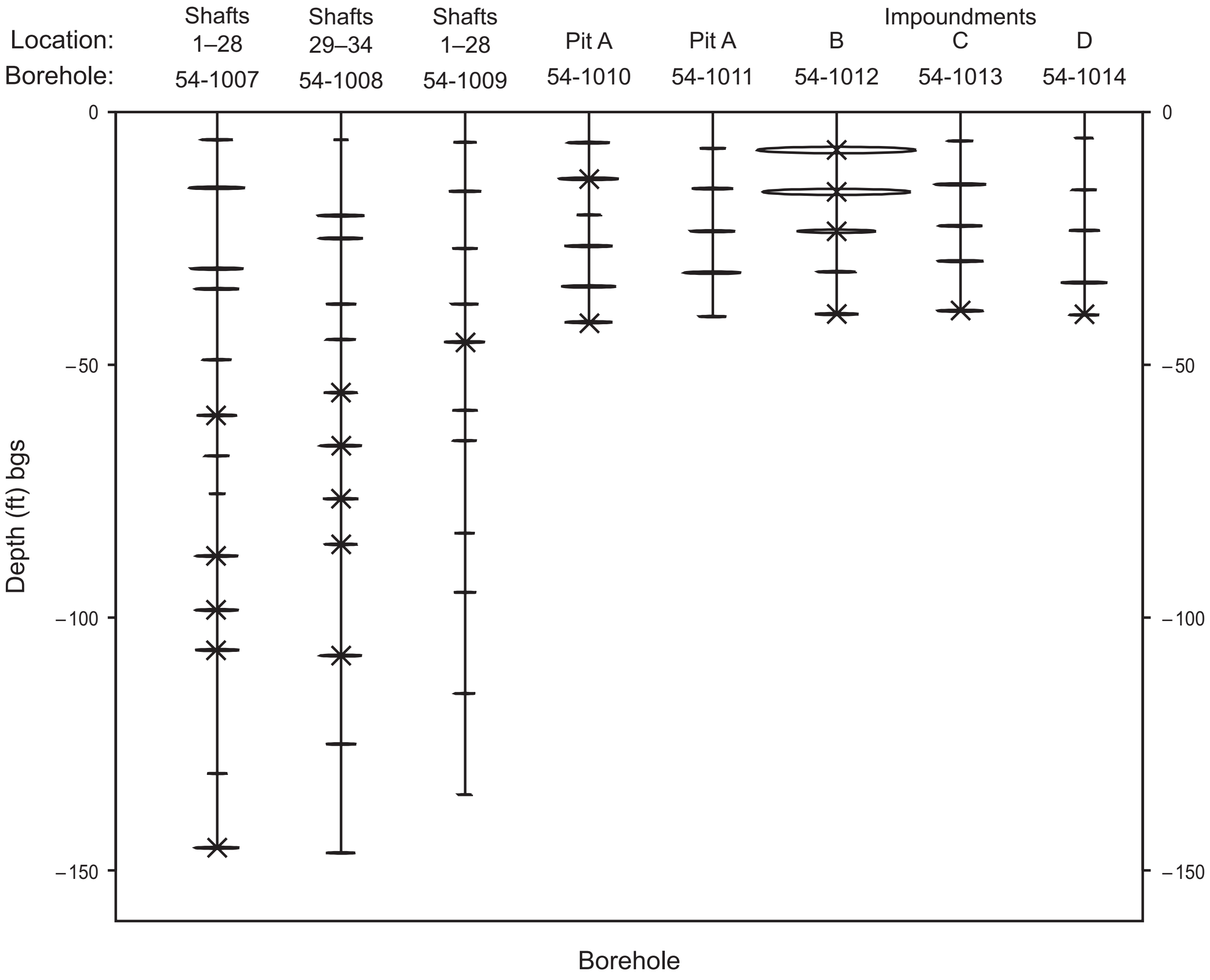
Source: Redondo, MWH, 092402B
Rev. for FB-10, MDA L IWP, 082803, cf

Figure B-10. Organic chemicals detected in the subsurface at MDA L



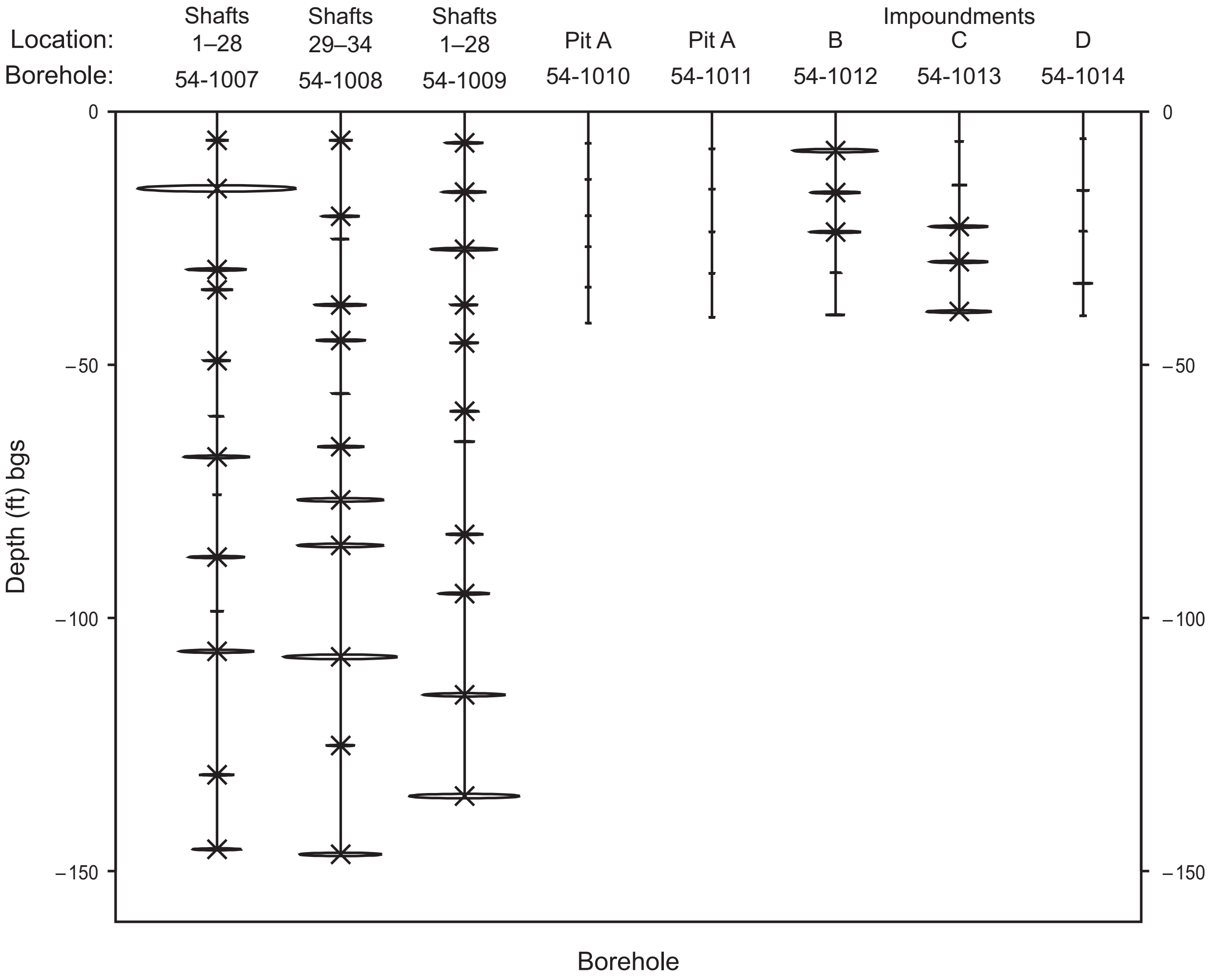
MDA L RFI rpt, 120402, PTM_Rev. for MDA L IWP, 082503, cf

Figure B-11. Surface flux concentrations of TCA at MDA L



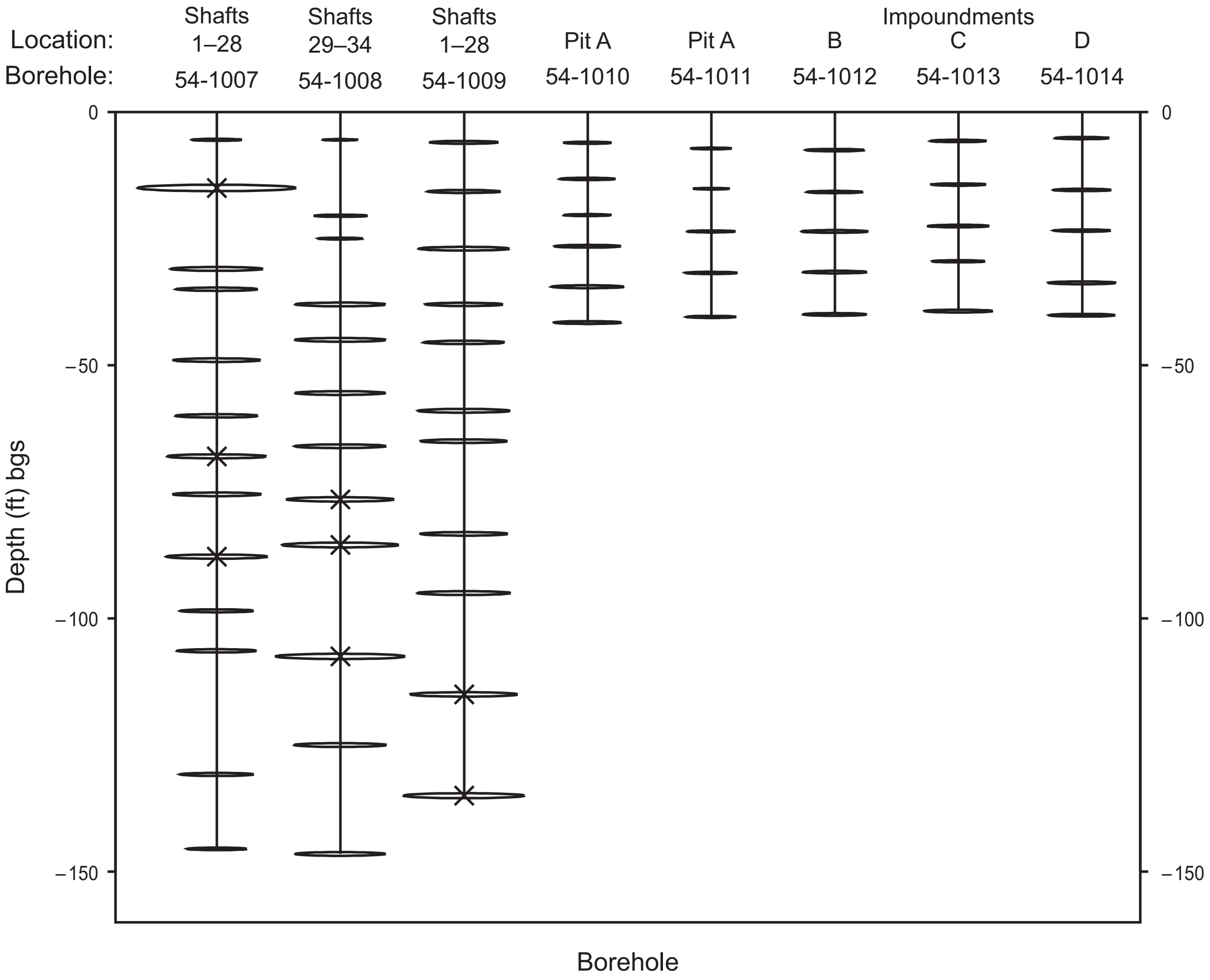
F6.1-16, TA-54 RFI RPT, 020100, PTM_Rev. for FB-12, MDA L IWP, 082503, cf

Figure B-12. **Chromium concentrations (mg/kg) in borehole core samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) from the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (13 mg/kg).**



F6.1-17, TA-54 RFI RPT, 020100, PTM_Rev. for FB-13, MDA L IWP, 082503, cf

Figure B-13. **Copper concentrations (mg/kg) in borehole core samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) within the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (6.2 mg/kg).**



F6.1-18, TA-54 RFI RPT, 020100, PTM_Rev. for FB-14, MDA L IWP, 082503, cf

Figure B-14. **Zinc concentrations (mg/kg) in borehole core samples at MDA L. Concentrations are proportional to the area enclosed by the oval and plotted at sampled depths (ft bgs) within the borehole. Symbol × indicates that the sample concentration is greater than the maximum concentration observed in tuff (all strata) at Laboratory background locations (74 mg/kg).**

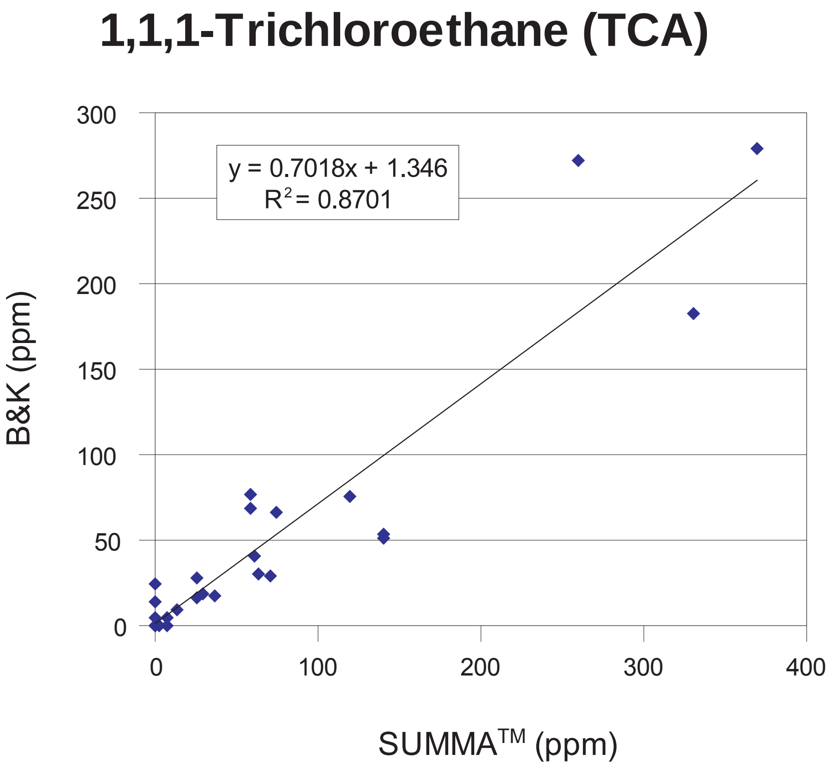


Figure B-15. **Correlation of B&K screening data to SUMMA™ canister analytical results for TCA**

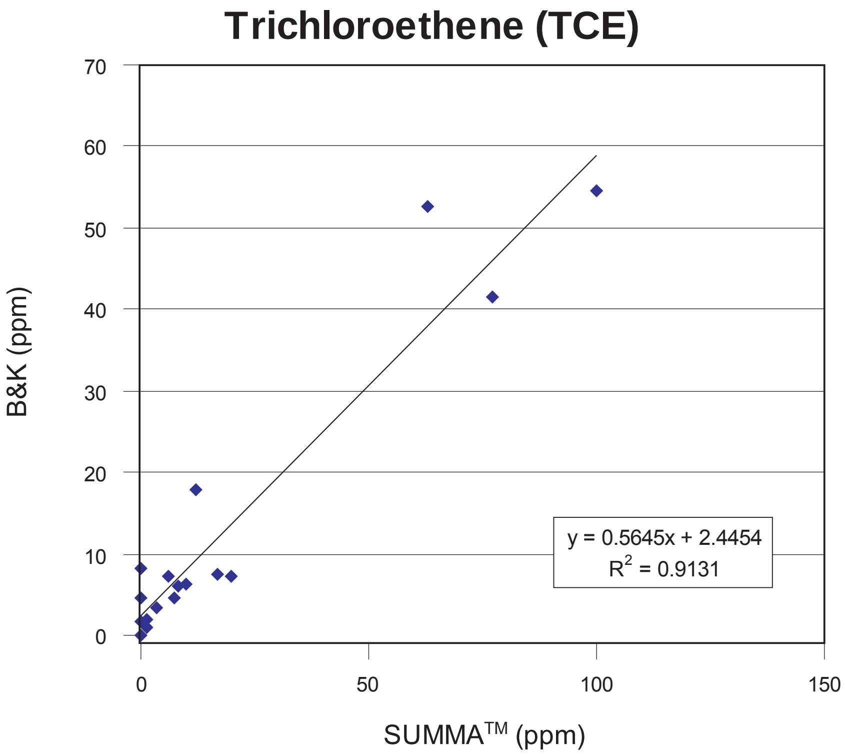
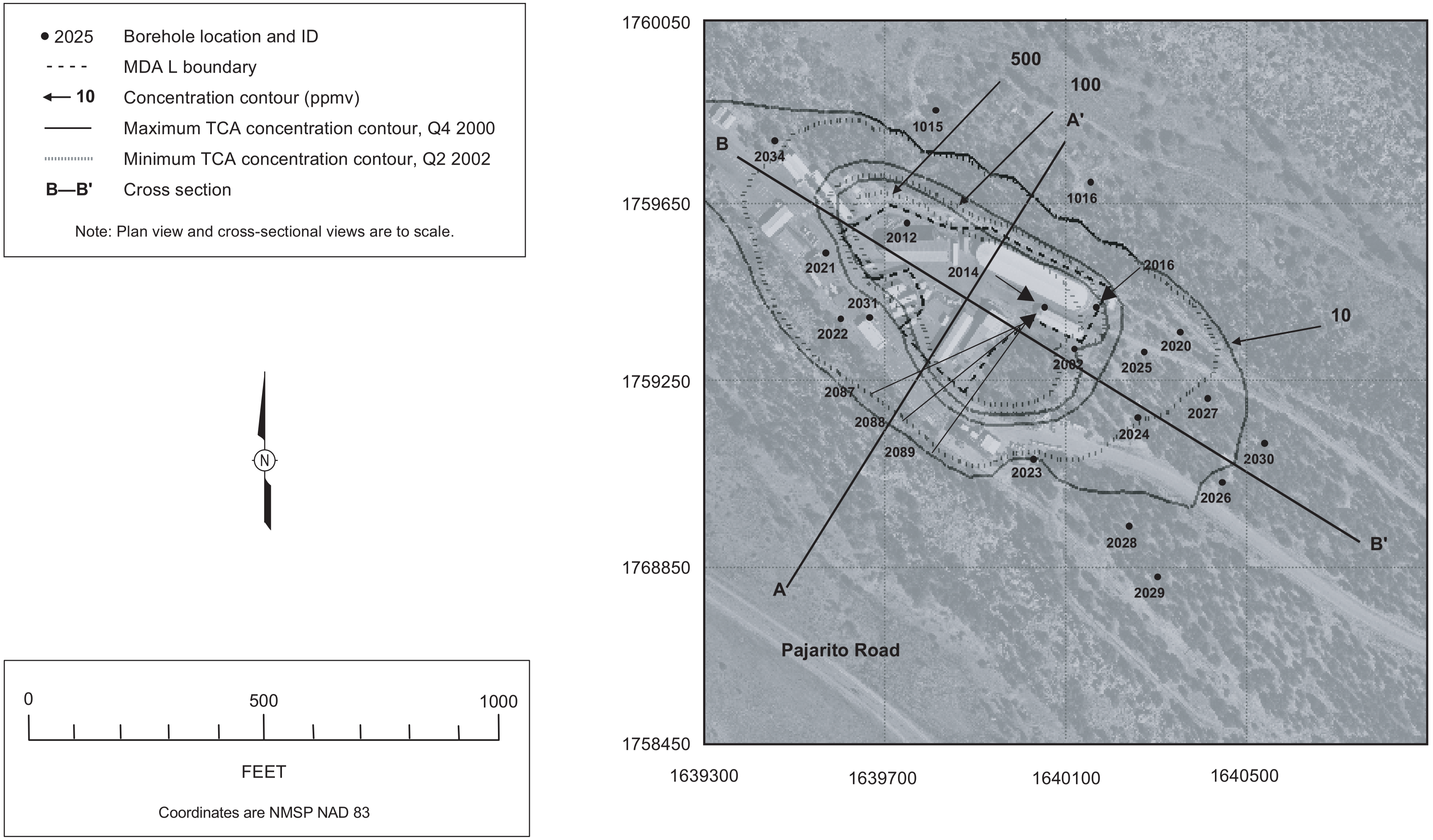
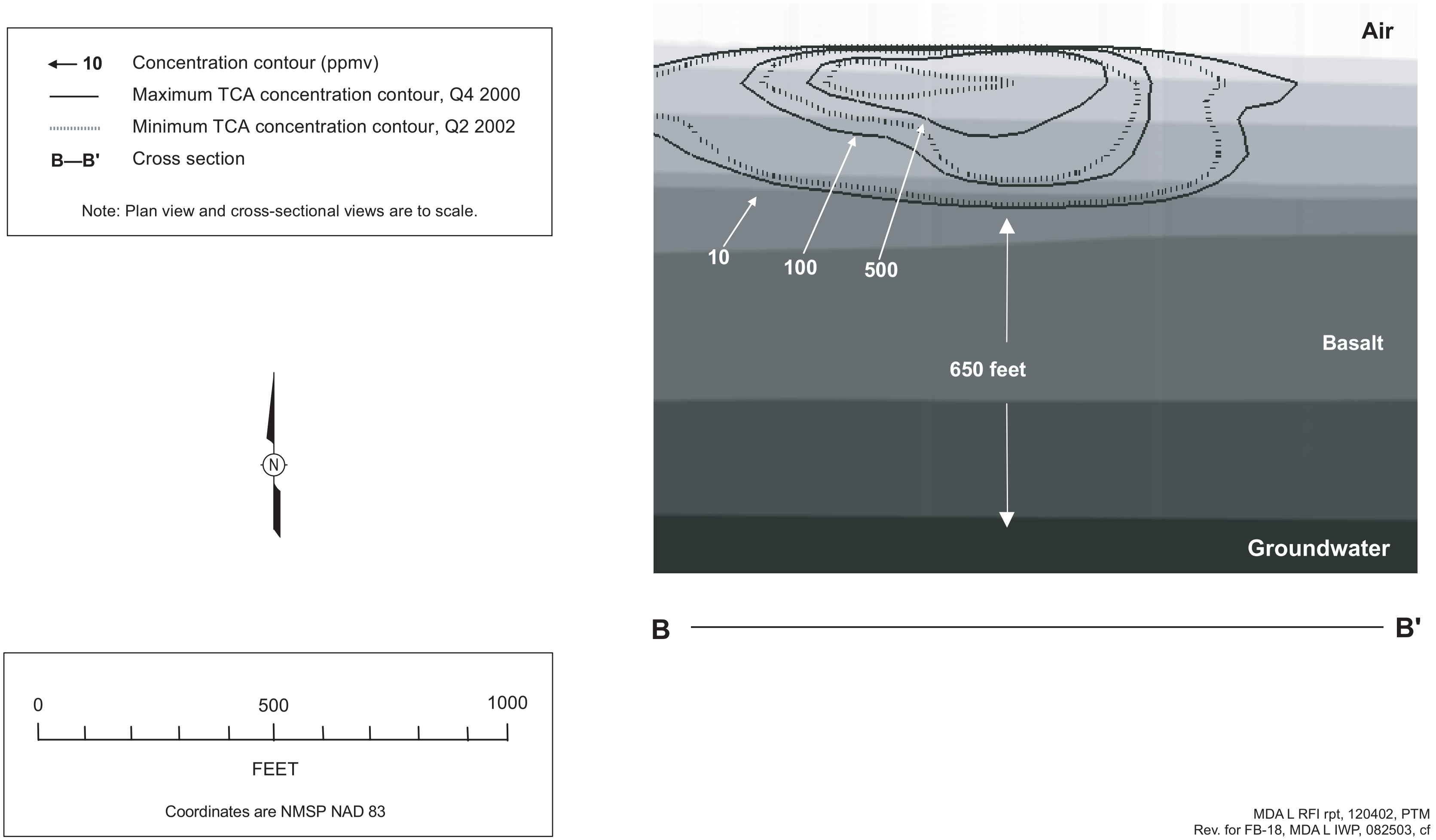


Figure B-16. **Correlation of B&K screening data to SUMMA™ canister analytical results for TCE**



MDA L RFI rpt / 120402 / PTM
Rev. for F14, MDA L IWP, 082503, cf

Figure B-17. Aerial view of the TCA plume at MDA L. Both maximum and minimum lateral extent contours are presented for the B&K screening data.



MDA L RFI rpt, 120402, PTM
Rev. for FB-18, MDA L IWP, 082503, cf

Figure B-18. North-south cross section (B–B') of the VOC plume, represented by TCA, at MDA L showing maximum and minimum vertical extent based on B&K screening

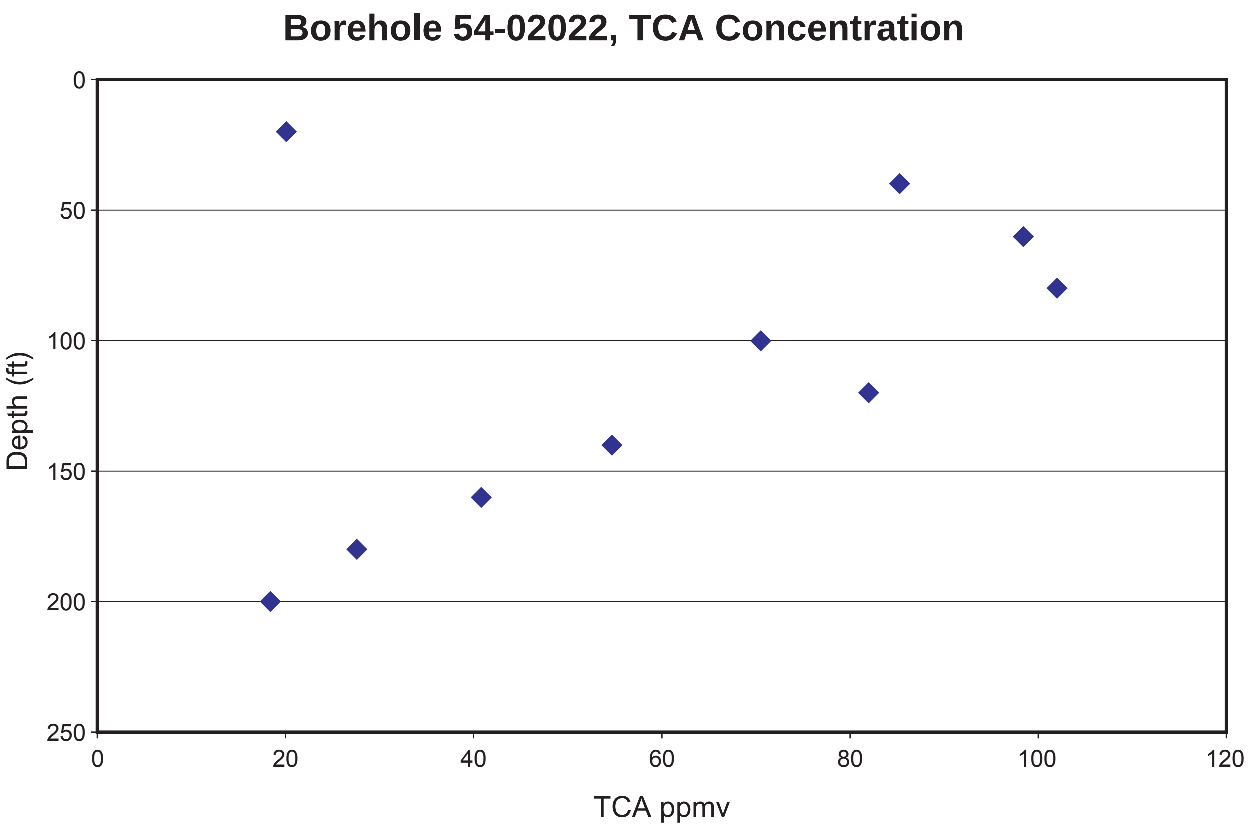
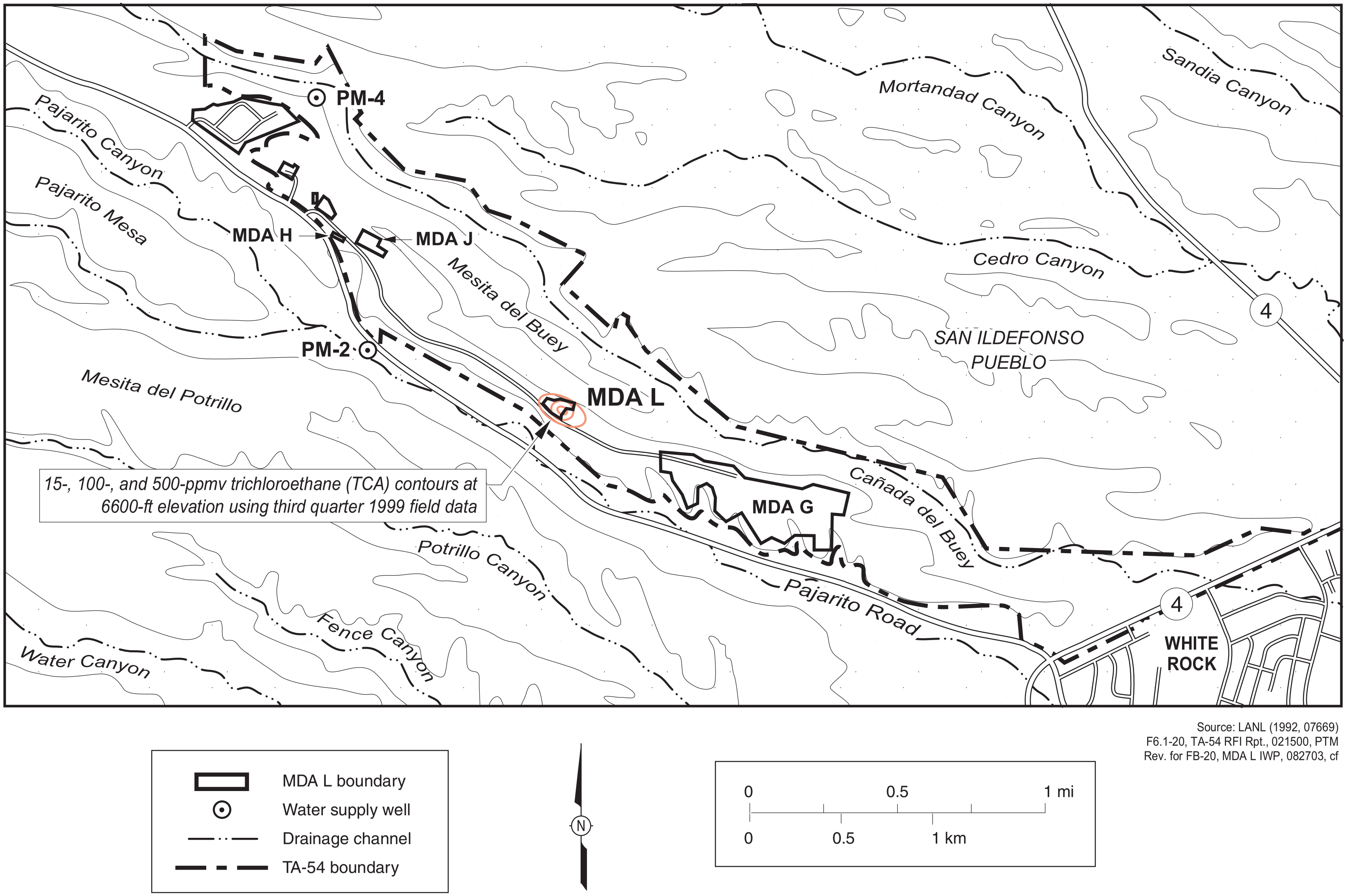


Figure B-19. **Pore-gas monitoring borehole 54-02022, TCA concentration versus depth. Note the characteristic increase in concentration to approximately 100 ft below the MDA L surface, followed by decreasing concentrations to the total depth of the well.**



Source: LANL (1992, 07669)
F6.1-20, TA-54 RFI Rpt., 021500, PTM
Rev. for FB-20, MDA L IWP, 082703, cf

Figure B-20. Areal extent of the VOC plume, represented by TCA, with respect to White Rock and surrounding wells

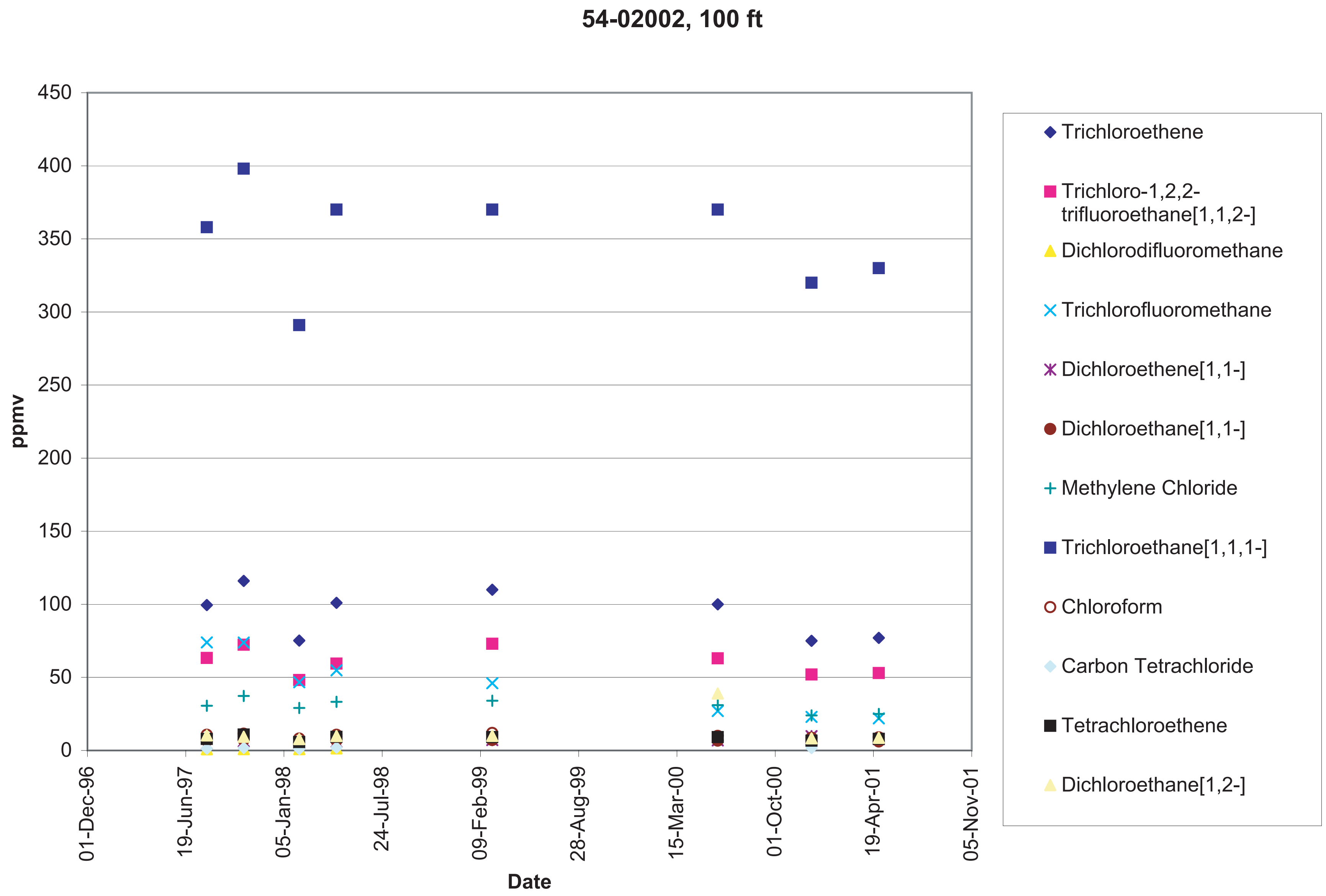


Figure B-21. Pore-gas monitoring borehole 54-02002—100 ft bgs at MDA L: quarterly analytical results over time for the most frequently detected VOCs

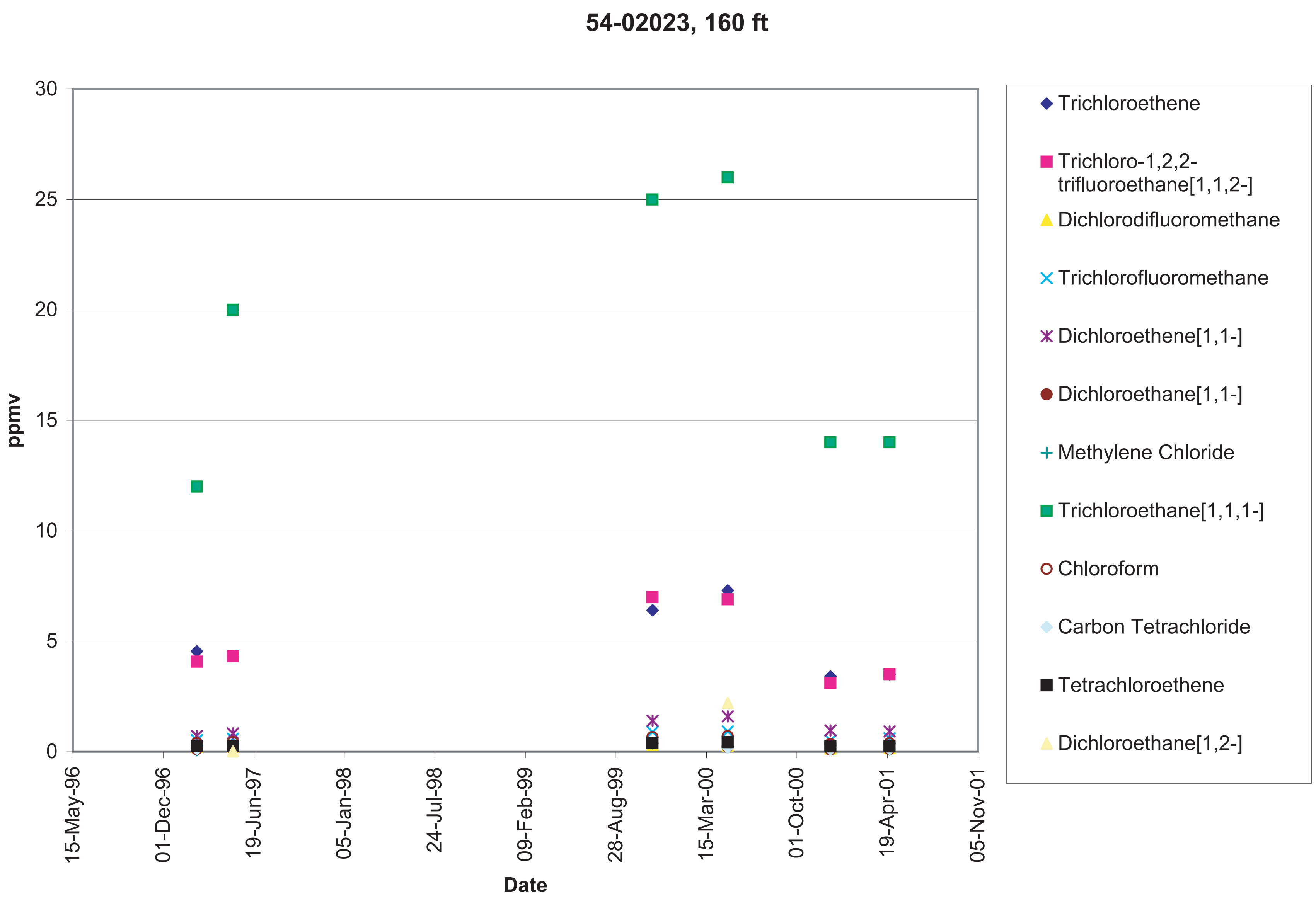


Figure B-22. Pore-gas monitoring borehole 54-02023—160 ft bgs at MDA L: quarterly analytical results over time for the most frequently detected VOCs

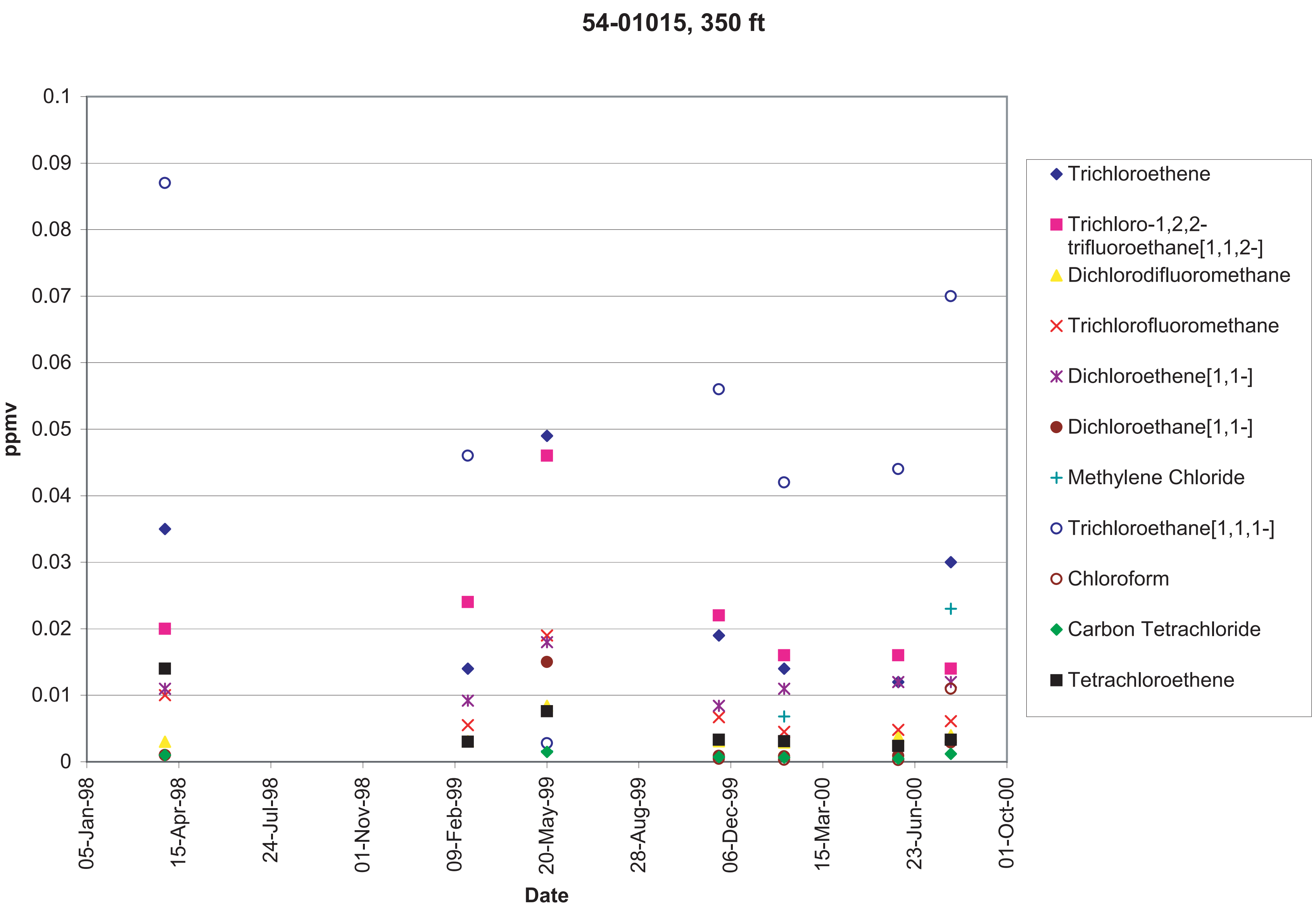


Figure B-23. Pore-gas monitoring borehole 54-01015—400 ft bgs at MDA L: quarterly analytical results over time for most frequently detected VOCs

Table B-1
Dimensions, Dates of Operation, and Capacity of Pit and Impoundments at MDA L

Impoundment/Pit	Dimensions (ft) (width x length x depth)	Period of Use	Months Used	Total Capacity (ft^3)
A	200 x 12 x 12	1950s–12/78	>228	28,800
B	60 x 18 x 10	1/79–6/85	78	7560
C	35 x 12 x 10	7/85–12/86	18	2940
D	75 x 18 x 10	1972–1984	156	9450

Table B-2
Dimensions of Disposal Shafts at MDA L

Shaft	Diameter (ft)	Depth (ft)	Shaft	Diameter (ft)	Depth (ft)
1	3	60	18	8	60
2	3	60	19	8	60
3	3	60	20	3	60
4	3	60	21	3	60
5	3	60	22	3	60
6	4	60	23	4	60
7	3	60	24	4	60
8	3	60	25	6	60
9	3	60	26	6	60
10	3	60	27	4	60
11	8	60	28	4	60
12	4	60	29	6	65
13	8	60	30	6	65
14	3	60	31	6	61
15	3	60	32	4	15
16	3	60	33	6	65
17	3	60	34	6	63

Table B-3
Dates of Operation and Capacity for Disposal Shafts at MDA L

Shaft	Period of Use	Months Used	Total Capacity (ft^3)	Shaft	Period of Use	Months Used	Total Capacity (ft^3)
1	4/80–8/83	41	424	18	6/79–5/80	12	3016
2	2/75–6/79	53	424	19	4/80–4/82	25	3016
3	2/75–10/78	45	424	20	3/82–8/83	18	424
4	2/75–4/80	63	424	21	3/82–12/84	46	424
5	2/75–5/77	28	424	22	3/82–8/83	18	424
6	6/75–5/79	48	754	23	4/82–2/84	23	754
7	6/75–5/79	48	424	24	4/82–3/84	24	754
8	6/75–5/79	48	424	25	9/82–4/85	32	1696
9	6/75–5/79	48	424	26	9/82–2/84	18	1696
10	6/75–5/79	48	424	27	1/83–1/85	25	754
11	1/78–6/79	18	3016	28	1/82–4/85	40	754
12	1/78–6/79	18	754	29	12/83–7/84	8	1838
13	6/79–4/82	35	3016	30	12/83–4/84	5	1838
14	6/79–4/82	35	424	31	12/83–8/84	9	1725
15	6/79–4/82	36	424	32	3/84–8/84	6	188
16	6/79–4/82	35	424	33	3/84–1/85	11	1838
17	6/79–4/82	35	424	34	2/85–4/85	2	1781

Note: Information was taken from the OU 1148 work plan (LANL 1992, 07669, p. 5-106).

Table B-4
Summary of Work Plan Specifications, Actual Fieldwork, and Rationale for Deviations

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
Sediment (drainages)	9	VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, herbicides, cyanide, gamma spectroscopy, gross alpha, beta, and gamma radiation	8 total: for gross radiation screening; Subset of 4 samples for offsite contract laboratory analysis	4 samples analyzed for pesticides/PCBs, herbicides, inorganic chemicals, gamma spec, Am-241, Sr-90, isotopic Pu, isotopic U, isotopic thorium, and tritium.	Eight samples were collected based on the geomorphic survey. All samples were field screened for alpha, beta, and gamma radiation to bias sample selection. One sample with the highest gross gamma level, the sample with the highest gross alpha and beta levels, and two other samples were sent to an offsite contract laboratory for analysis. (Glatzmaier 1994, 52015)
Core	126 (16 boreholes) See proposed drilling modifications (Glatzmaier 1994, 52015)	VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, cyanide, gross alpha and beta radiation, and gamma spectroscopy	89 total from 10 boreholes	VOCs, SVOCs, pesticides/ PCBs, herbicides, inorganic chemicals, cyanide, tritium, isotopic Pu, and isotopic U 77 – VOCs 55 – SVOCs 67 – TAL metals 62 – cyanide 11 – total uranium 48 – tritium 67 – pesticides/PCBs 38 – herbicides 5 – isotopic uranium and isotopic plutonium	Vertical boreholes 54-1007, 54-01008, and 54-01009 were also drilled adjacent to numerous shafts and Pit A to a TD of 150 ft. Thirty-eight core samples were collected at 10-ft intervals and submitted for offsite contract laboratory analysis of TAL metals, cyanide, pesticides/PCBs, herbicides, SVOCs, and VOCs. Five core samples from borehole 54-01009 were also submitted for offsite contract analysis of isotopic plutonium, isotopic uranium, and gamma spec. for Am-241 and Cs-137. Boreholes 54-01007, 54-01008, and 54-01009 were subsequently backfilled. Angle boreholes 54-01010 through 54-01014 were advanced beneath Pit A and Impoundments B, C, and D. The boreholes were backfilled and grouted closed. A total of 29 core samples were collected at 10-ft intervals and submitted to an off-site contract laboratory for analysis of TAL metals, pesticides/PCBs, SVOCs, VOCs, and tritium. Additional core samples submitted for off-site contract laboratory analyses included all 24 core samples from boreholes 54-01010, 54-01011, 54-01012, 54-01014 for cyanide; and 11 core samples

Table B-4 (continued)

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
			94 total from 6 boreholes 12 total from 1 borehole	Screened for VOCs Screened for VOCs and SVOCs	from boreholes 54-01010, 54-01013, and 54-01014 for total uranium. Two deep angle boreholes, 54-01015 and 54-01016, were drilled from the adjacent canyon slope northeast of MDA L within Cañada del Buey to investigate the possible presence of vapor-phase contaminants at depth beneath MDA L. These boreholes were drilled to depths of 530 ft and 607 ft, respectively. The boreholes were completed as vapor monitoring boreholes. Boreholes 54-01017 and 54-01018 were advanced directly east of MDA L. Borehole 54-01017 was designed as the extraction well for the pilot vapor extraction test, and borehole 54-01018, located 20 ft south-southeast of borehole 54-01017, was used to monitor pore gas. Both boreholes are maintained for vapor monitoring and are capped at the ground surface. 94 core samples were collected at 20-ft intervals from boreholes 54-01001 through 54-01006 and screened for VOCs and moisture. The 6 boreholes were instrumented for vapor monitoring. The RFI work plan specified locations for boreholes. Actual borehole locations were selected to maximize the area sampled and avoid obstacles such as buried utilities and waste.
Pore gas	99	VOCs	207	VOCs (EPA Method TO-14)	VOCs don't adsorb to the tuff matrix; gas phase analysis provides information about the nature and extent of VOCs in the subsurface. A summary of quarterly pore-gas monitoring results for pore-gas samples collected from 1985-2001 are provided in Appendix D.

Table B-4 (continued)

Media	Work Plan Specification[a]		Actual Fieldwork Performed		Rationale for Deviation
	Sample Number	Analytes Measured	Sample Number	Analytes Measured	
VOC surface flux	136	VOCs	102 8	VOCs Tritium	Surface flux data can help identify lateral extent of subsurface VOC contamination. Surface flux locations were restricted by asphalt and site structures on the surface of MDA L.
Air (Ambient)	48	Total suspended particulates, VOCs, SVOCs, inorganic chemicals, pesticides/PCBs, cyanide, and radionuclides	16	VOCs	ESH-17 air monitoring data from MDA L were reviewed for nature and extent of VOCs. (Jansen and Taylor 1996, 54959)
Air-Flow Velocity - Passive Vapor Extraction Test	n/a[b]	n/a	n/a	In 1997, airflow volume and VOC concentrations were measured at borehole 54-01006. In 1998, the tests were repeated using a one-way valve on borehole 54-01006 to allow only the exhalation of subsurface during periods of relatively high atmospheric pressure. During the 1998 study, vapor concentrations and pressure were measured at several subsurface ports in boreholes 54-01004, 54-01006, and 54-01018 and in atmospheric air.	None

[a] Based on proposed modifications to the RFI Work Plan for OU 1148 for drilling and core sampling at MDA L (Glatzmaier 1994, 52015)

[b] n/a = Not applicable.

Table B-5
Summary of Phase I RFI Channel Sediment Samples Collected at MDA L

Sample ID	Location ID	Depth (ft)	Media	Metals	Herbicides	PCBs	Pesticides	Americium-241	Gamma Spectroscopy	Tritium	Isotopic Plutonium	Isotopic Thorium	Isotopic Uranium	Strontium-90
AAB3134	54-05143	0–0.5	Sediment	18931	18049	18049	18049	18973	18973	18973	18973	18973	18973	18973
AAB3179	54-05145	0–0.5	Sediment	18931	18049	18049	18049	18973	18973	18973	18973	18973	18973	18973
AAB3149	54-05147	0–0.67	Sediment	18931	18049	18049	18049	18973	18973	18973	18973	18973	18973	18973
AAB3138	54-05148	0–0.5	Sediment	18931	18049	18049	18049	18973	18973	18973	18973	18973	18973	18973

Table B-6
Calculated Tritium Surface Flux
Concentration for Phase I RFI Samples Collected at MDA L

Sample Location	Collection Date	Emission Flux (pCi/min/m^2)
T1	1993	1.65
T2	1993	2.26
C11	1993	3.40
C29	1993	3.69
C30	1993	5.45*
S1	1994	2.90
S2	1994	19,500
S3	1994	28,600

*Higher of two duplicate samples.

Table B-7
Borehole Information

Borehole ID	Year Installed	Depth (ft bgs)	Declination (degrees from horizontal)	Adjacent Waste Disposal Unit	Current Status
Phase I RFI					
54-01001	1993	315	63.5	None	Surface cap
54-01002	1993	310	69	None	Surface cap
54-01003	1993	299	Vertical	None	Surface cap
54-01004	1993	340	Vertical	None	Surface cap
54-01005	1993	291	69	None	Surface cap
54-01006	1993	320	65	None	Surface cap
54-01007	1993	150	Vertical	Shafts 1–6	Backfilled
54-01008	1993	150	Vertical	Shafts 30–34	Backfilled
54-01009	1993	150	Vertical	Shaft 27; Pit A	Backfilled
54-01010	1994	60	45	Pit A	Backfilled
54-01011	1994	50	55	Pit A	Backfilled
54-01012	1994	50	55	Impoundment B	Backfilled
54-01013	1994	50	55	Impoundment C	Backfilled
54-01014	1994	50	55	Impoundments D and C	Backfilled
54-01015	1995	530	61.5	None	Pore-gas monitoring borehole
54-01016	1995	607	59.5	None	Pore-gas monitoring borehole
54-01017	1995	159	Vertical	None	Surface cap
54-01018	1995	328	Vertical	None	Surface cap

Table B-7 (continued)

Borehole ID	Year Installed	Depth (ft)	Declination (degrees from horizontal)	Adjacent Waste Disposal Unit	Current Status
Pre-RFI					
54-02001	1986	200	Vertical	Lead stringer shafts; shaft 33	Buried
54-02002	1986	200	Vertical	Shafts 7–11	Pore-gas monitoring borehole
54-02012	1985	42	Vertical	Shafts 30–34	Pore-gas monitoring borehole
54-02013	1985	63	Vertical	None	Pore-gas monitoring borehole
54-02014	1985	86	Vertical	Shafts 17–18	Pore-gas monitoring borehole
54-02015	1985	82	Vertical	Shafts 3–5	Pore-gas monitoring borehole
54-02016	1985	82	Vertical	Pit A	Pore-gas monitoring borehole
54-02020	1986	200	Vertical	None	Pore-gas monitoring borehole
54-02021	1986	200	Vertical	None	Pore-gas monitoring borehole
54-02022	1986	197	Vertical	None	Pore-gas monitoring borehole
54-02023	1986	200	Vertical	None	Pore-gas monitoring borehole
54-02024	1986	200	Vertical	None	Pore-gas monitoring borehole
54-02025	1988	190	Vertical	None	Pore-gas monitoring borehole
54-02026	1988	215	Vertical	None	Pore-gas monitoring borehole
54-02027	1988	250	Vertical	None	Pore-gas monitoring borehole
54-02028	1988	250	Vertical	None	Pore-gas monitoring borehole
54-02029	1988	288	Vertical	None	Pore-gas monitoring borehole
54-02030	1989	243	Vertical	None	Pore-gas monitoring borehole
54-02031	1989	260	Vertical	None	Pore-gas monitoring borehole
54-02034	1988	300	Vertical	None	Pore-gas monitoring borehole
54-02087	1985?	86	Vertical	None	Pore-gas monitoring borehole
54-02088	1985?	86	Vertical	None	Pore-gas monitoring borehole
54-02089	1985?	86	Vertical	None	Pore-gas monitoring borehole

Note: The -01000 series boreholes are Phase I RFI characterization boreholes. The -02000 series boreholes are pre-RFI boreholes drilled for pore-gas monitoring.

Table B-8
Summary of Phase I RFI Subsurface Core Samples Collected at MDA L

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAA4228	54-01001	20–21.2	Qbt 2	—	—	—	—	—	—	—	15640	—	—	—
AAA4233	54-01001	40–42.5	Qbt 1v	—	—	—	—	—	—	—	15661	—	—	—
AAA4237	54-01001	59.5–61	Qbt 1v	—	—	—	—	—	—	—	15661	—	—	—
AAA4245	54-01001	59.5–61	Qbt 1v	—	—	—	—	—	—	—	15661	—	—	—
AAA4241	54-01001	80.5–82.5	Qbt 1v	—	—	—	—	—	—	—	15664	—	—	—
AAA5537	54-01001	100.3–101.8	Qbt 1v	—	—	—	—	—	—	—	15664	—	—	—
AAA4248	54-01001	121–122	Qbt 1v	—	—	—	—	—	—	—	15664	—	—	—
AAA4257	54-01001	140.3–142.5	Qbt 1g	—	—	—	—	—	—	—	15664	—	—	—
AAA4253	54-01001	160.3–161	Qbt 1g	—	—	—	—	—	—	—	15664	—	—	—
AAA4261	54-01001	180–181.5	Qbt 1g	—	—	—	—	—	—	—	15681	—	—	—
AAA4273	54-01001	200.5–201.5	Qbt 1g	—	—	—	—	—	—	—	15681	—	—	—
AAA4265	54-01001	221.5–224.5	Qbt 1g	—	—	—	—	—	—	—	15681	—	—	—
AAA4269	54-01001	241–244.5	Qbt 1g	—	—	—	—	—	—	—	15699	—	—	—
AAA4277	54-01001	260.8–261.5	Qbt 1g	—	—	—	—	—	—	—	15699	—	—	—
AAA4278	54-01001	281.2–281.4	Qbt 1g	—	—	—	—	—	—	—	15699	—	—	—
AAA4324	54-01001	300.1–301	Qct	—	—	—	—	—	—	—	15699	—	—	—
AAA4323	54-01002	15.3–16	Qbt 2	—	—	—	—	—	—	—	15727	—	—	—
AAA4321	54-01002	40.1–40.8	Qbt 2	—	—	—	—	—	—	—	15753	—	—	—
AAA5373	54-01002	62.1–63	Qbt 1v	—	—	—	—	—	—	—	15753	—	—	—
AAA5378	54-01002	80.3–82	Qbt 1v	—	—	—	—	—	—	—	15753	—	—	—
AAA5374	54-01002	100.1–102.8	Qbt 1v	—	—	—	—	—	—	—	15753	—	—	—
AAA4320	54-01002	102.8–103.8	Qbt 1v	—	—	—	—	—	—	—	15753	—	—	—
AAA4322	54-01002	121–122.5	Qbt 1v	—	—	—	—	—	—	—	15765	—	—	—
AAA5377	54-01002	140.3–142	Qbt 1v	—	—	—	—	—	—	—	15765	—	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAA5540	54-01002	160.5–161.5	Qbt 1g	—	—	—	—	—	—	—	15765	—	—	—
AAA5542	54-01002	180.2–181.5	Qbt 1g	—	—	—	—	—	—	—	15765	—	—	—
AAA5541	54-01002	200.3–201	Qbt 1g	—	—	—	—	—	—	—	15765	—	—	—
AAA5376	54-01002	221.5–223.5	Qbt 1g	—	—	—	—	—	—	—	15785	—	—	—
AAA5488	54-01002	240.3–241	Qbt 1g	—	—	—	—	—	—	—	15785	—	—	—
AAA5486	54-01002	260.8–261.5	Qbt 1g	—	—	—	—	—	—	—	15785	—	—	—
AAA5483	54-01002	280–282	Qct	—	—	—	—	—	—	—	15785	—	—	—
AAA5375	54-01002	300.5–301.2	Qct	—	—	—	—	—	—	—	15785	—	—	—
AAA5433	54-01003	20.8–21.5	Qbt 2	—	—	—	—	—	—	—	15931	—	—	—
AAA5430	54-01003	43.8–45	Qbt 1v	—	—	—	—	—	—	—	15972	—	—	—
AAA5586	54-01003	44–45	Qbt 1v	—	—	—	—	—	—	—	15972	—	—	—
AAA5422	54-01003	66.5–67.7	Qbt 1v	—	—	—	—	—	—	—	15972	—	—	—
AAA5429	54-01003	81–81.5	Qbt 1v	—	—	—	—	—	—	—	15972	—	—	—
AAA5423	54-01003	103.8–104.5	Qbt 1v	—	—	—	—	—	—	—	15972	—	—	—
AAA5489	54-01003	120–123.2	Qbt 1v	—	—	—	—	—	—	—	15967	—	—	—
AAA5425	54-01003	145.6–147	Qbt 1g	—	—	—	—	—	—	—	15967	—	—	—
AAA5481	54-01003	160.8–162	Qbt 1g	—	—	—	—	—	—	—	15967	—	—	—
AAA5478	54-01003	180.8–181.5	Qbt 1g	—	—	—	—	—	—	—	15967	—	—	—
AAA5380	54-01003	201–202	Qbt 1g	—	—	—	—	—	—	—	15967	—	—	—
AAA5431	54-01003	220.8–221.5	Qbt 1g	—	—	—	—	—	—	—	15988	—	—	—
AAA5588	54-01003	240–240.7	Qbt 1g	—	—	—	—	—	—	—	15988	—	—	—
AAA5587	54-01003	260.7–263	Qbt 1g	—	—	—	—	—	—	—	15988	—	—	—
AAA5594	54-01003	281.6–282.5	Qct	—	—	—	—	—	—	—	15988	—	—	—
AAA5424	54-01004	21.5–22.2	Qbt 2	—	—	—	—	—	—	—	16009	—	—	—
AAA5477	54-01004	41.7–42.7	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—
AAA5484	54-01004	60.8–61.5	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAA5379	54-01004	80.3–81.5	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—
AAA5432	54-01004	100.3–102.5	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—
AAA5590	54-01004	101.5–102.5	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—
AAA5485	54-01004	120.8–121.5	Qbt 1v	—	—	—	—	—	—	—	16013	—	—	—
AAA5487	54-01004	140–140.7	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5482	54-01004	160.3–161	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5539	54-01004	180.8–181.5	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5535	54-01004	200.8–201.5	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5534	54-01004	221.3–222	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5536	54-01004	240.3–241	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5663	54-01004	261–261.7	Qbt 1g	—	—	—	—	—	—	—	16021	—	—	—
AAA5664	54-01004	280.8–281.5	Qct	—	—	—	—	—	—	—	16021	—	—	—
AAA5533	54-01004	300.8–301.5	Qbo	—	—	—	—	—	—	—	16039	—	—	—
AAA5531	54-01004	320.8–321.5	Qbo	—	—	—	—	—	—	—	16039	—	—	—
AAA7958	54-01005	24.3–25	Qbt 2	—	—	—	—	—	—	—	16376	—	—	—
AAA7957	54-01005	38.5–39.2	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7953	54-01005	60.8–61.5	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7950	54-01005	79–80	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7954	54-01005	79–80.2	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7959	54-01005	99.2–100	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7952	54-01005	118.5–119.2	Qbt 1v	—	—	—	—	—	—	—	16416	—	—	—
AAA7966	54-01005	140.5–141.3	Qbt 1g	—	—	—	—	—	—	—	16416	—	—	—
AAA7946	54-01005	159–160	Qbt 1g	—	—	—	—	—	—	—	16416	—	—	—
AAA7949	54-01005	179.3–180	Qbt 1g	—	—	—	—	—	—	—	16416	—	—	—
AAA7956	54-01005	201.8–202.5	Qbt 1g	—	—	—	—	—	—	—	16416	—	—	—
AAA7945	54-01005	221.7–222.5	Qbt 1g	—	—	—	—	—	—	—	16416	—	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAA7955	54-01005	238.7–239.5	Qbt 1g	—	—	—	—	—	—	—	16437	—	—	—
AAA8002	54-01005	259.2–260	Qbt 1g	—	—	—	—	—	—	—	16437	—	—	—
AAA8004	54-01005	278–278.7	Qct	—	—	—	—	—	—	—	16439	—	—	—
AAA5480	54-01006	20.2–21.6	Qbt 2	—	—	—	—	—	—	—	15801	—	—	—
AAA5589	54-01006	181.5–182.2	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5592	54-01006	200.8–201.5	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5591	54-01006	220.8–221.5	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5543	54-01006	240.8–242	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5583	54-01006	241–242	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5584	54-01006	261–261.7	Qbt 1g	—	—	—	—	—	—	—	15875	—	—	—
AAA5585	54-01006	280–281.2	Qbt 1g	—	—	—	—	—	—	—	15895	—	—	—
AAA5538	54-01006	300–300.7	Qct	—	—	—	—	—	—	—	15895	—	—	—
AAA6034	54-01007	5.5–6.5	Qbt 2	16354	16354	—	16344	16344	16344	16344	16344	—	—	—
AAA6035	54-01007	15–16.5	Qbt 2	16354	16354	—	16344	16344	16344	16344	16344	—	—	—
AAA7415	54-01007	31–32	Qbt 2	16354	16354	—	16344	16344	16344	16344	16344	—	—	—
AAA6036	54-01007	35–36	Qbt 2	16354	16354	—	16344	16344	16344	16344	16344	—	—	—
AAA7409	54-01007	49–50	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7408	54-01007	60–62.5	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7424	54-01007	60–62.5	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7420	54-01007	68–69.8	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7421	54-01007	75.5–77	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7446	54-01007	87.8–89	Qbt 1v	16356	16356	—	16346	16346	16346	16346	16346	—	—	—
AAA7450	54-01007	98.5–99.6	Qbt 1v	16388	16388	—	16375	16375	16375	16375	16375	—	—	—
AAA7451	54-01007	106.4–107.5	Qbt 1v	16388	16388	—	16375	16375	16375	16375	16375	—	—	—
AAA7447	54-01007	130.8–132	Qbt 1g	16388	16388	—	16375	16375	16375	16375	16375	—	—	—
AAA7449	54-01007	145.5–146.7	Qbt 1g	16388	16388	—	16375	16375	16375	16375	16375	—	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAA7413	54-01008	5.5–6.3	Qbt 2	16352	16352	—	16324	16324	16324	16324	16324	—	—	—
AAA7400	54-01008	20.5–22	Qbt 2	16352	16352	—	16324	16324	16324	16324	16324	—	—	—
AAA7418	54-01008	25–26.2	Qbt 2	16352	16352	—	16324	16324	16324	16324	16324	—	—	—
AAA7405	54-01008	38–39	Qbt 1v	16352	16352	—	16324	16324	16324	16324	16324	—	—	—
AAA7423	54-01008	45–46.2	Qbt 1v	16352	16352	—	16324	16324	16324	16324	16324	—	—	—
AAA7422	54-01008	55.5–57	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7448	54-01008	66–67	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7414	54-01008	76.5–77.5	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7398	54-01008	85.5–89	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7445	54-01008	107–108	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7419	54-01008	125–126.5	Qbt 1v	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7411	54-01008	146–147	Qbt 1g	16336	16336	—	16325	16325	16325	16325	16325	—	—	—
AAA7406	54-01009	6–7.5	Qbt 2	16360	16360	—	16337	16337	16337	16342	16342	—	16565	16565
AAA7417	54-01009	15.7–17	Qbt 2	16360	16360	—	16337	16337	16337	16359	16342	—	—	—
AAA7410	54-01009	26–27.5	Qbt 2	16360	16360	—	16337	16337	16337	16342	16342	—	—	—
AAA7401	54-01009	38–40	Qbt 1v	16360	16360	—	16337	16337	16337	16359	16342	—	16565	16565
AAA7397	54-01009	45.5–46.8	Qbt 1v	16360	16360	—	16337	16337	16337	16359	16342	—	—	—
AAA7412	54-01009	59–60	Qbt 1v	16360	16360	—	16337	16337	16337	16359	16342	—	16565	16565
AAA7404	54-01009	65–66	Qbt 1v	16360	16360	—	16337	16337	16337	16359	16342	—	16565	16565
AAA7407	54-01009	83.3–84.5	Qbt 1v	16360	16360	—	16337	16337	16337	16342	16342	—	—	—
AAA7402	54-01009	95–100	Qbt 1v	16360	16360	—	16337	16337	16337	16342	16342	—	—	—
AAA7416	54-01009	95–100	Qbt 1v	16360	16360	—	16337	16337	16337	16342	16342	—	—	—
AAA7403	54-01009	115.5–117	Qbt 1v	16360	16360	—	16337	16337	16337	16359	16342	—	16565	16565
AAA7399	54-01009	135–137	Qbt 1g	16360	16360	—	16337	16337	16337	16342	16342	—	—	—
AAB6794	54-01010	8.6–10	Qbt 2	18580	19207	—	—	18356	18356	18356	18356	19207	—	—
AAB6797	54-01010	18.7–20	Qbt 2	18580	19207	—	—	18356	18356	18356	18356	19207	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAB6808	54-01010	18.7–20	Qbt 2	18580	19207	—	—	18356	18356	18356	18356	19207	—	—
AAB6798	54-01010	28.8–30	Qbt 2	18580	19207	—	—	18356	18356	18356	18356	19207	—	—
AAB6802	54-01010	37.5–40	Qbt 2	18580	19207	—	—	18356	18356	18356	18356	19207	—	—
AAB6787	54-01010	48.8–49.5	Qbt 2	18643	18643	19662	—	18326	18326	18326	18326	19662	—	—
AAB6800	54-01010	58.8–59.5	Qbt 1v	18643	18643	19662	—	18326	18326	18326	18326	19662	—	—
AAB6790	54-01011	8.8–9.6	Qbt 2	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6785	54-01011	18.5–19.8	Qbt 2	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6804	54-01011	18.5–19.8	Qbt 2	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6796	54-01011	28.8–29.5	Qbt 2	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6789	54-01011	38.8–40	Qbt 2	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6788	54-01011	49.4–50	Qbt 1v	18300	19183	—	—	18273	18273	18273	18273	19183	—	—
AAB6807	54-01012	9.2–10	Qbt 2	18579	19180	—	—	18309	18309	18309	18309	19180	—	—
AAB6791	54-01012	19.3–20	Qbt 2	18579	19180	—	—	18309	18309	18309	18309	19180	—	—
AAB6780	54-01012	28.8–29.4	Qbt 2	18579	19180	—	—	18309	18309	18309	18309	19180	—	—
AAB6783	54-01012	38.6–39.7	Qbt 2	18579	19180	—	—	18309	18309	18309	18309	19180	—	—
AAB6782	54-01012	48.8–49.7	Qbt 1v	18579	19180	—	—	18309	18309	18309	18309	19180	—	—
AAB6811	54-01013	7–7.5	Qbt 2	—	19974	20168	—	18407	18407	18407	18407	20168	—	—
AAB6809	54-01013	17.5–18	Qbt 2	—	20263	20170	—	18400	18400	18400	18400	20170	—	—
AAB6799	54-01013	27.5–28.5	Qbt 2	—	20263	20170	—	18400	18400	18400	18400	20170	—	—
AAB6810	54-01013	36–37	Qbt 2	—	19028	—	—	18295	18295	18295	18295	19028	—	—
AAB6792	54-01013	48–50	Qbt 1v	—	19028	—	—	18295	18295	18295	18295	19028	—	—
AAB6801	54-01014	6.3–6.5	Qbt 2	18313	18313	20396	—	18311	18311	18311	18311	20396	—	—
AAB6786	54-01014	18.8–19.5	Qbt 2	18313	18313	20396	—	18311	18311	18311	18311	20396	—	—
AAB6784	54-01014	28.6–29.4	Qbt 2	18313	18313	20374	—	18311	18311	18311	18311	20374	—	—
AAB6793	54-01014	41.2–42.1	Qbt 2	18313	18313	20396	—	18311	18311	18311	18311	20396	—	—
AAB6805	54-01014	41.2–42.1	Qbt 2	18313	18313	20396	—	18311	18311	18311	18311	20396	—	—

Table B-8 (continued)

Sample ID	Location ID	Depth (ft)	Media	Cyanide	Metals	Uranium	Herbicides	PCBs	Pesticides	SVOCs	VOCs	Tritium	Isotopic Plutonium	Isotopic Uranium
AAB6781	54-01014	49–50	Qbt 1v	18313	18313	20396	—	18311	18311	18311	18311	20396	—	—
AAC0746	54-01015	262.5–264	Qbo	—	—	—	—	—	—	—	20381	20382	—	—
AAC0731	54-01015	303.5–304.5	Qbo	—	—	—	—	—	—	—	20451	—	—	—
AAC0748	54-01015	347–348	Qbo	—	—	—	—	—	—	—	20474	20475	—	—
AAC0730	54-01015	383.5–384.5	TCB	—	—	—	—	—	—	—	20552	—	—	—
AAC0722	54-01015	423.5–424.5	TCB	—	—	—	—	—	—	—	20658	20660	—	—
AAC0729	54-01015	464.5–465	TCB	—	—	—	—	—	—	—	20703	—	—	—
AAC0721	54-01015	502–503	TCB	—	—	—	—	—	—	—	20772	20773	—	—
AAC0724	54-01015	502–503	TCB	—	—	—	—	—	—	—	20772	20773	—	—
AAC0723	54-01015	514–515	TCB	—	—	—	—	—	—	—	20782	20783	—	—
AAC0725	54-01016	262.5–264	Qbo	—	—	—	—	—	—	—	21306	21307	—	—
AAC0734	54-01016	302.5–303.5	Qbo	—	—	—	—	—	—	—	21294	21299	—	—
AAC0735	54-01016	312–313.5	Qbo	—	—	—	—	—	—	—	21315	21324	—	—
AAC0736	54-01016	320.6–321	TCB	—	—	—	—	—	—	—	21342	21343	—	—
AAC0737	54-01016	322–322.6	TCB	—	—	—	—	—	—	—	21342	21343	—	—
AAC0738	54-01016	361–361.8	TCB	—	—	—	—	—	—	—	21342	21343	—	—
AAC0739	54-01016	402.5–404	TCB	—	—	—	—	—	—	—	21398	21399	—	—
AAC0745	54-01016	443–443.8	TCB	—	—	—	—	—	—	—	21426	21427	—	—
AAC0747	54-01016	483.3–484	TCB	—	—	—	—	—	—	—	21443	21444	—	—
AAC0740	54-01016	524.9–525.7	TCB	—	—	—	—	—	—	—	21458	21459	—	—
AAC0741	54-01016	566.5–567.5	TCB	—	—	—	—	—	—	—	21492	21494	—	—
AAC0770	54-01016	594.1–596.8	TCB	—	—	—	—	—	—	—	21523	21524	—	—
AAC0777	54-01016	594.1–596.8	TCB	—	—	—	—	—	—	—	21523	21524	—	—

Note: Shaded values in cells indicate on-site mobile screening laboratory.

Table B-9
Depths of Pore-Gas Sampling Ports in Boreholes at MDA L

Borehole Number	Sample Port Depth (feet from surface)
54-01015	45, 187, 350, 385, 435, 485, 525
54-01016	36, 188, 318, 390, 481, 533, 601
54-02001	20, 40, 60, 80, 100, 130, 140, 160, 180, 200
54-02002	20, 40, 60, 80, 100, 120, 140, 160, 180, 200
54-02012	7, 27, 42
54-02014	13, 31, 46, 86
54-02015	8, 31, 82
54-02016	7, 8, 31, 82
54-02020	20, 40, 60, 80, 100, 130, 140, 160, 180, 200
54-02021	20, 40, 60, 80, 100, 130, 140, 160, 180, 200
54-02022	20, 40, 60, 80, 100, 120, 140, 160, 180, 197
54-02023	20, 40, 60, 80, 100, 120, 140, 160, 180, 200
54-02024	20, 40, 60, 80, 100, 120, 140, 160, 180, 200
54-02025	20, 60, 100, 160, 190
54-02026	20, 60, 100, 160, 200, 215
54-02027	20, 60, 100, 160, 200, 220, 250
24-02028	20, 60, 100, 160, 200, 220, 250
54-02029	20, 60, 100, 160, 200, 220, 260, 288
54-02030	20, 60, 100, 160, 200, 220, 243
54-02031	20, 60, 100, 160, 200, 220, 260
54-02034	60, 100, 160, 200, 220, 260, 300
54-02087	13, 31, 46, 86
54-02088	13, 31, 46, 86
54-02089	13, 31, 46, 86

Note: The -01000 series boreholes are Phase I RFI characterization boreholes. The -02000 series boreholes are pre-RFI boreholes drilled for pore-gas monitoring.

Table B-10
Frequency of Detected Inorganic Chemicals Above the Background Value in Channel Sediment Samples at MDA L

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
Aluminum	Sediment	4	4	2270 to 3940	15400	0/4	0/4
Antimony	Sediment	4	0	[0.2 to 0.21]	0.83	0/4	0/4
Arsenic	Sediment	4	0	[0.78 to 1.5]	3.98	0/4	0/4
Barium	Sediment	4	3	[37] to 65.7	127	0/4	0/4
Beryllium	Sediment	4	0	[0.25 to 0.51]	1.31	0/4	0/4
Cadmium	Sediment	4	0	[0.4 to 0.67]	0.4	0/4	3/4
Calcium	Sediment	4	4	1130 to 1830	4420	0/4	0/4
Chromium	Sediment	4	4	2 to 4.2	10.5	0/4	0/4
Cobalt	Sediment	4	0	[1.4 to 2.6]	4.73	0/4	0/4
Copper	Sediment	4	0	[3.6 to 4.7]	11.2	0/4	0/4
Iron	Sediment	4	4	3540 to 4870	13800	0/4	0/4
Lead	Sediment	4	4	7.3 to 15.3	19.7	0/4	0/4
Magnesium	Sediment	4	0	[506 to 872]	2370	0/4	0/4
Manganese	Sediment	4	4	138 to 224	543	0/4	0/4
Mercury	Sediment	4	0	[0.02 to 0.02]	0.1	0/4	0/4
Nickel	Sediment	4	0	[2.7 to 3.8]	9.38	0/4	0/4
Potassium	Sediment	4	0	[545 to 805]	2690	0/4	0/4
Selenium	Sediment	4	0	[0.6 to 0.64]	0.3	0/4	4/4
Silver	Sediment	4	0	[2 to 2.1]	1	0/4	4/4
Sodium	Sediment	4	0	[35.6 to 74]	1470	0/4	0/4
Thallium	Sediment	4	0	[0.2 to 0.21]	0.73	0/4	0/4
Vanadium	Sediment	4	0	[4.7 to 7.7]	19.7	0/4	0/4
Zinc	Sediment	4	4	20.7 to 30.3	60.2	0/4	0/4

[a] Values in square brackets indicate detection limits for nondetects.

[b] Sediment BVs obtained from LANL (1998, 59730).

Table B-11
Frequency of Detected Radionuclides
Above the Background Value in Channel Sediment Samples at MDA L

Analyte	Media	Number of Analyses	Number of Detects	Concentration Range[a] (pCi/g)	Background Value[b] (pCi/g)	Frequency of Detects Above Background Value
Americium-241	Sediment	4	4	0.004 to 0.009	0.04	0/4
Cesium-137	Sediment	4	2	[0.09] to 0.38	0.9	0/4
Cobalt-60	Sediment	4	0	[0.02 to 0.09]	na[c]	0/4
Plutonium-238	Sediment	4	4	0.003 to 0.011	0.006	1/4
Plutonium-239	Sediment	4	4	0.01 to 0.017	0.068	0/4
Strontium-90	Sediment	4	4	-0.04 to 0.12	1.04	0/4
Technitium-99	Sediment	4	0	[0.2] to [0.2]	na	0/4
Thorium-228	Sediment	4	4	1.26 to 1.92	2.28	0/4
Thorium-230	Sediment	4	4	1.12 to 1.69	2.29	0/4
Thorium-232	Sediment	4	4	1.28 to 1.84	2.33	0/4
Tritium	Sediment	4	4	6.84E-03 to 3.30E-02	0.093	0/4
Uranium-234	Sediment	4	4	1.12 to 1.81	2.59	0/4
Uranium-235	Sediment	4	4	0.07 to 0.1	0.2	0/4
Uranium-238	Sediment	4	4	1.37 to 2.03	2.29	0/4

[a] Values in square brackets indicate detection limits for nondetects.

[b] Sediment background and fallout values obtained from LANL (1998, 59730).

[c] na = Not available.

Table B-12
Frequency of Inorganic Chemicals Detected Above BV in Subsurface Core Samples at MDA L

Analyte	Geologic Unit	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Background Value (mg/kg)	Frequency of Detects Above Background Value	Frequency of Nondetects Above Background Value
Aluminum	Qbt 2	34	34	130 to 10000	7340	1/34	0/34
Aluminum	Qbt 1g	4	4	563 to 1200	3560	0/4	0/4
Aluminum	Qbt 1v	29	29	270 to 4700	8170	0/29	0/29
Antimony	Qbt 2	34	1	[0.1 to 4.5]	0.5	0/34	1/34
Antimony	Qbt 1g	4	0	[0.2 to 0.3]	0.5	0/4	0/4
Antimony	Qbt 1v	29	0	[0.12 to 0.3]	0.5	0/29	0/29
Arsenic	Qbt 2	34	9	[0.2 to 1.6]	2.79	0/34	0/34
Arsenic	Qbt 1g	4	1	[0.2 to 1.5]	0.56	0/4	2/4
Arsenic	Qbt 1v	29	13	[0.2] to 1.7	1.81	0/29	0/29
Barium	Qbt 2	34	11	3.5 to 138	46	3/34	0/34
Barium	Qbt 1g	4	2	[16.4] to 44	25.7	1/4	0/4
Barium	Qbt 1v	29	21	[3.4] to 44	26.5	8/29	029
Beryllium	Qbt 2	34	7	[0.08] to 1.5	1.21	1/34	0/34
Beryllium	Qbt 1g	4	2	[0.42] to 1.6	1.44	1/4	0/4
Beryllium	Qbt 1v	29	18	[0.22] to 3.3	1.7	1/29	0/29
Boron	Qbt 2	27	1	[1.7 to 6.8]	na[b]	1/27	na
Boron	Qbt 1g	3	0	[3 to 4.1]	na	0/3	na
Boron	Qbt 1v	20	0	[1.7 to 3.9]	na	0/20	na
Cadmium	Qbt 2	34	2	[0.04] to 1.4	1.63	0/34	0/34
Cadmium	Qbt 1g	4	0	[0.3 to 0.64]	0.4	0/4	2/4
Cadmium	Qbt 1v	29	1	[0.27] to 1.7	0.4	1/29	4/29
Calcium	Qbt 2	34	9	[203] to 79000	2200	1/34	3/34
Calcium	Qbt 1g	4	1	[784 to 3100]	1900	0/4	1/4
Calcium	Qbt 1v	29	16	[565 to 3100]	3700	0/29	0/29
Chromium	Qbt 2	34	24	[0.5] to 57.8	7.14	4/34	0/34
Chromium	Qbt 1g	4	3	0.4 to 4.3	2.6	1/4	0/4
Chromium	Qbt 1v	29	27	0.6 to 4.8	2.24	14/29	0/29
Cobalt	Qbt 2	34	10	[0.51 to 3.9]	3.14	1/34	1/34
Cobalt	Qbt 1g	4	2	0.7 to 2.4	8.89	0/4	0/4
Cobalt	Qbt 1v	29	20	[0.5] to 6.1	1.78	4/29	2/29
Copper	Qbt 2	34	16	[0.63] to 370	4.66	15/34	0/34
Copper	Qbt 1g	4	4	17.3 to 180	3.96	4/4	0/4
Copper	Qbt 1v	29	24	[0.64] to 190	3.26	21/29	1/29
Cyanide (total)	Qbt 2	30	1	[0.00005] to 0.96	0.5	1/30	na

Table B-12 (continued)

Analyte	Geologic Unit	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Background Value (mg/kg)	Frequency of Detects Above Background Value	Frequency of Nondetects Above Background Value
Cyanide (Total)	Qbt 1g	4	0	[0.00005 to 0.21]	0.5	0/4	na
Cyanide (Total)	Qbt 1v	28	0	[0.00005 to 0.34]	0.5	0/28	na
Iron	Qbt 2	34	34	1020 to 10000	14500	0/34	0/34
Iron	Qbt 1g	4	4	1450 to 5000	3700	1/4	0/4
Iron	Qbt 1v	29	29	2550 to 9700	9900	0/29	0/29
Lead	Qbt 2	34	30	1.2 to 13	11.2	1/34	0/34
Lead	Qbt 1g	4	3	3 to 7.1	13.5	0/4	0/4
Lead	Qbt 1v	29	27	3.5 to 20	18.4	1/29	0/29
Magnesium	Qbt 2	33	9	52 to 1300	1690	0/33	0/33
Magnesium	Qbt 1g	4	2	[59 to 309]	739	0/4	0/4
Magnesium	Qbt 1v	28	21	[48.5] to 730	780	0/28	0/28
Manganese	Qbt 2	34	34	79 to 770	482	1/34	0/34
Manganese	Qbt 1g	4	4	149 to 210	189	1/4	0/4
Manganese	Qbt 1v	29	29	156 to 460	408	4/29	0/29
Mercury	Qbt 2	30	2	[0.02] to 0.16	0.1	2/30	0/230
Mercury	Qbt 1g	4	0	[0.02 to 0.1]	0.1	0/4	0/4
Mercury	Qbt 1v	28	0	[0.02 to 0.1]	0.1	0/28	0/28
Molybdenum	Qbt 2	30	3	0.3 to [5.9]	na	3/30	na
Molybdenum	Qbt 1g	4	1	0.7 to [6.2]	na	1/4	na
Molybdenum	Qbt 1v	28	9	0.3 to [5.9]	na	9/28	na
Nickel	Qbt 2	34	7	[1.3] to 17.3	6.58	3/34	0/34
Nickel	Qbt 1g	4	1	[2] to 2.6	2	1/4	2/4
Nickel	Qbt 1v	29	7	[1.3] to 22.4	2	7/29	4/29
Potassium	Qbt 2	34	10	120 to 1000	3500	0/34	0/34
Potassium	Qbt 1g	4	2	[220 to 777]	2390	0/4	0/4
Potassium	Qbt 1v	29	22	140 to [754]	6670	0/29	0/29
Selenium	Qbt 2	24	3	[0.2] to 1	0.3	1/24	14/24
Selenium	Qbt 1g	4	0	[0.2 to 0.43]	0.3	0/4	2/4
Selenium	Qbt 1v	26	1	[0.2 to 0.67]	0.3	0/26	4/26
Silver	Qbt 2	34	0	[0.06 to 2.2]	1	0/34	1/34
Silver	Qbt 1g	4	0	[0.3 to 1.1]	1	0/4	1/4
Silver	Qbt 1v	29	0	[0.3 to 2.2]	1	0/29	1/29
Sodium	Qbt 2	34	13	[135] to 2100	2770	0/34	0/34
Sodium	Qbt 1g	4	2	[256] to 720	4350	0/4	0/4
Sodium	Qbt 1v	29	23	150 to 1090	6330	0/29	0/29
Thallium	Qbt 2	34	1	[0.1 to 0.62]	1.1	0/34	0/34

Table B-12 (continued)

Analyte	Geologic Unit	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Background Value (mg/kg)	Frequency of Detects Above Background Value	Frequency of Nondetects Above Background Value
Thallium	Qbt 1g	4	0	[0.2 to 0.3]	1.22	0/4	0/4
Thallium	Qbt 1v	29	0	[0.12 to 0.4]	1.24	0/29	0/29
Uranium	Qbt 2	24	24	0.601 to 9.54	2.4	12/24	0/24
Uranium	Qbt 1v	5	5	0.628 to 5.9	6.22	0/5	0/5
Vanadium	Qbt 2	34	9	[0.8] to 9.5	17	0/34	0/34
Vanadium	Qbt 1g	4	2	0.7 to 1.7	4.59	0/4	0/4
Vanadium	Qbt 1v	29	21	0.8 to 4.5	4.48	1/29	0/29
Zinc	Qbt 2	34	34	12 to 240	63.5	4/34	0/34
Zinc	Qbt 1g	4	4	34.3 to 140	40	3/4	0/4
Zinc	Qbt 1v	29	29	23.7 to 160	84.6	7/29	0/29

[a] Values in square brackets indicate detection limits for nondetects.

[b] na = Not available.

Table B-13
Frequency of Detected Radionuclides Above BV or Detects (for Fallout Radionuclides) in Subsurface Samples at MDA L

Analyte	Geologic Unit	Number of Analyses	Number of Detects	Concentration Range (pCi/g)[a]	Background Value (pCi/g)	Frequency of Detects Above Background Value
Plutonium-238	Qbt 2	1	0	[0.003 to 0.003]	n/a[b]	0/1
Plutonium-238	Qbt 1v	4	0	[0 to 0.004]	n/a	0/4
Plutonium-239	Qbt 2	1	0	[0.001 to 0.001]	n/a	0/1
Plutonium-239	Qbt 1v	4	0	[-0.001 to 0.005]	n/a	0/4
Tritium	Qbt 2	24	16	[-1.95E-02] to 11.63	n/a	16/24
Tritium	Qbo	5	0	[-5.50E-02 to 3.91E-02]	n/a	0/5
Tritium	Qbt 1v	5	4	5.30E-02 to 0.34	n/a	4/5
Tritium	TCB[c]	14	2	[-9.9E-04] to 0.13	n/a	2/14
Uranium-234	Qbt 2	1	1	1.617 to 1.617	1.98	0/1
Uranium-234	Qbt 1v	4	4	1.953 to 2.479	3.12	0/4
Uranium-235	Qbt 2	1	0	[0.084 to 0.084]	0.09	0/1
Uranium-235	Qbt 1v	4	0	[0.075 to 0.144]	0.14	0/4
Uranium-238	Qbt 2	1	1	1.733 to 1.733	1.93	0/1
Uranium-238	Qbt 1v	4	4	2.24 to 2.777	3.05	0/4

[a] Values in brackets indicate detection limits for nondetects

[b] n/a = Not applicable.

[c] TCB = Tertiary Cerros del Rio basalts.

Table B-14
Summary of Tritium Concentrations in Subsurface Samples at MDA L

Sample ID	Location ID	Depth (ft)	Geologic Unit	Concentration (pCi/g)
AAB6794	54-01010	8.60–10.00	Qbt 2	0.16
AAB6797	54-01010	18.70–20.00	Qbt 2	0.17
AAB6808	54-01010	18.70–20.00	Qbt 2	0.33
AAB6798	54-01010	28.80–30.00	Qbt 2	11.63
AAB6802	54-01010	37.50–40.00	Qbt 2	0.71
AAB6787	54-01010	48.80–49.50	Qbt 2	0.14
AAB6800	54-01010	58.80–59.50	Qbt 1v	0.34
AAB6790	54-01011	8.80–9.60	Qbt 2	0.03
AAB6785	54-01011	18.50–19.80	Qbt 2	0.08
AAB6796	54-01011	28.80–29.50	Qbt 2	0.70
AAB6789	54-01011	38.80–40.00	Qbt 2	0.33
AAB6788	54-01011	49.40–50.00	Qbt 1v	0.32
AAB6809	54-01013	17.50–18.00	Qbt 2	0.09
AAB6799	54-01013	27.50–28.50	Qbt 2	0.12
AAB6810	54-01013	36.00–37.00	Qbt 2	0.09
AAB6792	54-01013	48.00–50.00	Qbt 1v	0.14
AAB6784	54-01014	28.60–29.40	Qbt 2	0.09
AAB6793	54-01014	41.20–42.10	Qbt 2	0.06
AAB6805	54-01014	41.20–42.10	Qbt 2	0.04
AAB6781	54-01014	49.00–50.00	Qbt 1v	0.05
AAC0721	54-01015	502–503	TCB*	0.13
AAC0777	54-01016	594.1–596.8	TCB	0.001

*TCB = Tertiary Cerros del Rio basalts.

Table B-15
Frequency of Detected Organic Chemicals in the Subsurface Samples at MDA L

Analyte	Geologic Unit	Number of Analyses	Number of Detects	Concentration Range[a] (mg/kg)	EQL[b] (mg/kg)	Frequency of Detects
Acetone	Qbt 2	31	7	[0.01] to 2.1	0.06	7/31
Acetone	Qbo	6	1	[0.022 to 0.043]	0.06	1/6
Acetone	Qbt 1v	21	6	[0.01] to 0.7	0.06	6/21
Aroclor-1260	Qbt 2	34	1	[0.013] to 0.313	0.033	1/34
Bis(2-ethylhexyl)phthalate	Qbt 2	31	1	[0.14] to 0.8	0.59	1/31
Butanone[2-]	Qbt 2	31	4	[0.01] to 4.8	0.027	4/31
Butanone[2-]	Qbt 1v	21	5	[0.01] to 0.88	0.027	5/21
DDD[4,4'-]	Qbt 2	34	2	[0.00067] to 0.0114	0.004	2/34
Dichloroethane[1,2-]	Qbt 2	31	3	[0.005] to 0.02	0.006	3/31
Dichloropropane[1,2-]	Qbt 2	31	1	[0.005] to 0.01	0.006	1/31
Methoxychlor[4,4'-]	Sediment	4	2	[0.0171] to 0.063	0.022	2/4
Methoxychlor[4,4'-]	Qbt 1v	29	1	[0.00067] to 0.076	0.027	1/29
Methyl-2-pentanone[4-]	Qbt 1v	21	2	[0.01 to 0.022]	0.027	2/21
Methylene chloride	Qbt 2	31	3	[0.005] to 0.014	0.028	3/31
Pentachlorophenol	Qbt 2	31	2	[0.83] to 13	1.2	2/31
Tetrachloroethene	Qbt 2	31	1	[0.005] to 0.009	0.007	1/31
Trichloroethane[1,1,1-]	Qbt 2	31	2	[0.005] to 0.015	0.006	2/31
Trichloroethene	Qbt 2	31	3	[0.005] to 0.008	0.006	3/31

[a] Values in square brackets indicate detection limits for nondetects.

[b] EQL is the maximum EQL reported for the organic chemical.

Table B-16
Frequency of VOCs Detected in Pore Gas at MDA L
Second Quarter FY 1997 through First Quarter 2002

Analyte	Media Type	Number of Analyses	Number of Detects	Concentration[a] (ppbv)	EQL (ppbv)	Frequency of Detects
Acetone	Pore gas	197	34	0.5–[1100000]	5	34/197
Acetonitrile	Pore gas	153	3	1.8–[210000]	1	3/153
Acetophenone	Pore gas	74	1	[5]–[10000]	0.2	1/74
Acrolein	Pore gas	153	0	[1.2]–[110000]	0.5	0/153
Acrylonitrile	Pore gas	153	2	[1.2]–[110000]	0.5	2/153
Benzene	Pore gas	206	72	0.13–[42000]	0.2	72/206
Benzonitrile	Pore gas	74	5	1.2–[10000]	0.5	5/74
Benzyl chloride	Pore gas	170	0	[0.47]–[42000]	0.2	0/170
Bromodichloromethane	Pore gas	196	1	[0.47]–[42000]	0.2	1/196
Bromoform	Pore gas	197	7	[0.47]–[42000]	0.2	7/197
Bromomethane	Pore gas	206	8	[0.47]–[42000]	0.5	8/206

Table B-16 (continued)

Analyte	Media Type	Number of Analyses	Number of Detects	Concentration[a] (ppbv)	EQL (ppbv)	Frequency of Detects
Butadiene[1,3-]	Pore gas	196	2	[0.47]–[42000]	0.2	2/196
Butane[n-]	Pore gas	153	65	[0.48]–[42000]	0.2	65/153
Butanol[1-]	Pore gas	197	3	[1.2]–[110000]	0.5	3/197
Butanone[2-]	Pore gas	197	1	[1.2]–[110000]	0.5	1/197
Butene[1-]	Pore gas	74	39	[1.6]–2950	0.2	39/74
Butene[cis-2-]	Pore gas	74	37	[0.19]–8550	0.2	37/74
Butene[trans-2-]	Pore gas	74	28	[0.15]–[1000]	0.2	28/74
Carbon disulfide	Pore gas	197	6	[0.12]–[42000]	0.2	6/197
Carbon Tetrachloride	Pore gas	206	115	0.47–[42000]	0.2	115/206
Chloro-1,3-butadiene[2-]	Pore gas	73	2	[0.5]–[1000]	0.2	2/73
Chloro-1-propene[3-]	Pore gas	152	0	[0.47]–[42000]	0.2	0/152
Chlorobenzene	Pore gas	207	49	0.04–[42000]	0.2	49/207
Chlorodibromomethane	Pore gas	196	3	0.4–[42000]	0.2	3/196
Chlorodifluoromethane	Pore gas	189	31	[0.47]–[42000]	0.2	31/189
Chloroethane	Pore gas	206	36	[0.47]–[42000]	0.5	36/206
Chloroform	Pore gas	206	153	[0.26]–46700	0.2	153/206
Chloromethane	Pore gas	206	16	[0.82]–[110000]	0.5	16/206
Cyclohexane	Pore gas	197	66	0.44–[73000]	0.5	66/197
Cyclohexanone	Pore gas	74	1	[5]–[10000]	0.2	1/74
Cyclopentane	Pore gas	74	46	0.12–1340	0.2	46/74
Cyclopentene	Pore gas	74	13	0.2–[1000]	0.2	13/74
Decane[n-]	Pore gas	78	0	[0.47]–[42000]	na[b]	0/78
Dibromoethane[1,2-]	Pore gas	169	11	[0.47]–[42000]	0.2	11/169
Dibromomethane	Pore gas	79	0	[0.47]–[42000]	na	0/79
Dichloro-1,1,2,2-tetrafluoroethane[1,2-]	Pore gas	169	3	[0.47]–[42000]	0.2	3/169
Dichlorobenzene[1,2-]	Pore gas	207	2	0.2–[42000]	0.2	2/207
Dichlorobenzene[1,3-]	Pore gas	207	0	[0.47]–[42000]	0.2	0/207
Dichlorobenzene[1,4-]	Pore gas	207	22	[0.2]–[42000]	0.2	22/207
Dichlorodifluoromethane	Pore gas	169	117	[2.4]–[42000]	0.2	117/169
Dichloroethane[1,1-]	Pore gas	205	171	0.81–287000	0.2	171/205
Dichloroethane[1,2-]	Pore gas	206	99	0.22–240000	0.2	99/206
Dichloroethene[1,1-]	Pore gas	206	195	3.4–49000	0.2	195/206
Dichloroethene[cis-1,2-]	Pore gas	206	24	[0.47]–[42000]	0.2	24/206
Dichloroethene[trans-1,2-]	Pore gas	195	27	[0.47]–[42000]	0.2	27/195
Dichloropropane[1,2-]	Pore gas	206	91	[0.47]–144000	0.2	91/206
Dichloropropene[cis-1,3-]	Pore gas	206	2	[0.47]–[42000]	0.2	2/206
Dichloropropene[trans-1,3-]	Pore gas	205	1	[0.47]–[42000]	0.2	1/205

Table B-16 (continued)

Analyte	Media Type	Number of Analyses	Number of Detects	Concentration[a] (ppbv)	EQL (ppbv)	Frequency of Detects
Diethyl Ether	Pore gas	153	26	[1.2]–[110000]	0.5	26/153
Dimethylbutane[2,2-]	Pore gas	74	40	[0.12]–[1000]	0.2	40/74
Dimethylbutane[2,3-]	Pore gas	74	32	[0.5]–2370	0.2	32/74
Dimethylpentane[2,3-]	Pore gas	69	33	[0.14]–1888	0.2	33/69
Dioxane[1,4-]	Pore gas	118	2	[3.3]–[35000]	1	2/118
Dodecane[n-]	Pore gas	79	0	[0.47]–[42000]	na	0/79
Ethanol	Pore gas	118	10	1.8–58000	0.5	10/118
Ethyl acrylate	Pore gas	74	1	4–[10000]	0.2	1/74
Ethyl tert-butyl ether	Pore gas	74	3	0.8–[10000]	0.2	3/74
Ethylbenzene	Pore gas	207	27	0.22–[42000]	0.2	27/207
Ethyltoluene[4-]	Pore gas	7	0	[8.6]–[8600]	na	0/7
Hexachlorobutadiene	Pore gas	207	5	[0.05]–[42000]	0.2	5/207
Hexane	Pore gas	196	59	0.1–[42000]	0.2	59/196
Hexanone[2-]	Pore gas	197	2	[1.2]–[110000]	0.5	2/197
Hexene[cis-3-]	Pore gas	74	7	[0.5]–[1000]	0.2	7/74
Hexene[trans-2-]	Pore gas	74	6	[0.5]–[1000]	0.2	6/74
Isobutane	Pore gas	74	56	1.13–3290	0.2	56/74
Isooctane	Pore gas	74	51	0.02–2230	0.2	51/74
Isopentane	Pore gas	73	55	0.4–1010	0.2	55/73
Isoprene	Pore gas	74	12	[0.5]–[1000]	0.2	12/74
Isopropylbenzene	Pore gas	153	9	[0.47]–[42000]	0.2	9/153
Methacrylonitrile	Pore gas	74	0	[5]–[10000]	0.5	0/74
Methanol	Pore gas	197	22	[2.4]–[2100000]	10	22/197
Methyl methacrylate	Pore gas	74	4	0.05–[10000]	0.2	4/74
Methyl tert-butyl ether	Pore gas	197	4	[1.2]–[110000]	0.2	4/197
Methyl-1-butene[3-]	Pore gas	74	22	0.2–[1000]	0.2	22/74
Methyl-1-pentene[2-]	Pore gas	74	13	[0.5]–[1000]	0.2	13/74
Methyl-1-pentene[4-]	Pore gas	74	14	[0.5]–[1000]	0.2	14/74
Methyl-2-butene[2-]	Pore gas	74	29	0.05–[1000]	0.2	29/74
Methyl-2-pentanone[4-]	Pore gas	197	7	[1.2]–[110000]	0.5	7/197
Methylcyclohexane	Pore gas	74	56	0.2–3530	0.2	56/74
Methylcyclopentane	Pore gas	74	65	[0.22]–3180	0.2	65/74
Methylene chloride	Pore gas	206	174	0.31–660000	0.2	174/206
Methylheptane[2-]	Pore gas	74	18	[0.02]–[1000]	0.2	18/74
Methylheptane[3-]	Pore gas	74	17	[0.01]–[1000]	0.2	17/74
Methylhexane[2-]	Pore gas	72	18	[0.01]–[1000]	0.2	18/72
Methylhexane[3-]	Pore gas	74	41	[0.13]–3980	0.2	41/74
Methylpentane[2-]	Pore gas	74	53	[0.17]–2330	0.2	53/74

Table B-16 (continued)

Analyte	Media Type	Number of Analyses	Number of Detects	Concentration[a] (ppbv)	EQL (ppbv)	Frequency of Detects
Methylpentane[3-]	Pore gas	73	57	0.2–2360	0.2	57/73
Methylstyrene[alpha-]	Pore gas	153	2	0.3–[42000]	0.2	2/153
Naphthalene	Pore gas	79	1	[0.47]–[42000]	na	1/79
n-Heptane	Pore gas	195	27	[0.47]–[42000]	na	27/195
Nitrobenzene	Pore gas	74	1	[5]–[10000]	0.2	1/74
Nitropropane[2-]	Pore gas	74	2	0.8–[10000]	0.2	2/74
Nonane[1-]	Pore gas	153	14	[0.3]–[42000]	0.2	14/153
Octane[n-]	Pore gas	153	17	[0.47]–[42000]	0.2	17/153
Pentane	Pore gas	152	61	[0.68]–[110000]	0.5	61/152
Pentene[1-]	Pore gas	74	18	[0.08]–[1000]	0.2	18/74
Pentene[cis-2-]	Pore gas	74	16	0.2–[1000]	0.2	16/74
Pentene[trans-2-]	Pore gas	74	15	0.3–[1000]	0.2	15/74
Pinene[alpha-]	Pore gas	74	9	[0.5]–[1000]	0.2	9/74
Pinene[beta-]	Pore gas	74	7	[0.5]–[1000]	0.2	7/74
Propanol[2-]	Pore gas	118	9	0.6–48000	0.5	9/118
Propionitrile	Pore gas	74	0	[5]–[10000]	0.5	0/74
Propylbenzene[1-]	Pore gas	153	7	0.4–[42000]	0.2	7/153
Propylene	Pore gas	117	45	[1.51]–[35000]	0.2	45/117
Styrene	Pore gas	207	6	[0.47]–[42000]	0.2	6/207
Tetrachloroethane[1,1,2,2-]	Pore gas	207	9	[0.47]–[42000]	0.2	9/207
Tetrachloroethene (PCE)	Pore gas	207	193	0.95–1130000	0.2	193/207
Tetrahydrofuran	Pore gas	118	15	[3.3]–36600	0.2	15/118
Toluene	Pore gas	206	73	0.41–[42000]	0.2	73/206
Trichloro-1,2,2-trifluoroethane[1,1,2-] (Freon 113)	Pore gas	206	201	1.5–400000	0.2	201/206
Trichlorobenzene[1,2,4-]	Pore gas	207	7	[0.47]–[42000]	0.2	7/207
Trichloroethane[1,1,1-] (TCA)	Pore gas	206	204	7.2–6970000	0.2	204/206
Trichloroethane[1,1,2-]	Pore gas	206	28	[0.47]–[42000]	0.2	28/206
Trichloroethene (TCE)	Pore gas	206	205	2.4–2600000	0.2	205/206
Trichlorofluoromethane	Pore gas	169	147	2–81000	0.2	147/169
Trimethylbenzene[1,2,4-]	Pore gas	207	16	[0.04]–[42000]	0.2	16/207
Trimethylbenzene[1,3,5-]	Pore gas	207	7	[0.47]–[42000]	0.2	7/207
Trimethylpentane[2,3,4-]	Pore gas	74	17	0.4–[1000]	0.2	17/74
Undecane[n-]	Pore gas	79	1	[0.47]–[42000]	na	1/79
Vinyl acetate	Pore gas	197	5	[1.2]–[110000]	0.5	5/197
Vinyl chloride	Pore gas	205	38	0.08–[42000]	0.2	38/205
Xylene (total)	Pore gas	85	6	[0.49]–[42000]	na	6/85
Xylene[1,2-]	Pore gas	207	38	0.3–[42000]	0.2	38/207

Table B-16 (continued)

Analyte	Media Type	Number of Analyses	Number of Detects	Concentration[a] (ppbv)	EQL (ppbv)	Frequency of Detects
Xylene[1,3-]	Pore gas	74	26	0.4–4470	0.2	26/74
Xylene[1,3-]+xylene[1,4-]	Pore gas	48	3	[0.47]–[27000]	na	3/48

[a] Values in square brackets indicate detection limits for nondetects.

[b] na = Not available.

Table B-17
Maximum Pore-Gas Concentrations in the Fourth Quarter of FY 1999 (EPA Method TO-14) at MDA L

Compound[a]	Well Number	Port Depth (ft)	Maximum Concentration (ppmv)[b]
1,1,1-Trichloroethane (TCA)	54-02012	28	2600
Trichloroethene (TCE)	54-02012	28	2100
Methylene Chloride	54-02012	28	190
Trichloro-1,2,2-trifluoroethane[1,1,2-] (Freon 113)	54-02089	31	160
Tetrachloroethene (PCE)	54-02012	28	120
Dichloroethane[1,1-]	54-02012	28	82
Trichlorofluoromethane (Freon 11)	54-02002	180	36
Chloroform	54-02002	180	14
Toluene	54-02002	180	9.9
Dichlorodifluoromethane	54-02034	160	0.044

[a] Listed in order of decreasing concentration.

[b] ppmv = Parts per million by volume.

Table B-18
Maximum Pore-Gas Concentrations in the First Quarter of FY 2002 (EPA Method TO-14) at MDA L

Compound[a]	Well Number	Port Depth (ft)	Maximum Concentration (ppmv)[b]
1,1,1-Trichloroethane (TCA)	54-02002	100	390
Trichloroethene (TCE)	54-02002	100	78
Ethanol	54-02002	100	58
Trichloro-1,2,2-trifluoroethane(Freon 113)	54-02002	100	49
Methanol	54-02009	62	35
Methylene chloride	54-02002	100	23
Trichlorofluoromethane (Freon 11)	54-02002	100	18
1,2-Dichloropropane	54-02002	100	16
2-Propanol	54-02002	100	16
Tetrahydrofuran	54-02002	100	13
Chloroform	54-02002	100	9.4
Carbon tetrachloride	54-02030	100	8.9
Tetrachloroethene (PCE)	54-02002	100	7.4
1,1-Dichloroethane	54-02002	100	6.8
Toluene	54-02002	100	5.6
m,p-Xylene	54-02002	100	2.3
Dichlorodifluoromethane	54-02021	100	0.35
Tetrachloroethene (PCE)	54-02023	153	0.26
Benzene	54-01015	385	0.003

[a] Listed in order of decreasing concentration.

[b] ppmv = parts per million by volume.

Table B-19
Air Concentrations of Selected VOCs at MDA L, Location 4

VOC	Ambient Concentration (ppbv)							
	6/16/94	6/17/94	6/29/94	6/30/94	7/28/94	8/01/94	8/02/94	8/03/94
Chlorodifluoromethane	0.6	0.2	0.3	0.6	ND*	ND	ND	ND
Chloromethane	0.3	0.3	ND	0.6	ND	0.3	ND	ND
Dichlorodifluoromethane	0.4	0.4	0.4	0.4	0.3	0.4	0.06	0.07
n-hexane	ND	ND	ND	ND	0.2	0.3	0.3	0.5
Trichlorofluoromethane	0.2	0.2	0.1	0.1	0.1	0.2	0.05	0.03
Freon 113	0.04	0.05	0.03	0.06	ND	0.06	ND	ND
TCA	0.7	0.4	0.9	0.4	1.0	0.7	0.5	0.4
Benzene	0.2	0.1	0.2	0.2	0.2	0.4	0.4	0.6
Carbon tetrachloride	0.1	0.06	0.06	ND	0.06	0.07	0.05	0.08
Trichloroethene	ND	0.1	0.06	ND	0.3	0.1	0.07	ND
Toluene	0.2	0.1	0.2	0.2	0.4	1.0	0.8	0.9

*ND = Not detected.

Table B-20
Air Concentrations of Selected VOCs at MDA L, Location 5

VOC	Ambient Concentration (ppbv)							
	6/16/94	6/17/94	6/29/94	6/30/94	7/28/94	8/01/94	8/02/94	8/03/94
Chloromethane	0.3	0.3	ND*	0.7	ND	0.7	ND	0.2
Dichlorodifluoromethane	0.5	0.3	0.3	0.4	0.2	0.4	0.06	0.4
Trichlorofluoromethane	0.2	0.2	0.2	0.2	0.09	0.3	0.08	0.2
Methylene chloride	1.6	0.4	1.3	1.2	0.6	1.0	1.7	0.9
Freon 113	0.2	0.1	0.1	0.3	0.07	0.4	0.2	ND
TCA	15.2	6.0	8.6	4.0	0.6	1.0	0.8	2.4
Benzene	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2
Carbon tetrachloride	ND	0.1	ND	0.05	0.05	0.1	ND	0.07
Trichloroethene	ND	0.2	0.1	0.03	0.1	ND	0.06	0.1
Toluene	0.3	0.2	0.3	0.6	0.3	0.2	0.3	0.2
Xylene	ND	ND	0.1	0.2	0.2	0.09	0.1	ND

*ND = Not detected.

Table B-21
Air Concentrations of Selected VOCs at Bandelier National Monument, Location 3 (Background)

VOC	Background Ambient Concentration (ppbv)							
	6/16/94	6/17/94	6/29/94	6/30/94	7/28/94	8/01/94	8/02/94	8/03/94
Chlorodifluoromethane	ND*	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	0.4	ND	0.6	ND	ND	ND	ND
Dichlorodifluoromethane	0.3	0.3	0.3	0.4	0.2	0.3	ND	ND
n-hexane	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.1	0.1	0.1	0.05	0.07	0.09	0.03	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	ND	ND	ND	0.04	ND	ND	0.03	ND
TCA	0.1	0.1	0.08	ND	0.04	0.03	ND	ND
Benzene	ND	0.2	ND	0.02	ND	0.1	0.1	0.2
Carbon tetrachloride	ND	0.05	0.04	ND	0.04	0.03	ND	ND
Trichloroethene	ND	0.05	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	0.1	ND	0.1	0.1	0.2	0.1
Xylene	ND	ND	ND	ND	ND	0.1	ND	ND

*ND = not detected.

Table B-22
Summary of Data Review Results

Analyte	Medium	COPC?	Rationale	Appendix D Table
Inorganic chemicals (except cadmium, selenium, and silver)	Sediment	No	Inorganic chemical data were either less than the BVs or not different from background data sets	D-2.0-1
Cadmium	Sediment	Yes	Elevated DLs > BV	
Selenium	Sediment	Yes	Elevated DLs > BV	
Silver	Sediment	Yes	Elevated DLs > BV	
Inorganic chemicals (except for barium, cobalt, copper, chromium, manganese, nickel, uranium, and zinc)	Tuff	No	Inorganic chemical data were either less than the BVs or not different from background data sets	D-2.0-5
Barium	Tuff	Yes	Detected above BV in 11 samples	
Cobalt	Tuff	Yes	Detected above BV in 5 samples	
Copper	Tuff	Yes	Detected above BV in 40 samples	
Chromium	Tuff	Yes	Detected above BV in 19 samples	
Manganese	Tuff	Yes	Detected above BV in 6 samples	
Nickel	Tuff	Yes	Detected above BV in 11 samples	
Uranium	Tuff	Yes	Detected above BV in 12 samples	
Zinc	Tuff	Yes	Detected above BV in 14 samples	
Radionuclides (except tritium and plutonium)	Sediment, ambient air, pore gas, tuff	No	Radiological data were either less than the BVs or not detected	D-2.02, D-2.0-4, D-2.0-6
Tritium	Ambient air, tuff	Yes	Tritium was detected in these media	
	Sediment	No	Not detected above sediment BV	
Plutonium-238	Sediment	Yes	Detected above sediment BV in one sample	
Organic chemicals				D-2.0-4
VOCs	Tuff	Yes	Detected in the media	
	Ambient air	Yes	Detected in the media	
	Pore gas	Yes	Detected in the media	
SVOCs	Air/pore gas			D-2.0-7
	Tuff	No	Detected but extent defined	
Pesticides				D-2.0-3
Methoxychlor	Tuff	No	Detected but extent defined	
	Sediment	Yes	Detected in 3 sediment samples	
DDD	Tuff	No	Detected but extent defined	
PCBs				D-2.0-3
Aroclor-1260	Tuff	No	Detected but extent defined	

Appendix C

Quality Assurance/Quality Control Process

APPENDIX C QUALITY ASSURANCE/QUALITY CONTROL PROCESS

The data evaluation and qualification for the samples taken at Material Disposal Area (MDA) L are discussed below. Only samples qualified for various reasons are mentioned for inorganics, organics and radionuclides.

For inorganics, 68 samples were qualified. Forty-five samples were qualified as estimated (J/UJ) for the following reasons. All of the samples are usable for data assessment. In ten samples, the recoveries in the matrix spike were low. In 24 samples, recoveries for the internal analytical laboratory control samples (LCS) were low. In 6 samples the recoveries for silver were high in the LCS sample and for 5 samples the recoveries for copper in the matrix spike were high.

Twenty-three samples were qualified as rejected (R) and are not usable in risk assessment for the following reasons. Nine samples analyzed for selenium were rejected because the quality control (QC) sample results were high (>200%). Five samples for arsenic and selenium were rejected because the recoveries in the QC samples were low (<10%). The other 9 samples were rejected because the holding time had been exceeded.

The following discussion on VOCs and SVOCs applies to both analytical data and screening data. Data on VOCs and SVOCs from boreholes (locations) 54-01001 through 54-01006 and 54-01009 are screening level data from an on-site mobile chemical laboratory.

For organics, 59 samples for volatile organics (VOCs) were qualified and all qualified data are usable in data assessment. Forty samples were qualified as not detected (U) because the results were less than 5/10 times the analytes found in the method blank. Six samples were qualified as estimated (J/UJ) because the surrogate recoveries associated with these analytes were low. Eleven samples were qualified as estimated (J) for acetone and 2-butanone because the results were less than the practical quantitation limit (PQL) but greater than the method detection limit (MDL). Two were qualified as estimated (J) because the holding time had been exceeded.

Eleven semivolatile organic (SVOCs) samples were qualified, and eight samples can be used for data assessment. Six samples were qualified as estimated (J/UJ) because of the holding time had been exceeded. Two were qualified as estimated (J) because the results were less than the PQL but greater than the MDL. Three samples were rejected (R) and are not usable for data assessment because the surrogate recoveries associated with the analytes were low (10%).

For pesticides/polychlorinated biphenyls (pest/PCBs), two samples were qualified as estimated (J/UJ) because the holding time had been exceeded. These data can be used in data assessment.

For herbicides, four samples were qualified as rejected (R) because the recoveries for the analyte, Dicamba, in the QC samples were low (<10%). These data cannot be used in data assessment.

Appendix D

Phase I RFI Data
(CD on inside back cover of this report)

Appendix E

Statistical Results for Chemical Analytical Data

APPENDIX E STATISTICAL RESULTS FOR CHEMICAL ANALYTICAL DATA

E-1.0 INTRODUCTION

This appendix provides detailed statistical evaluations to support Section B-4.0 (data review) and Section B-5.0 (nature and extent) To support the data review and nature and extent, the statistical analyses include summary statistics, exploratory data analyses, spatial plots, and background comparisons.

The plots and evaluation results for Material Disposal Area (MDA) L at Technical Area 54 of Los Alamos National Laboratory (the Laboratory or LANL) are presented in Section E-3.0. This section is organized by categories of sampling media and analytical suites. Separate sections are presented for each medium (channel sediments and subsurface tuff). The analytical data consist of inorganic chemicals (metals and cyanide), radionuclides, and organic chemicals (volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs], polychlorinated biphenyls [PCBs], pesticides, and herbicides).

E-2.0 OVERVIEW OF STATISTICAL ANALYSES

A variety of statistical methods may be applied to each of the data sets. The use of any of these methods depends on how appropriate it is for the available data.

E-2.1 Summary Statistics

The summary statistics are calculated and presented as tables in Appendix B of this report. For values reported as detected, summary statistics include both the minimum and maximum reported concentrations, median, and arithmetic average concentrations. These values provide some indication of the central tendency and skew of the concentration distribution. For data sets containing values reported as undetected, the summary table includes the minimum and maximum reported detection limits (DLs) or estimated quantitation limits (EQLs).

E-2.2 Exploratory Data Analyses

The graphical analyses include box plots and borehole profiles. These analyses provide a visual representation of the data and aid in determining the presence of outliers or other anomalous data that might affect statistical results and interpretations. Specifically, the plots allow a visual comparison among distributions of concentrations for different analytes. The differences of interest may include an overall shift in concentration (shift of central location) or, when the centers are nearly equal, a difference between the upper tails of the two distributions (elevated concentrations in a small fraction of one distribution). The plots may be used in conjunction with the statistical tests (distributional comparisons) to evaluate the statistical results. Unless otherwise noted, the nondetects are included in plots at their reported DL or EQL.

Box plots. A box plot consists of a box, a line across the box, whiskers (lines extended beyond the box and terminated with a short perpendicular line), and points outside the whiskers. The box area of the plot is the region between the 25th percentile and the 75th percentile of the data, the interquartile range or middle half of the data. The horizontal line within the box represents the median (50th percentile) of the data. The whiskers give an interval of 1.5 times the interquartile range, outside of which the data may be evaluated for their potential to be outliers. When box plots are presented from more than two groups, the box representing the baseline or background set is the leftmost box; unless otherwise noted, the remaining boxes are arranged in ascending order by group medians. Often, the concentrations are plotted as points overlaying the box plot. When a data set contains both detected concentrations and nondetected results, reported as DLs, the detected concentrations are plotted as x's and the nondetected results are reported as o's.

Borehole profile plots. Borehole profile plots depict the concentration results by depth in boreholes. They are used to evaluate evidence of release from the disposal structure associated with a given borehole and to determine if the extent of contamination has been bounded (decreasing trend).

E-2.3 Comparisons Between Distributions

Comparisons between data sets that might represent different concentration distributions, such as site data and Laboratory background data, are performed using a variety of statistical methods. For background comparisons, these methods begin with a simple screening comparison of site-specific data with an upper tolerance limit (UTL) estimated from the background data (UTL [95, 95] or the 95% upper confidence bound on the 95th quantile). UTLs are used to represent the upper end of concentration distribution and are also referred to as background values (BVs). When appropriate, BV comparisons are followed by statistical tests that evaluate potential differences between the distributions. These tests are used for testing hypotheses about data from two potentially different distributions. One specific example would be the test of the hypothesis that site concentrations are elevated above background levels.

E-3.0 MDA L ANALYTICAL DATA

E-3.1 Surface Soil and Sediments

Runoff from MDA L is concentrated into a single drainage to the north. The drainage includes multiple braided channels traversing a 50- to 65-ft-wide area of a colluvial slope on the floor of a tributary of Cañada del Buey. These channels begin in one area along the MDA L fence and diverge below the cliffs on the north side of Mesita del Buey. Eight locations were selected for sediment sampling; these locations included areas with coarse sediment deposition upslope and areas with finer sediment deposition on the lower slopes (LANL 1996, 54462, Figure 1-11). The samples were field screened for gross alpha, beta, and gamma radiation to bias sample selection. A total of four samples (the sample with the highest gross alpha and gross beta, the sample with the highest gross gamma, and two other samples) were submitted for analysis of target analyte list (TAL) metals, PCBs, pesticides, and radionuclides. All results from the sediments are used without qualification except for tritium, which was qualified J (estimated) because of results from the blind quality control (QC) sample were outside acceptance limits.

E-3.1.1 Inorganic Chemicals in Sediment

The concentrations of inorganic chemicals for the four channel sediment samples were compared to Laboratory-wide sediment BVs (LANL 1998, 59730). No inorganic chemical was detected above its sediment BV. Three inorganic chemicals (cadmium, selenium, and silver) were not detected but have DLs larger than their respective sediment BVs. The inorganic chemical results are summarized in Table B-10 in Appendix B.

Box plots comparing the distribution of inorganic chemical concentrations in MDA L channel sediment samples to the concentrations from Laboratory background sediment samples support the conclusion that inorganic chemicals do not differ from background (Figure E-1). The inorganic chemicals with elevated DLs (cadmium, selenium, and silver) are identified in Appendix B as COPCs in sediment.

E-3.1.2 Radionuclides in Sediment

The channel sediment samples were analyzed for radionuclides. The detected concentrations for americium-241, cesium-137, tritium, plutonium-238, plutionium-239, radium-226, and strontium-90 were compared to sediment fallout values (FVs); the isotopes in the uranium and thorium decay chains were compared to BVs for these naturally occurring radiochemicals (LANL 1998, 59730). A summary of the radionuclide activities is presented in Table B-11 in Appendix B, including a separate summary for detected results and DLs for nondetects, the frequency of detection, and the frequency at which detected radionuclides exceed BVs or FVs.

Plutonium-238 was the only detected radionuclide (0.011 pCi/g) above the sediment BV of 0.006 pCi/g. The background comparison tests concluded that the plutonium-238 concentration is above sediment background.

E-3.1.3 Organic Chemicals in Sediment

Channel sediment samples were analyzed for pesticides and PCBs. One pesticide (methoxychlor) was detected in two of the four samples at concentrations of 0.028 mg/kg (location 5405143) and 0.063 mg/kg (location 54-05145). The concentrations were about two to three times above the sample EQL of 0.017 mg/kg.

E-3.2 Subsurface Tuff

One hundred and eighty-four samples of subsurface core were collected from 16 (RFI boreholes at MDA L. The locations of the boreholes relative to the disposal structures are shown in Figure B-6, Appendix B. The core samples were analyzed for TAL metals, cyanide, pesticides/PCBs, herbicides, VOCs, SVOCs, and radionuclides. However, not all samples were analyzed for every suite. Six of the boreholes were drilled to investigate the vapor plume east of MDA L; the core samples from these boreholes were analyzed only for VOCs. Two deep characterization boreholes were drilled at an angle from pads on Mesita del Buey to investigate the possibility of vapor-phase contaminants at depth below MDA L; the core samples from these boreholes were analyzed only for VOCs and tritium.

The eight boreholes drilled in the vicinity of the disposal units (i.e., disposal pit, impoundments, and shafts) were analyzed for all, or a majority of, the suites depending on the location of the borehole. The subsurface tuff investigation was intended to support the characterization of releases from a local source term (waste structures) either through a relatively uniform, homogeneous substratum (general dispersal in a volume through a subsurface medium) or through a heterogeneous fractured substratum. Evidence of a release through a uniform medium would include the consistent presence of concentrations greater than BVs (i.e., at two or more consecutive sampling depths). Evidence of migration through a fractured medium might include intermittent detects of several analytes within a borehole, or across boreholes, as fractures were occasionally intersected.

E-3.2.1 Inorganic Chemicals in Tuff

Subsurface core data for inorganic chemicals were obtained from the eight boreholes in closest proximity to the disposal units. Some of these data were rejected. Five out of the 67 mercury and cyanide analyses were rejected because holding times were substantially exceeded, while 4 out of 67 arsenic and selenium results were rejected because of low analyte recovery from a QC sample in the batch. The analytical results for the inorganic chemicals were compared to the BVs from the appropriate tuff strata of Laboratory-wide background data (LANL 1998, 59730). Inorganic chemicals with detected concentrations greater than the BVs were barium, copper, chromium, manganese, mercury, nickel, uranium, and zinc. Some inorganic chemicals had concentrations that were just greater than BVs, and a few inorganic chemicals were reported as nondetects with DLs larger than BVs. A summary of the results for the inorganic chemicals, separated by the tuff strata, is given in Table B-12 in Appendix B.

Sample concentrations were compared with BVs and evaluated by borehole. Barium, chromium, cobalt, copper, nickel, uranium, and zinc were detected at concentrations above their BVs in one or more borehole(s) at consecutive sampling depths or were detected above BVs in two out of three consecutive sampling depths. These data indicate a subsurface release from a disposal unit. Other inorganic chemicals that were detected at a single location or at random (i.e., in samples taken from two or three different boreholes at different sampling depths) with concentrations above BVs are less likely to indicate a release. This section discusses the releases of certain inorganic chemicals in some boreholes by disposal unit and by borehole.

All concentrations above their BV are discussed and shown in [Figures E-2 through E-7]. The figures show the borehole profile or pattern of concentrations by depth below ground surface (bgs) for the sampled cores within the individual boreholes. Detected concentrations (filled circles) and DLs for nondetects (open circles) are plotted at the midpoint of the sample depth interval (ft bgs). The unit-specific BVs are displayed in the figures as dotted lines.

Impoundments B, C, and D: Boreholes 54-01012, 54-01013, and 54-01014 were drilled at an angle beneath Impoundments B, C, and D, respectively. Analytical results were used to look for evidence of a release from these disposal units. The borehole locations relative to the impoundments are shown in Figure B-6 in Appendix B. Borehole profile plots show the angle of the boreholes and subsurface locations of the sampled cores relative to the disposal unit specified.

Impoundments B and C were used to dispose of liquid electroplating wastes. The analytical results for boreholes 54-01012 and 54-01013 are consistent with their operational records; inorganic chemicals detected above background in core samples include chromium, copper, and nickel. Concentrations of chromium and copper above their respective BVs were detected at three consecutive sampling depths in core samples from 54-01012 beneath Impoundment B (Figure E-2). Copper and nickel were similarly detected in 54-01013 beneath Impoundment C (Figure E-3, top row). In 54-01013, the detected concentrations for copper are above the BV at three consecutive sampling depths, while nickel concentrations exceeded the BV at two out of three consecutive sampling depths in borehole 54-01013. These results indicate that copper and chromium have been released from Impoundment B, and copper and nickel have been released from Impoundment C.

In borehole 54-01012 (Impoundment B) the patterns for other inorganic chemicals above their BVs were less indicative of a release. There were single detected concentrations of beryllium, cadmium, cyanide, mercury, and uranium, scattered among the different depth intervals (Figure E-2).

In borehole 54-01013 (Impoundment C), cadmium and chromium were detected above their BVs in a single sample at the deepest sampling interval. For both inorganic chemicals, the concentrations at this depth are similar to the concentrations (and reported DLs) of the samples at depths directly above it (i.e., sample concentrations do not represent an increase). The sampled core interval falls immediately below the Tshirege unit 2/unit 1v interface, but the BVs for these two units differ. In both cases, the sample concentrations at the interface fall between the BVs for the different units. The BV for cadmium in Qbt 1v is a nominal DL because there were no Laboratory background data for cadmium from that tuff unit. In contrast, cadmium was analyzed in background samples from Qbt 2 tuff, and had a BV of 1.63 mg/kg. The results for cadmium and chromium do not indicate a release from Impoundment C.

Borehole 54-01014 was drilled between Impoundments C and D at an angle to pass beneath Impoundment D. Uranium was the only inorganic chemical detected above its BV at several consecutive sampling depths (Figure E-3, bottom row). The concentrations of uranium are slightly above the Qbt 2 BV. The pattern may indicate natural variability, or it may indicate that a release of uranium at low concentrations to the surrounding subsurface tuff occurred from Impoundment D. There were also single detects of nickel and copper above their BVs at different sampling depths. Nickel was reported in the shallowest sampling depth between Impoundments C and D. The copper concentration above the BV was not replicated in the field duplicate sample (a second core taken from the same depth interval). The copper and nickel data do not indicate releases from Impoundment D.

Pit A: Boreholes 54-01009, 54-01010, and 54-01011 were drilled to characterize subsurface media near Pit A. Boreholes 54-01010 (at –45 degrees) and 54-01011 (at –55 degrees) were drilled at an angle to pass beneath the eastern and western portions of Pit A, respectively. Borehole 54-01009 was drilled vertically on the south side of Pit A near the west end. As shown in Figure B-6 of Appendix B, borehole 54-01009 is about 20 ft south of Pit A and is nearly equidistant between the pit and Shafts 1 through 28. If a release had occurred from Pit A, the placement of borehole 54-01009 could be used to bound the lateral extent of the release. Instead, the results from 54-01009 are different from those beneath Pit A but similar to results from borehole 54-01007 at the other end of Shafts 1 through 28. The similarity of borehole results from 54-01007 and 54-01009 might be expected based on the knowledge that Shafts 1 through 22 received uncontained liquid waste with no absorbents added. The results for borehole 54-01009 are discussed in the section on Shafts 1 through 28 below.

Analytical results from the boreholes angled beneath Pit A do not provide evidence of a release. Borehole 54-01011 had only one inorganic chemical (barium) detected in one sample at approximately twice the BV of 26.5 mg/kg for Qbt 1v (Figure E-4, bottom row). The detected concentrations of barium at all other sampling depths in this borehole were below BV. The analytical results for borehole 54-01010 indicate the presence of inorganic chemicals at concentrations above BVs at random depths (Figure E-4, top row). Three of the borehole 54-01010 sample concentrations (cadmium, uranium, and chromium) come from core samples collected just above or just below the unit 2/unit 1v interface, and the reported concentrations were between the BVs for the two strata. The chromium concentration in the sample collected from unit 2 was above the unit 2 BV but within the range of concentrations reported for the Laboratory background data (0.25 to 13.0 mg/kg [LANL 1998, 59730]).

Shafts 1 through 28: Both boreholes 54-01007 and 54-01009 are more than twice as deep as disposal Shafts 1 through 28. Both boreholes are vertical and are 25 to 30 ft from the nearest disposal shaft. The pattern of inorganic chemical concentrations in these boreholes provides evidence of a release. The most likely source of the release is the shafts. The primary component of the release is copper, with smaller contributions from chromium, barium, and zinc. Nickel was also detected above its BV in the lower tuff strata (Units 1v and 1g).

The distributions of copper, barium, and zinc in samples collected from borehole 54-01009 (Figure E-5) are similar to those noted for borehole 54-01007 (Figure E-6). The copper concentrations are much larger than the BVs in approximately half of the samples, while barium and zinc were reported at concentrations above the BVs in a few samples. Single samples had concentrations of beryllium, chromium, and manganese that were slightly above their BVs. The beryllium and manganese reported in a core sample were collected just below the unit 1v/unit 1g interface at concentrations between the BVs for the two tuff strata. Nickel was detected above its BV of 2 mg/kg, a nominal DL, in one of ten samples in borehole 54-01007 and in seven of nine samples in borehole 54-01009 in unit 1v or unit 1g samples, but all the results were below the unit 2 BV (6.58 mg/kg).

Borehole 54-01007 was drilled about 30 ft south of the southeastern corner of Shafts 1 through 28. Analysis of core samples detected copper, chromium, barium, and zinc at concentrations above their BVs (Figure E-6). Copper concentrations were greater than the BV in 10 of 13 samples, often by more than a factor of 10. Chromium concentrations were greater than its BV in 5 of 13 samples but did not exceed background by more than a factor of 2. Copper and chromium remained elevated at the deepest sampling depth (146 ft bgs). Barium and zinc concentrations were more than twice their BVs in a single sample and at concentrations slightly above their BVs in two and in four sampling depths (some consecutive depths), respectively. The concentrations of barium and zinc decreased to less than their BVs at the deeper sampling intervals.

Aluminum, lead, and manganese were detected in samples from borehole 54-01007 at concentrations that exceeded their BVs in a single sample or in two core samples at nonconsecutive sampling depths

Shafts 29 through 34. Borehole 54-01008 is a vertical 150-ft borehole located about 20 ft to the southeast of Shafts 29 through 34. The borehole was drilled to characterize the subsurface media in the vicinity of these shafts. The inorganic chemicals reported at concentrations above background include copper, zinc, and chromium (Figure E-7). Copper concentrations exceeded its BVs in the majority of the samples (10 out of 12); several concentrations were more than 10 times the BV for copper. Zinc and chromium were detected at three or more consecutive sampling depths at concentrations exceeding their BVs by a factor of two or less. Manganese and cobalt concentrations were also above their BVs at two consecutive sampling depths. Manganese was marginally above its BV; one of the five cobalt concentrations with values above its BV was more than double its BV. Other inorganic chemicals with single detected concentrations above the BVs include barium, beryllium, iron, and lead.

E-3.2.2 Radionuclides in Tuff

Tuff core samples from seven boreholes were analyzed for tritium. The seven boreholes included the five shallow (vertical depths to 60 ft) holes angled beneath the Pit A and Impoundments B, C, and D (boreholes 54-01010 through 54-01014) and two additional deep boreholes (54-01015 and 54-01016) drilled at an angle from Cañada del Buey to the north. Borehole 54-01015 passes beneath Pit A at a depth of about 470 ft and terminates beneath the array of Shafts 1 through 28 at a vertical depth of about 600 ft. Borehole 54-01016 terminates beneath Shafts 29 through 34 at a vertical depth of about 550 ft. Analytical results for 1 of 46 tritium samples were rejected because of a laboratory error. With the exception of the one rejected sample, the tritium results from the MDA L boreholes are useable.

The tritium results for the shallow boreholes (54-01010 through 54-01014) ranged between 0.1 pCi/mL and 196 pCi/mL. The samples with the highest concentrations (13.1 pCi/mL and 196 pCi/mL) were collected at depths between 20 and 25 ft below Pit A. The concentrations at deeper depths (35 to 45 ft) below Pit A decreased to approximately 5 pCi/ml. The tritium results in the deep boreholes (54-01015 and 54-01016) were variable primarily because of low (<2%) moisture content in the samples collected. Low moisture tends to increase analytical counting error and accuracy of the dilution factor that multiplies the final result. With the exception of a single detect of 1.5 pCi/mL, all the samples with moisture contents greater than about 2% for the deep boreholes were reported at low DLs (less than 0.5 pCi/mLl).

Figure E-8 shows the tritium results by borehole. The largest concentration (196 pCi/mL from borehole 54-01010) is omitted from the plot so as to better depict the differences in results at lower concentrations; the omitted concentration is more than 10 times greater than the largest concentration shown in the figure. The tritium results from samples with low moisture content are plotted as triangles, and the results from greater moisture content are plotted as circles. Low moisture content was reported only in samples from the deep boreholes. The results based on sample moisture content of greater than 2% (circles) are clustered at the low end of the concentration range. The results based on samples with lower moisture content (triangles) are scattered across the full range of concentrations and include most of the largest results reported for the deep boreholes.

A tritium plume beneath MDA L is evident from the sampling results. The concentrations of tritium are highest (13 to 196 pCi/mL) at a depth between 20 and 25 ft beneath Pit A and are not detected or detected at concentrations of less than about 5 pCi/mL in all boreholes and all other sampling depths. The results from the deep boreholes provide some evidence that tritium contamination is restricted to the vicinity of MDA L.

Five core samples from borehole 54-01009 were analyzed for five radionuclides (plutonium-238, -239 and uranium-234, -235, and -238). The naturally occurring uranium isotopes were compared to Laboratory-wide BVs from the appropriate tuff strata. Plutonium-238 and -239 were evaluated on the basis of detection status. Uranium-235 was detected in a single sample at a concentration that is essentially equal to its BV. The plutonium isotopes were detected at trace concentrations (below the minimum DL). The results are not indicative of a release from MDA L. A summary of the radionuclide concentrations is presented in Table B-13 in Appendix B.

E-3.2.3 Organic Chemicals in Tuff

Borehole core samples were analyzed for SVOCs, pesticides, PCBs, herbicides, and VOCs. Core from all 16 boreholes was analyzed for VOCs. The eight boreholes drilled in the vicinity of the disposal units (54-01007 through 54-01014) were analyzed for SVOCs, pesticides, and PCBs, in addition to the VOCs at an off-site contract laboratory. The exception is samples from borehole 54-01009. These samples were submitted to an on-site mobile chemical laboratory for VOC and SVOC analysis. The three boreholes closest to the disposal shafts (54-01007 through 54-01009) were also analyzed for herbicides.

No herbicides were detected in any samples. Detected organic chemicals included 4 SVOCs, 1 PCB, 2 pesticides, and 15 VOCs; most concentrations were less than or equal to three times their EQLs. The only notable exception was Aroclor-1260, which was detected at a concentration more than 10 times its EQL. The most frequently detected VOCs were acetone and 2-butanone, which are common laboratory contaminants. A summary of the detected organic chemicals is presented in Table B-15 in Appendix B.

Twenty-two organic chemicals were detected, most at negligible concentrations (i.e., less than or slightly above their EQLs). The larger concentrations (i.e., concentrations above their EQLs) were detected in borehole samples beneath Pit A (54-01010 and 54-01011), between Pit A and the array of Shafts 1 through 28 (54-01009), and at the east end of the array of Shafts 1 through 28 (54-01007).

Two pesticides, Aroclor-1260, and three SVOCs were detected at a few sampling depths. Only Aroclor-1260 was reported in borehole 54-1010 at a concentration (0.313 mg/kg) that was much greater than its sample EQL (0.0044 mg/kg). Methoxychlor was detected at different sampling depths in borehole 54-01010, and dichlorodiphenyldichloroethane (DDD) was detected in a single sample at a concentration (0.00588 mg/kg), marginally above the EQL (0.0044 mg/kg) in borehole 54-01011. Bis(2-ethylhexyl)phthalate was detected at a concentration (0.8 mg/kg), which was 25% greater than its EQL (0.6 mg/kg) at one sampling depth beneath Pit A. Pentachlorophenol was detected at concentrations that were more than three times the EQL at two sampling depths below Impoundment B (in borehole 54-01012).

Detected VOCs were more widespread but generally occurred at low concentrations (less than or near the EQLs). Six VOCs (bromobenzene, dibromomethane, 1,2-dichloropropane, 4-isopropyltoluene, tetrachloroethene) were reported as detected in a single sample (borehole 54-01003 on the mesa top outside the perimeter of MDA L) at concentrations less than or equal to their reported EQLs. One VOC

(1,3-dichloropropane) was detected below the EQL in two boreholes (54-01003, 54-01005) on the mesa to the east of MDA L. Acetone was detected at low concentrations in the majority of the boreholes (12 of 16) but was detected at concentrations more than 10 times its EQL (0.06 mg/kg) in four samples from 54-01007 (at the east end of Shafts 1 through 28). The VOCs below Pit A included trichloroethane (0.008 and 0.015 mg/kg) and trichloroethene (three samples at 0.008 mg/kg), methylene chloride at approximately twice its EQL (0.010 to 0.014 mg/kg) in two samples, and 1,2-dichloroethane at concentrations more than three times its EQL (0.018 and 0.020 mg/kg) in two samples. Between Pit A and Shafts 1 through 28 (borehole 54-01009), 1,2-dichloroethane was detected in a single sample at a concentration slightly above its EQL (0.0093 mg/kg) and 1,3-dichlorobenzene was detected once (at 0.011 above its EQL (0.005 mg/kg), and 4-methyl-2-pentanone was detected in two samples at concentrations that were up to three times its EQL (0.034 and 0.078 mg/kg) in two samples.

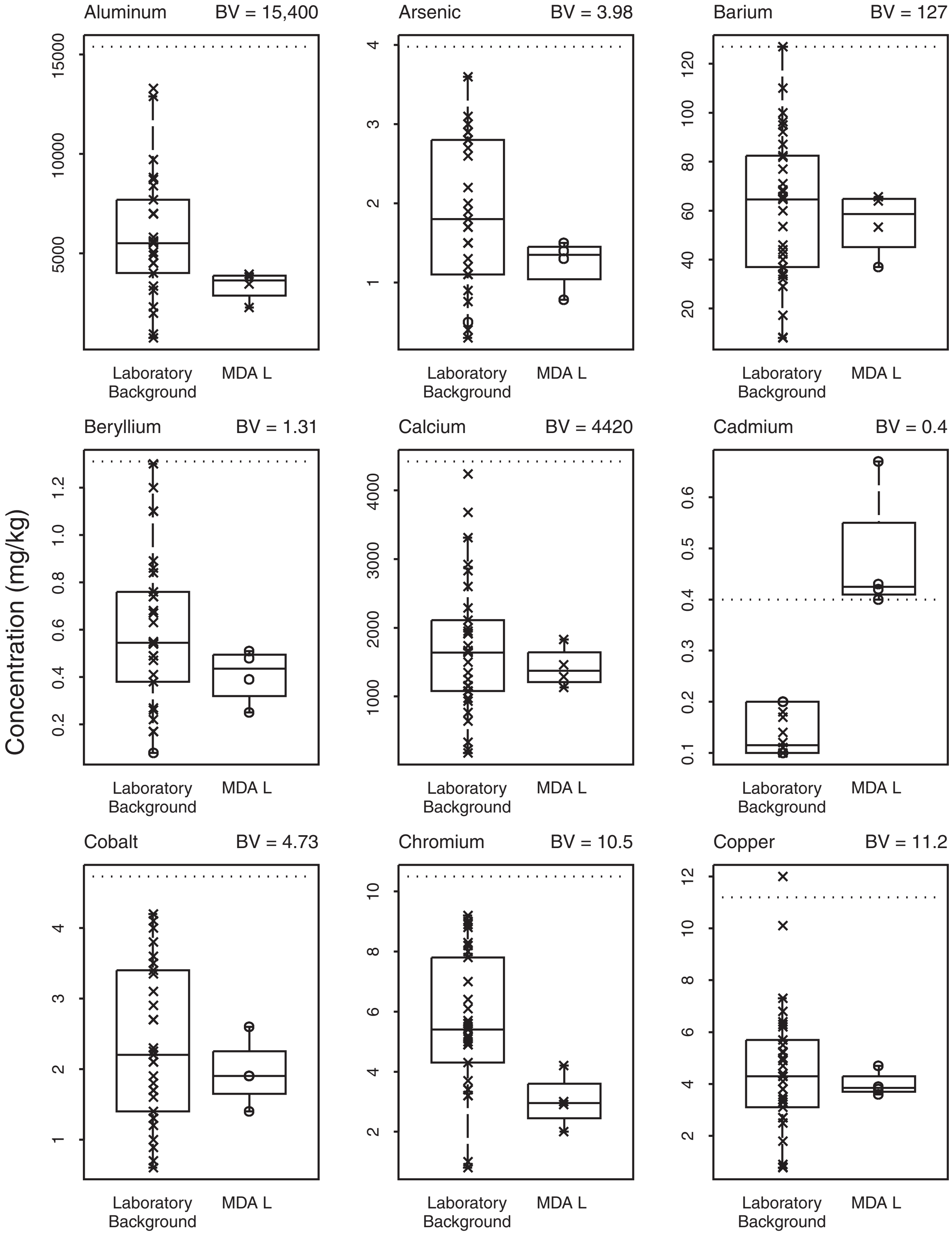
In summary, organic chemicals were reported in the subsurface media near Pit A and the array of Shafts 1 through 28. The organic chemicals detected at concentrations lower than the EQLs are less reliably quantified because VOCs may be lost in tuff media samples during sample and analysis.

REFERENCES

The following list includes all references cited in this appendix. Parenthetical information following each reference provides the author, publication date, and the RRES record identification (ER ID) number. This information also is included in the citations in the text. ER ID numbers are assigned by the Laboratory's RRES-RS Program (formerly the ER Project) to track records.

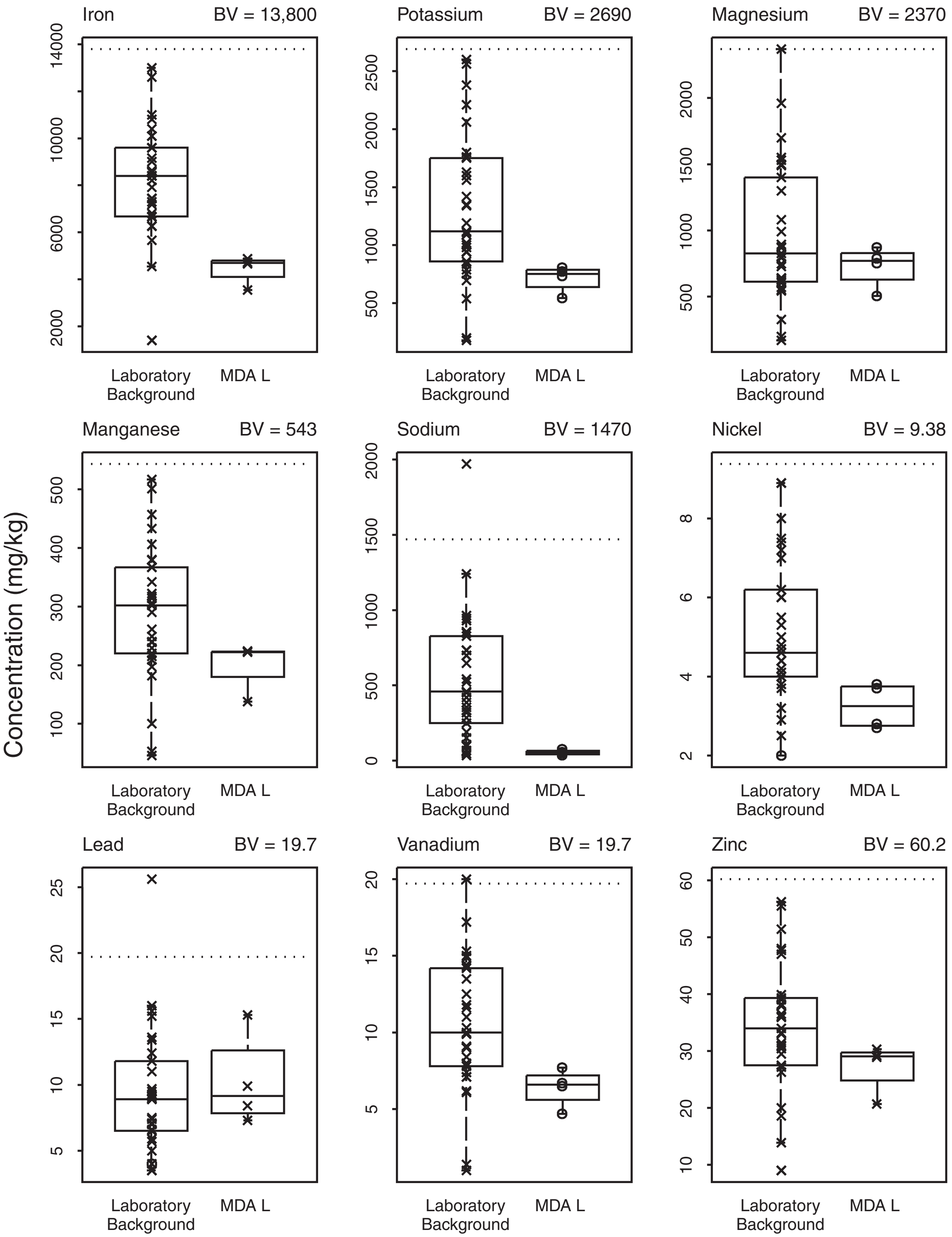
LANL (Los Alamos National Laboratory), February 1996. “RFI Report for Channel Sediment Pathways from MDAs G, H, J, and L, TA-54, (Located in Former Operable Unit 1148), Field Unit 5,” Los Alamos National Laboratory document LA-UR-96-110, Los Alamos, New Mexico. (LANL 1996, 54462)

LANL (Los Alamos National Laboratory), September 1998. "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory" Los Alamos National Laboratory document LA-UR-98-4847 (draft), Los Alamos, New Mexico. (LANL 1998, 59730)



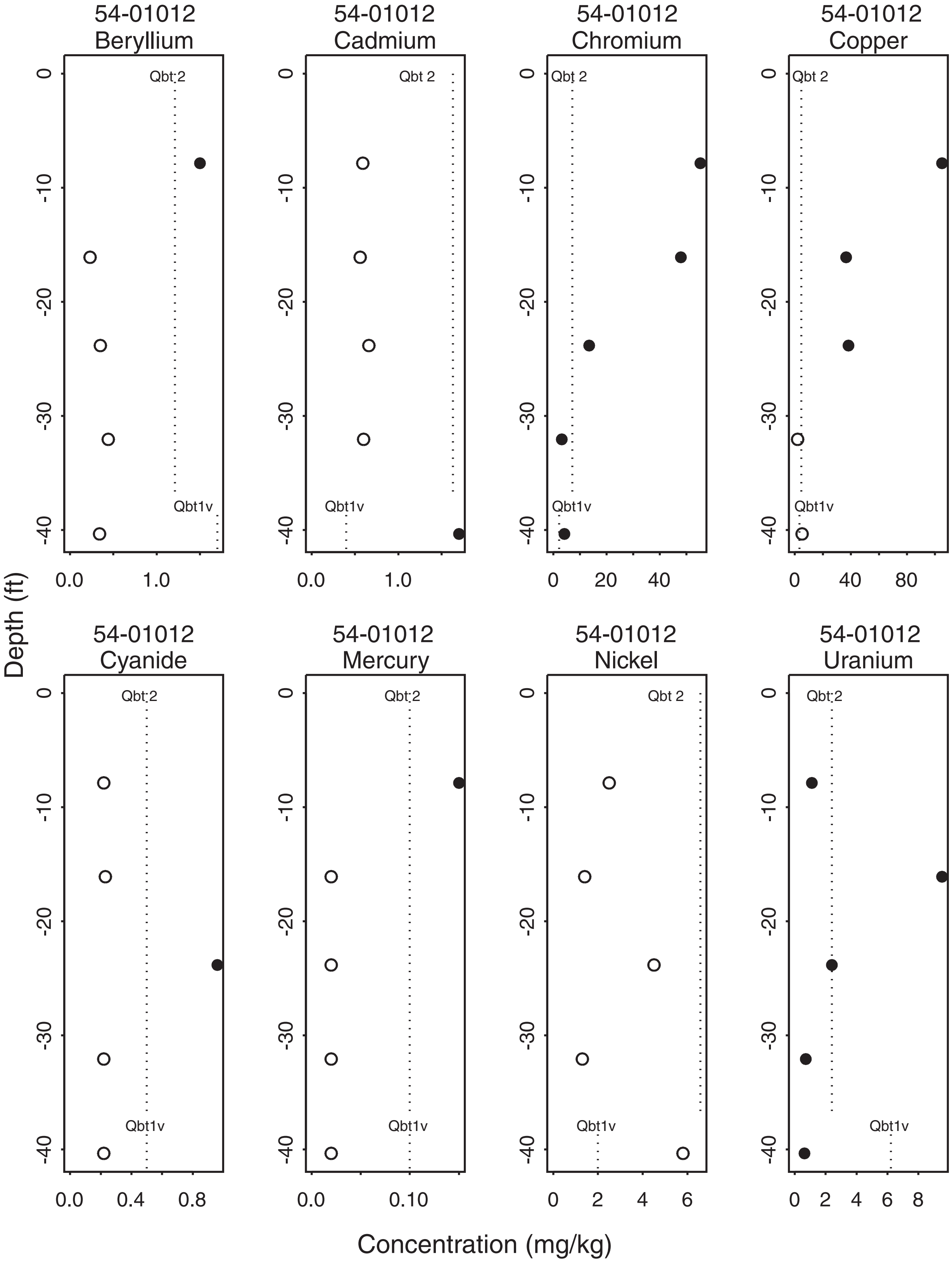
FE-1 / MDA L IWP / 082503 / PTM

Figure E-1. **Box plots of inorganic chemical concentrations from channel sediments at MDA L and from Laboratory background sediments**



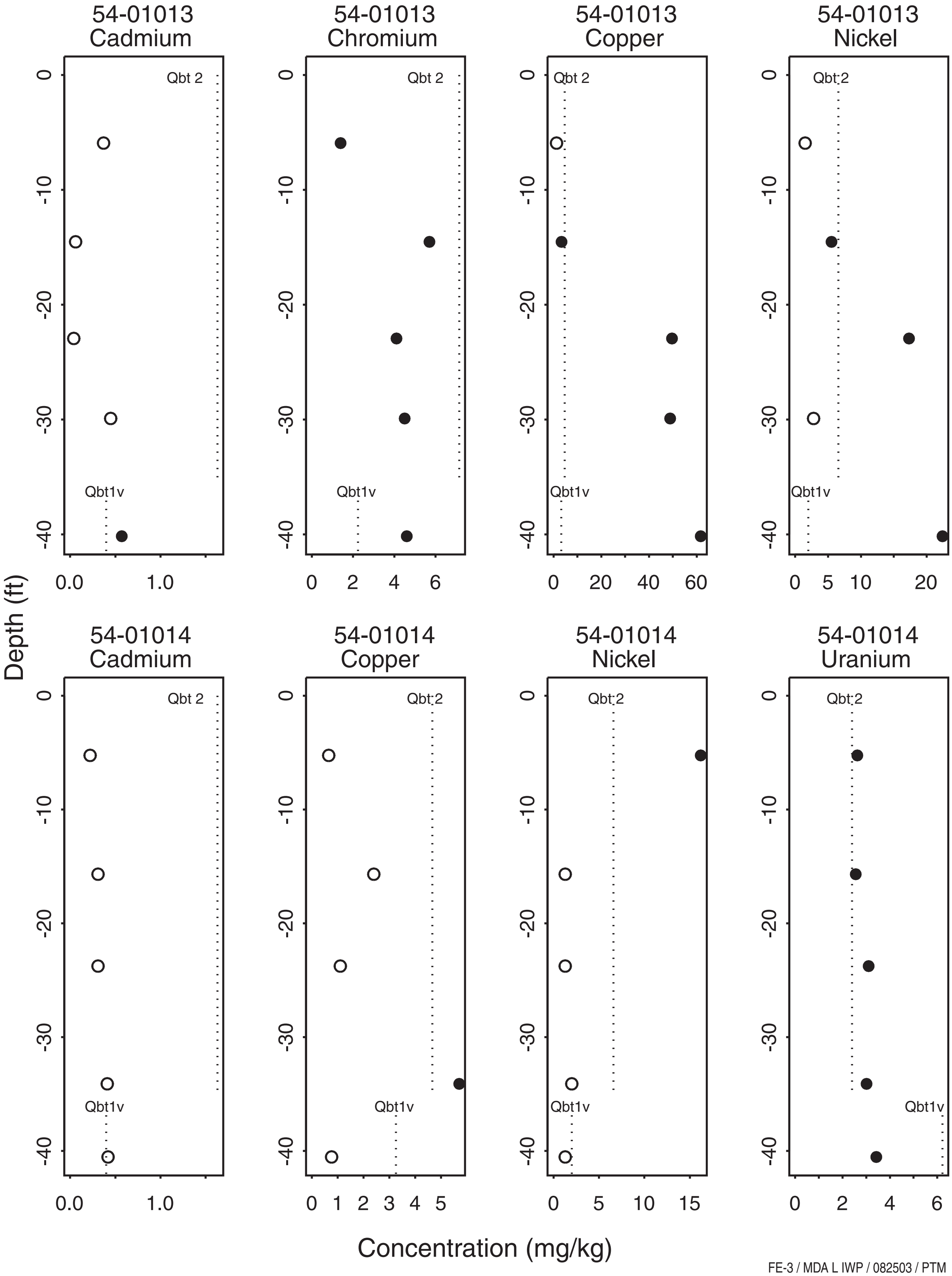
FE-1 (cont.) / MDA L IWP / 082503 / PTM

Figure E-1 (continued). **Box plots of inorganic chemical concentrations from channel sediments at MDA L and from Laboratory background sediments**



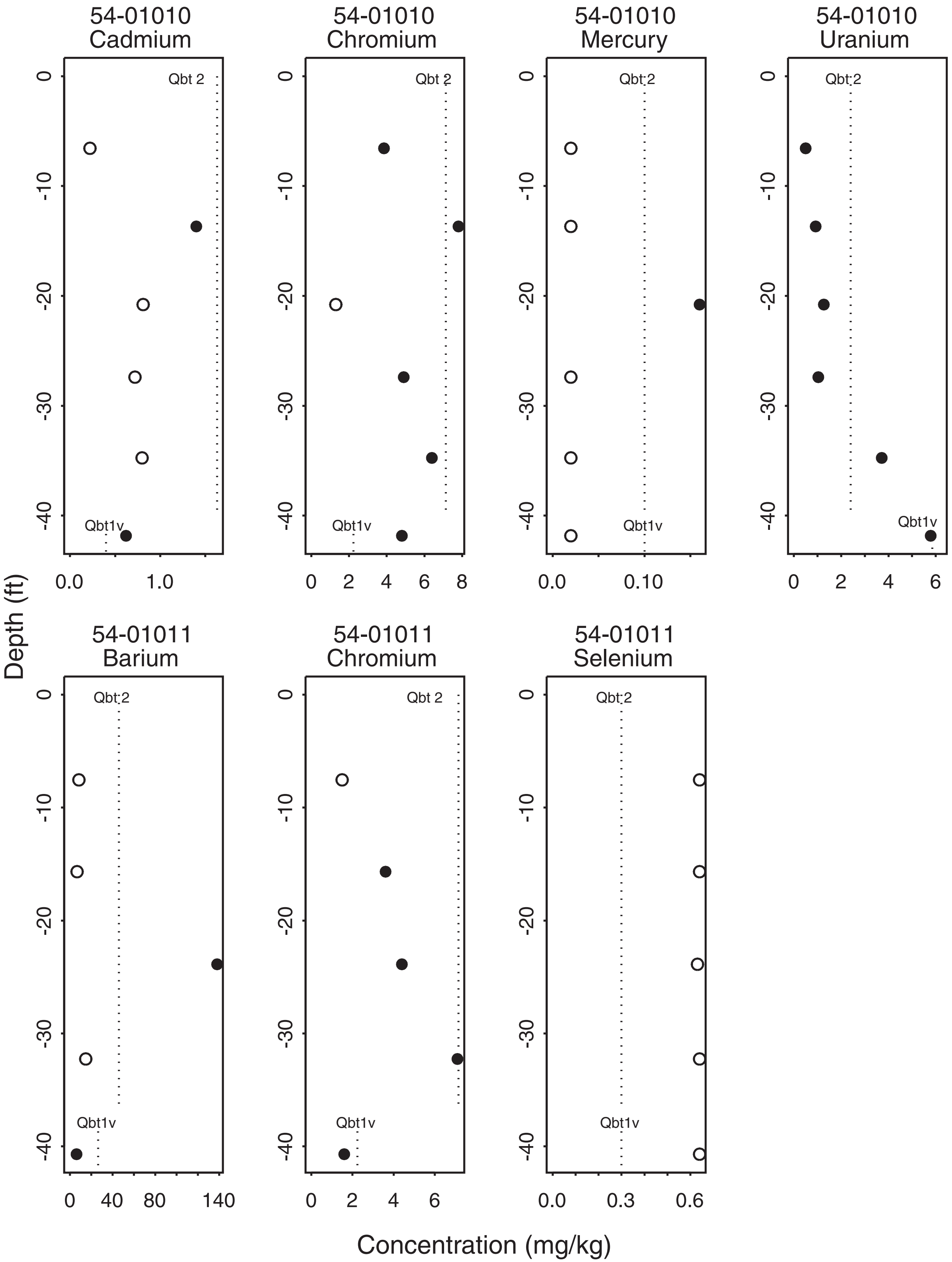
FE-2 / MDA L IWP / 082503 / PTM

Figure E-2. **Inorganic chemical concentration profiles from borehole 54-01012 at MDA L**



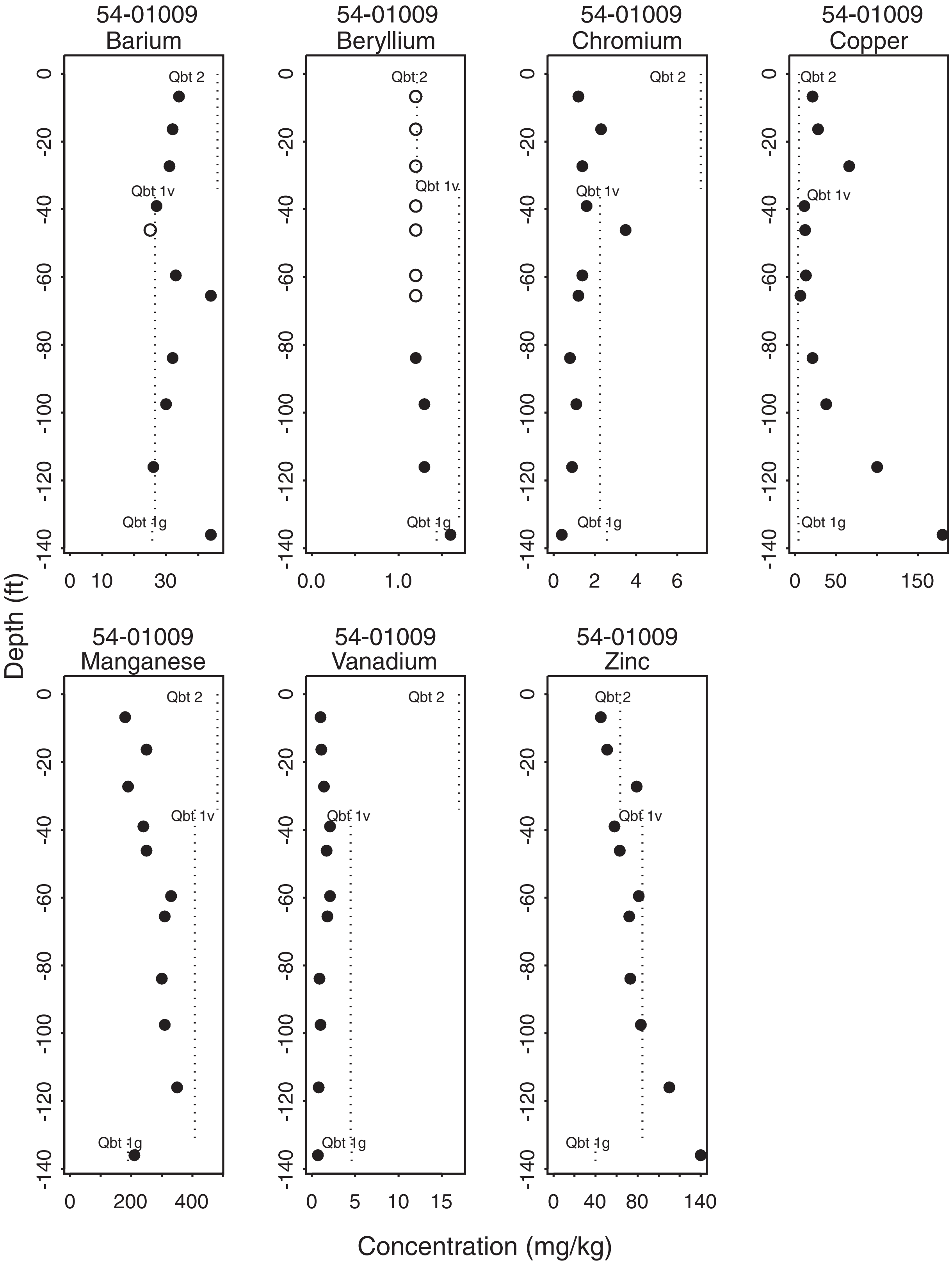
FE-3 / MDA L IWP / 082503 / PTM

Figure E-3. **Inorganic chemical concentration profiles from boreholes 54-01013 and 54-01014 at MDA L**



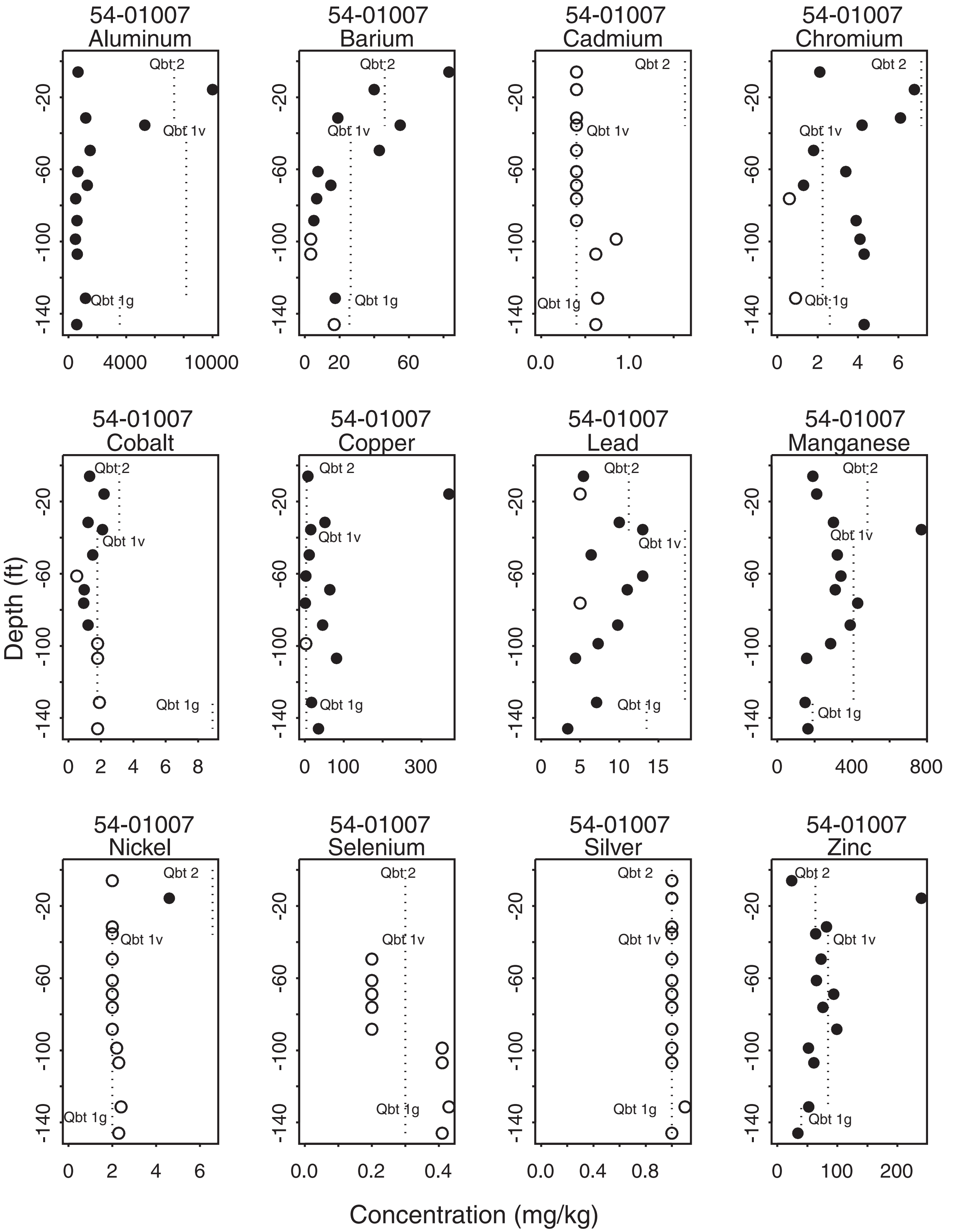
FE-4 / MDA L IWP / 082503 / PTM

Figure E-4. **Inorganic chemical concentration profiles from boreholes 54-01010 and 54-01011 at MDA L**



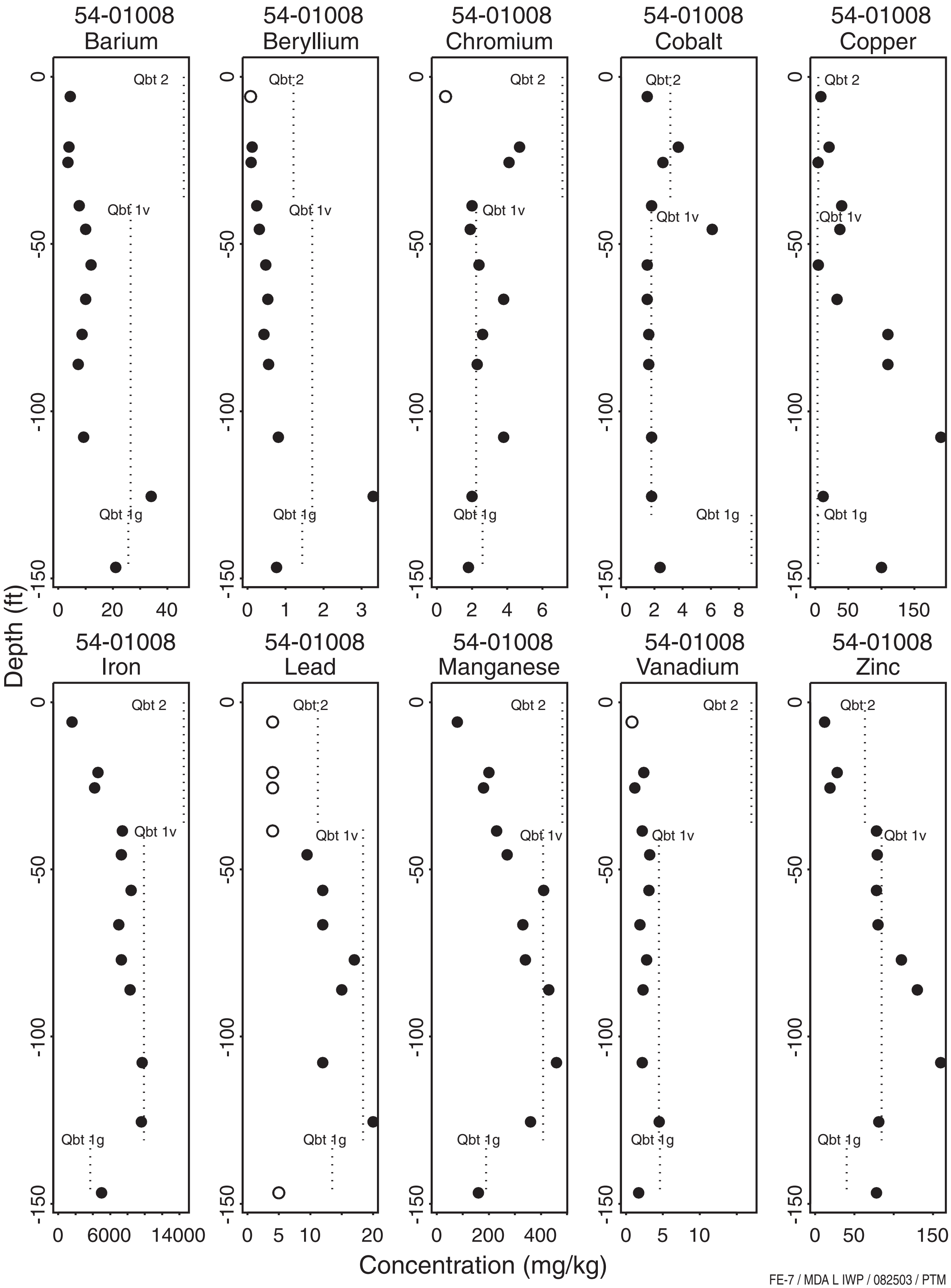
FE-5 / MDA L IWP / 082503 / PTM

Figure E-5. Inorganic chemical concentration profiles from borehole 54-01009 at MDA L



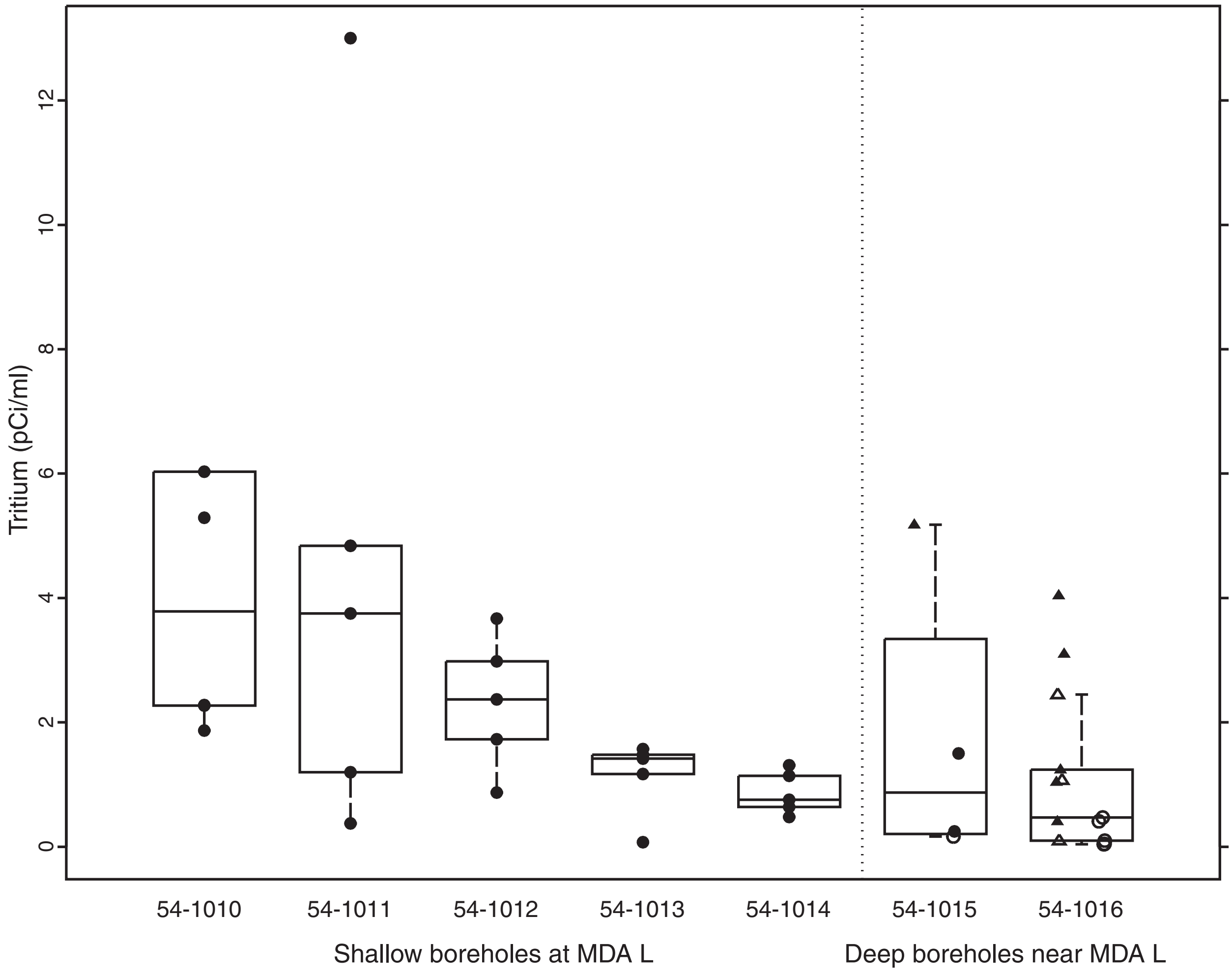
FE-6 / MDA L IWP / 082503 / PTM

Figure E-6. **Inorganic chemical concentration profiles from borehole 54-01007 at MDA L**



FE-7 / MDA L IWP / 082503 / PTM

Figure E-7. **Inorganic chemical concentration profiles from borehole 54-01008 at MDA L**



FE-8 / MDA L IWP / 082503 / PTM

Figure E-8. **Box plots of tritium concentrations by borehole at MDA L.**
The concentration of 196 pCi/ml at 54-01010 is not shown. Triangles are used for samples with low (less than 2%) moisture content; circles are used when moisture content is greater than 2%. Solid symbols (filled triangles or circles) are used for detects; open symbols (outline of triangles or circles) are used for nondetects.

Appendix F

Regulatory History and Documents

APPENDIX F REGULATORY HISTORY AND DOCUMENTS

This appendix describes the regulatory history and status of solid waste management units (SWMUs) and areas of concern (AOCs) at Technical Area (TA-)54, Area L, one of which is addressed in this investigation work plan. This information is presented because TA-54, Area L, is comprised of a number of active and inactive waste management units, some of which are subject to corrective action while others are subject to other regulatory programs.

The operable unit (OU) 1148 Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan included five AOCs in TA-51 and 46 SWMUs and AOCs in TA-54 (LANL 1992, 7669). Most SWMUs and AOCs in TA-54 are associated with waste management Areas G, H, J, and L. Table F-1 identifies the SWMUS and AOCs associated with Area L, provides brief descriptions of the sites, and identifies the appropriate regulatory program for managing and closing the sites.

The 13 SWMUs and AOCS listed in Table F-1 can be placed into the following categories:

- sites for which no further action (NFA) was recommended and approved [SWMU 54-001(c), AOC 54-008, AOC 54-015(g), and AOC 54-015(i)];
- active sites that will be investigated and, if necessary, cleaned up by the Risk Reduction and Environmental Stewardship Division–Remediation Services (RRES-RS) in accordance with the corrective action requirements of the Hazardous and Solid Waste Amendments (HSWA) Module (Module VIII) of the Los Alamos National Laboratory (LANL or the Laboratory) Hazardous Waste Facility Permit [SWMU 54-006 and SWMU 54-012(b)];
- sites that will undergo RCRA closure under the Laboratory's Hazardous Waste Facility Permit [SWMU 54-001(a), SWMU 54-001(b), AOC 54-001(e), AOC 54-002, AOC 54-009, and AOC 54-014(a)]; and
- an active site that manages polychlorinated biphenyls (PCBs) will be closed in accordance with requirements of the Toxic Substances Control Act [(TSCA) AOC 54-001(d)].

SWMU 54-006 (in the second category) consists of inactive subsurface waste management units that are collectively referred to as material disposal area (MDA) L and are the subject of the investigation described in this investigation work plan. The other SWMU in the second category and the SWMUs and AOCs in the other three categories are not within the scope of this investigation work plan, and the disposition of these sites is presented in Table F-1.

The process for investigating MDA L was initially described in the OU 1148 RFI work plan (LANL 1992, 7669) and has been subsequently modified by other documents. The chronology of documents is presented below.

1. April 23, 1993. The US Environmental Protection Agency (EPA) issued a notice of deficiency (NOD) for the RFI work plan for OU 1148 (Reiter 1993, 6743).
2. July 27, 1993. The Laboratory submitted revised Appendix A to OU 1148 RFI work plan to the US Department of Energy-Los Alamos Area Office (DOE-LAAO) for transmittal to EPA (Tiedman 1993, 22430). This appendix consisted of a revised pilot extraction study plan for treatment of the volatile organic compound (VOC) plume beneath MDA L.
3. August 25, 1993. EPA approved the revised Appendix A to the OU 1148 RFI work plan (Honker 1993, 30522).

4. October 19, 1993. The the Laboratory held a conference call with the EPA Region 6 office to discuss proposed modifications to the OU 1148 RFI work plan. The Laboratory and EPA personnel discussed changes to the Laboratory-proposed drilling plan at MDA L and received verbal approval from EPA to drill boreholes 54-1007, 54-1008, and 54-1009 to 150 ft rather than to the 300-ft and 500-ft depths proposed in the RFI work plan. These changes and the approval were later referenced in a June 1994 proposal for work plan modifications (Item 10).

5. November 1, 1993. DOE-LAAO submitted proposed modifications to the approved pilot extraction study plan to EPA (Taylor 1993, 30249). These modifications addressed changes to drilling near MDA L.

6. November 15, 1993. The New Mexico Environment Department (NMED) submitted technical comment memorandum for the OU 1148 RFI work plan (Swanton 1993, 63981).

7. November 23, 1993. DOE-LAAO submitted responses to the NOD for the OU 1148 RFI work plan to EPA (Vozella 1993, 30327).

8. December 14, 1993. EPA approved the OU 1148 RFI work plan, as modified by the November 23, 1993, NOD response (Davis 1993, 38812). The approval concurred with the no further action (NFA) recommendations for potential release sites (PRSs) 54-001(c), 54-008, 54-015(g), and 54-015(i), but indicated that a Class III permit modification would be necessary to remove SWMU 54-001(c) from the HSWA Module.

9. April 21, 1994. The Laboratory documented minutes of conference call discussions with EPA Region 6 on April 8, 1994, concerning proposed modifications to the OU 1148 RFI work plan (Glatzmaier 1994, 35207). These discussions related to channel sediment sampling at TA-54 MDAs, deep borehole drilling beneath MDA L, and passive air sampling using the EMFLUX® system. EPA concurred with proposed modifications except those addressing passive air sampling.

10. June 8, 1994. The Laboratory submitted proposed modifications to the OU 1148 RFI work plan to DOE-LAAO for transmittal to EPA. These modifications addressed channel sediment sampling, deep borehole sampling, passive air sampling, and existing vapor well sampling at MDA L. These modifications had been previously discussed with EPA, but the modification request was never formally transmitted to EPA by DOE-LAAO.

11. July 18, 1994. EPA approved use of EMFLUX® passive air-sampling method for estimating extent and semiqualitative nature of vapor-phase plumes. This approval was based on a draft report of passive soil gas sampling performed at OU 1148, dated May 3, 1994, that was submitted to EPA for review.

12. March 28, 1995. The Laboratory submitted a permit modification request to NMED for PRSs requested for NFA (LANL 1995, 45365). Request included SWMU 54-001(c), which was listed in the HSWA Module, and AOCs 54-008, 54-015(g), and 54-015(i), which were not listed in the HSWA module.

13. October 11, 1995. DOE-LAAO concurred with the NFA determination for non-HSWA units contained in the March 1995 permit modification request (Taylor 1995, 50023). This concurrence included AOCs 54-008, 54-015(g), and 54-015(i).

14. December 10, 1996. NMED submitted a notice of determination on permit modification requests for units proposed for NFA (Dinwiddie 1996, 55815). This notice concurred that SWMU 54-001(c) was suitable for a Class III permit modification.
15. February 27, 1996. The Laboratory submitted the “RFI Report for Channels Sediment Pathways from MDAs G, H, J, and L, TA-54” to the EPA (Jansen and Taylor 1996, 54462).
16. September 23, 1997. NMED approved the RFI report for channels sediment pathways from MDAs G, H, J, and L, TA-54 (Dinwiddie 1997, 63982).
17. December 23, 1998. NMED approved a Class III permit modification for removal of 99 SWMUs from HSWA Module (Kelley 1998, 63042). The permit modification included removal of SWMU 54-001(c).

REFERENCES

The following list includes all references cited in this appendix. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of actual documents at the RRES-RS Records Processing Facility.

Davis, A., December 14, 1993. “RFI Work Plan for OU 1148, Approval, Los Alamos National Laboratory NM0890010515,” Los Alamos National Laboratory letter to J. Vozella, DOE, Region VI, from A. Davis, EPA, Region VI, Los Alamos, New Mexico. (Davis 1993, 38812)

Dinwiddie, R. S., September 23, 1997. “Approval of RCRA Investigation Report for Channel Sediment Pathways from Material Disposal Areas (MDAs) G, H, J, and L at Technical Area 54 (TA-54), Los Alamos National Laboratory NM0890010515,” Los Alamos National Laboratory letter to S. Hecker and T. Todd, DOE-LAAO, from R. S. Dinwiddie, NMED-HRMB, Los Alamos, New Mexico. (Dinwiddie 1997, 63982)

Dinwiddie, R. S., December 10, 1996. “Notice of Determination Requests for Permit Modification Units Proposed for No Further Action, March and September 1995, Los Alamos National Laboratory NM0890010515,” Los Alamos National Laboratory letter to T. Taylor and J. Jensen, EM/ER, from R. S. Dinwiddie, NMED-HRMB, Los Alamos, New Mexico. (Dinwiddie 1996, 55815)

Glatzmaier, T., April 21, 1994. “Summary of Conference Call with Barbara Driscoll, Environmental Protection Agency (EPA), Region 6,” Los Alamos National Laboratory memorandum (EM/ER:94-A153) from T. Glatzmaier, Los Alamos, New Mexico. (Glatzmaier 1994, 35207)

Honker, W. K., August 25, 1993. “Pilot Extraction Plan for the Organic Vapor Plume (MDA L), Los Alamos National Laboratory, NM0890010515,” Los Alamos National Laboratory letter to J. Vozella, DOE, from W. K. Honker, EPA, Los Alamos, New Mexico. (Honker 1993, 30522)

Jansen, J., and T. Taylor, February 27, 1996. “Submittal of the Resource Conservation and Recovery Act Facility Investigation (RFI) Report for Channels from Material Disposal Areas (MDAs) G, H, J, and L in Technical Area (TA) 54,” Los Alamos National Laboratory letter (EM/ER:96-007) to D. Neleigh, EPA, Los Alamos, New Mexico. (Jansen and Taylor 1996, 54462)

Kelley, E., December 21, 1998. “Approval: Class III Permit Modification to Remove Ninety-Nine (99) Solid Waste Management Units from the Department ff Energy/Los Alamos National Laboratory RCRA Permit,” Los Alamos National Laboratory letter to T. Taylor, DOE-LAAO, and J. Browne, LANL, from E. Kelley, Los Alamos, New Mexico. (Kelley 1998, 63042)

LANL (Los Alamos National Laboratory), May 1992. "RFI Work Plan for Operable Unit 1148," Los Alamos National Laboratory document LA-UR-92-855, Los Alamos, New Mexico. (LANL 1992, 7669)

LANL (Los Alamos National Laboratory), March 1995. “Request for Permit Modification Units Proposed for NFA, March 1995,” Los Alamos National Laboratory document LA-UR-95-767, Los Alamos, New Mexico. (LANL 1995, 45365)

Reiter, G., April 23, 1993. “RFI Work Plan for OU 1148 Notice of Deficiency, Los Alamos National Laboratory NM0890010515,” Los Alamos National Laboratory letter to J. L. Bellows, DOE-LAAO, from G. Reiter, EPA, Region 6, Los Alamos, New Mexico. (Reiter 1993, 6743)

Swanton, B., November 15, 1995. “Review of LANL's May 1992 RCRA Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1148 (Agreement in Principles [AIP] Technical Comments Attached),” Los Alamos National Laboratory letter to D. Webb, DOE-LAAO, from B. Swanton, NMED, Los Alamos, New Mexico. (Swanton 1993, 63981)

Taylor, T., November 1, 1993. “Cover Letter for the Modification to the EPA-Approved Pilot Study for MDA L at OU 1148,” Los Alamos National Laboratory letter (LESH:7TT-004) to B. Driscoll, EPA, from T. Taylor, Program Manager, DOE-LAAO, Los Alamos, New Mexico. (Taylor 1993, 30249)

Taylor, T., October 11, 1995. “NFA Permit Modification, March 1995 (DOE Concurrence in Determination of NFA for AOCs Non-HSWA Units),” Los Alamos National Laboratory letter (LAAMEP:CGF:NFA Approval) to J. Jansen, EM/ER, from T. Taylor, DOE, Los Alamos, New Mexico. (Taylor 1995, 50023)

Tiedman, A., July 27, 1993. “Pilot Extraction Study Plan for the Organic Vapor Plume at Material Disposal Area (MDA) L,” Los Alamos National Laboratory letter (ADO/93-614-U) to J. Bellows, DOE-LLAO, from A. Tiedman, ADO, Los Alamos, New Mexico. (Tiedman 1993, 22430)

Vozella, J. C., November 23, 1993. “Cover Letter for Response to Notice of Deficiency for Work Plan for Operable Unit 1148 for ER Program,” Los Alamos National Laboratory letter to W. Honker, Chief, EPA Region 6, from J. C. Vozella, Chief, DOE, Los Alamos, New Mexico. (Vozella 1993, 30327)

Table F-1
Status of Potential Release Sites at TA-54 Area L

PRS Number	Unit Type	HSWA PRS (Y/N)	Active Waste Management Areas (Y/N)	Regulatory Status
54-001(a)	Radioactive mixed waste storage area	Y	Y	Active mixed waste storage area currently operated under RCRA interim status. Unit will be permitted in next revision to the Laboratory's Hazardous Waste Facility Permit. Unit will be closed under RCRA closure requirements for permitted storage units.
54-001(b)	Hazardous waste storage area	N	Y	Active hazardous waste storage area currently operated under the Laboratory's Hazardous Waste Facility Permit. Unit will be closed under RCRA closure requirements for permitted storage units.
54-001(c)	Storage tank and containment berm	Y (Removed)	N (Removed)	Unit was never used for management of solid waste. Unit was recommended for NFA in RFI work plan and was removed from HSWA Module in December 1998.
54-001(d)	PCB waste storage area	N	Y	Active PCB waste storage area operated under EPA TSCA authorization. Unit will be closed under TSCA closure requirements for storage units.
54-001(e)	Hazardous waste storage area	N	Y	Active hazardous waste storage area currently operated under the Laboratory's Hazardous Waste Facility Permit. Unit will be closed under RCRA closure requirements for permitted storage units.
54-002	Hazardous waste storage area	N	Y	Active hazardous waste storage area currently operated under the Laboratory's Hazardous Waste Facility Permit. Unit will be closed under RCRA closure requirements for permitted storage units.
54-006	Subsurface waste disposal (pit, shafts, impoundments)	Y	N	Site is being addressed under RCRA corrective action.
54-008	Sanitary sewage holding tanks	N	Y	Tanks are permitted holding tanks operated under NMED Liquid Waste Disposal Regulations. Unit was recommended for NFA in RFI work plan. EPA and DOE concurred with NFA recommendation and unit has been administratively closed.
54-009	Hazardous waste storage/treatment tanks	N	N (Removed)	Tanks were operated under the Laboratory's Hazardous Waste Facility Permit and were closed at risk without approved closure plan. Unit will be formally closed under RCRA following submittal of RCRA closure plan.
54-012(b)	Former site of drum compactor	Y	N	Site is being addressed under RCRA corrective action.

Table F-1 (continued)

PRS Number	Unit Type	HSWA PRS (Y/N)	Active Waste Management Areas (Y/N)	Regulatory Status
54-014(a)	Mixed waste storage shafts	N	Y	Active mixed waste storage area currently operated under RCRA interim status. Unit will not be added to the Laboratory's Hazardous Waste Facility Permit. RCRA closure plan has been submitted to NMED for closure of unit.
54-015(g)	Former lead cask storage area	N	N	No releases occurred from storage activities at this site. Unit was recommended for NFA in RFI work plan. EPA and DOE concurred with NFA recommendation and unit has been administratively closed.
54-015(i)	Former battery storage area	N	N	No releases occurred from storage activities at this site. Unit was recommended for NFA in RFI work plan. EPA and DOE concurred with NFA recommendation and unit has been administratively closed.

Appendix G

History of Monitoring for Subsurface Volatile Organic Compound Plumes at Material Disposal Area L

APPENDIX G HISTORY OF MONITORING FOR SUBSURFACE VOLATILE ORGANIC COMPOUND PLUMES AT MATERIAL DISPOSAL AREA L

G-1.0 PORE-GAS MONITORING WELL NETWORK

A total of 32 monitoring boreholes are available for pore-gas monitoring and sampling at Technical Area (TA) 54. Of these 32, 24 are available specifically for pore gas monitoring and sampling at MDA L. Details on the installation and locations of the boreholes currently used for vadose zone monitoring at material disposal area (MDA) L are described in Sections 2 and 3. Figure G-1 shows the location of the pore-gas monitoring wells at MDA L. Detailed borehole logs including lithologies and well construction are presented in Appendix H of this report. The depths of the pore-gas sampling ports are shown in Table G-1.

G-2.0 METHODS OF PORE-GAS COLLECTION AND ANALYSIS

Methods of pore-gas collection and analysis have changed during the years of monitoring the vapor-phase plume. Each change was an improvement over the previous method in terms of number of analytes, precision, accuracy, and/or cost. A brief review is necessary to understand variations in sampling results. Table G-2 lists the sampling methods used from 1988 to the present. Table G-3 lists the analytical methods used for the different pore-gas analytes. Pore-gas sampling at the Laboratory is governed by LANL-ER-SOP-06.31, current version, Sampling Sub-Atmospheric Air. The following sections review the historic analytical methods used to measure volatile organic compounds (VOCs) in pore gas.

Solvent Desorption Gas Chromatograph/Mass Spectrometer

In the solvent desorption gas chromatograph/mass spectrometer (SDGCMS) method, a positive-displacement pump purges the borehole sampling lines and draws a pore-gas sample through a single-sample ampule containing granulated activated charcoal as a sorbent. After the sampling line is purged of one volume, the ampule is opened and connected in series with the well; an additional 1.2 L of pore gas is pumped through the ampule. In the laboratory, the granulated charcoal is desorbed by solvent extraction using carbon disulfide. The solute obtained by this extraction is analyzed by gas chromatography/mass spectrometry (GCMS) for 12 analytes using the National Institute of Occupational Safety and Health Volatile Sample Train (NIOSH VOST) method. Results of the SDGCMS sampling are summarized in revised Appendix A of the operable unit (OU) 1148 work plan (LANL 1993, 22430).

Thermal Desorption Gas Chromatograph/Mass Spectrometer

Thermal desorption gas chromotograph/mass spectrometer (TDGCMS) is a method developed in 1993 because more precise results were needed for remediation designs (Neeper 1993, 55533). Forty-eight analytes were analyzed by TDGCMS. This method uses two glass sample tubes with three specified sorbent beds in each tube instead of the single ampules of granulated activated charcoal used in the SDGCMS method. The sorbents can be chosen to maximize absorption of the chemicals expected to be present. To obtain representative pore-gas samples, at least two headspace volumes are purged from the line to each monitor port before sampling. After purging, the gas line to the sampling port is never opened to the atmosphere but directed to the sampling unit by switching valves. The gas flow is split such that one sample tube receives 10 times more pore gas than the other. In addition to increasing the dynamic range of the measurement, the TDGCMS method uses an integrating mass flow meter to measure the volume accurately.

One tube was sampled at 10 mL/min, and the other tube was sampled at 100 mL/min. The method used for analysis was a modified US Environmental Protection Agency (EPA) Method TO-1/TO-2, which specifies a flow of 30- to 50-mL/min. At flow rates higher than 50-mL/min, light volatile compounds such as vinyl chloride will pass through the absorbent trap. The low flow-rate tube data (10 mL/min) can be used with greater confidence because even though the flow rate is not proper for collecting heavier compounds, breakthrough and loss of the lighter compounds does not occur.

For these results the laboratory used liquid injections for all gas chromotograph/mass spectrometer (GCMS) calibrations of gaseous samples. The EPA method requires dynamic calibration, that is, the calibration of an analytical system using gas standards introduced into the analytical system in the same manner as the samples. The calibration standards are identical or very similar to the samples to be analyzed.

Photoacoustic Radiometry

Beginning in the third quarter of calendar year 1993, the former ER Project, now Risk Reduction and Environmental Stewardship–Remediation Services (RRES-RS), adopted an infrared technique, called photoacoustic radiometer (PAR), as a screening method to monitor the vapor plume. Although specific ports in selected monitoring wells are still analyzed by GCMS, the PAR is used to monitor each sampling port in each borehole. Since the first quarter of 1998, PAR has been used to screen all wells at all depths. The PAR technique uses a Bruel & Kjaer (B&K) model 1302 infrared field-screening instrument to measure up to five analytes at a time at each port. The results are reliable and immediately available in the field. Through 1999, samples from the port in each well that has the highest total concentration of VOCs (using PAR) are then analyzed by the GCMS method. During this period, the sampling program targeted the maximum concentration of the plume. Beginning in 2000, samples were collected from a defined list for analysis by the GCMS method to address data gaps that remained for defining the nature and extent of contamination. The methodology and analyte list for the PAR screening has changed since 1993. The current procedure requires purging each sample port with a pump until carbon dioxide levels have stabilized at levels representative of subsurface pore gas. The carbon dioxide concentration is measured with an in-line carbon dioxide detector. The B&K gas analyzer is then used to measure the concentrations of 1,1,1-trichloroethane (TCA), trichloroethene (TCE), tetrachloroethene (PCA), and Freon 11. In addition, the B&K measures the pore gas carbon dioxide and water vapor concentration.

Tedlar Bag Sampling and GCMS Analysis

The multiple-port monitoring boreholes at MDA L have sampling ports located over a great range of depths. Consequently, the gas impedance in sampling lines to discrete ports varies over a factor of about 300. To sample and analyze those ports with high impedance, a lung box was employed to fill Tedlar sample bags with the pore gas. Using PAR, the pore gas was analyzed directly from the Tedlar bag. The same Tedlar bag (containing the pore gas) was submitted for GCMS analysis of 60 chemicals. Analysis was done within eight hours. The Tedlar bag GCMS method was used during the first quarter of 1996. Dynamic calibration was not employed for these samples. The quality assurance (QA) audit of this technique resulted in a shut down of the pore-gas program because of sampling and analytical deficiencies.

SUMMA™ Canisters and GCMS Analysis

Since 1997, pore-gas samples have been collected using SUMMA™ canisters with analysis by GCMS by EPA Method TO-14. Through fiscal year (FY) 2000, SUMMA™ canister samples were drawn from the port with the highest contaminant concentration (determined by field screening every port with the PAR field instrument). Starting in FY 2001, a defined list of ports were sampled using SUMMA™ canisters for GCMS analysis by EPA Method TO-14. The defined list of ports is provided in the annual report at the end of each fiscal year. The 2001 list was defined at the end of the fourth quarter of 2000, and the 2002 list was defined at the end of the fourth quarter of 2001. The defined list of ports was based on an evaluation of past data for data needs with respect to nature and extent.

Currently samples are collected in SUMMA™ canisters from 12 boreholes each quarter. This protocol has been in place since the EPA approved amended Appendix A of the OU 1148 work plan. Of the 12 boreholes sampled, 7 are at MDA L (Figure G-1), 2 are located at MDA G, and 3 are discretionary samples collected from the remaining wells at either MDA L or MDA G. In addition to the required SUMMA sampling, all available ports in the available boreholes are screened with a B&K model 1302 infrared field-screening instrument.

Most recently, the quarterly pore-gas monitoring has focused on

- identifying changes in contaminant concentrations at the perimeter of the well-characterized plume at MDA L as an indicator of outward plume behavior,
- identifying changes in the source area as an indicator of new releases, and
- addressing data needs for estimating nature and extent.

Field quality assurance (QA) samples include a duplicate sample drawn from one well, an equipment blank of zero air or nitrogen drawn through the sampling apparatus in the working area, and a sample of a known calibration gas. Laboratory QA for the EPA Method TO-14 gas chromatography includes internal surrogates, replicates, blanks, laboratory control samples, and reference standards.

G-3.0 PORE-GAS MONITORING RESULTS

G-3.1 Quarterly Monitoring Results (Pre-1993)

Characterization and monitoring of the MDA L vapor plume began in the mid-1980s. Results of MDA L monitoring before the RFI began in 1993 are presented in this section.

Plume Composition as Determined by Pre-1993 Data

Analytical results on discrete pore-gas samples collected from the monitoring well network for MDA L from 1985 to 1988 are presented in a report by Trent (1990, 12557). Revised Appendix A to the OU 1148 work plan summarizes analytical results on pore-gas samples collected at MDA L during the period 1988 to 1992 and states that “the principal vapor phase organic compounds, listed in descending order of concentration, were 1,1,1-trichloroethane (TCA), trichloroethene (TCE), carbon tetrachloride, chloroform, tetrachloroethene (PCE), toluene, and benzene. Other contaminants that have been detected but at much lower concentrations include chlorobenzene, xylenes, and 1,2,4-trimethylbenzene. In addition to having the greatest concentration, TCA also exhibits the greatest lateral and vertical extent in the organic chemical vapor plume. The measured concentrations of TCA are almost an order of magnitude greater than values measured for TCE, the contaminant of second highest concentration.” The SDGCMS method was used to measure 12 VOCs in the pore gas.

G-3.2 QUARTERLY MONITORING RESULTS (POST-1993)

Plume Composition as Determined by 1993–1996 Data

Before 1993, pore-gas samples for the MDA L plume were analyzed for only 12 chemicals. In the first quarter of 1996, using the Tedlar bag GCMS method, pore-gas samples were analyzed for 60 chemicals. In the first quarter of 1996, the total number of chemicals detected was 21. The compound TCA was the dominant analyte; PCE, and trichlorotrifluoroethane (Freon 113) were next in abundance. Prior to 1993, Freons had not been detected because they were not included in the analytical suite. QA deficiencies were identified in the analytical methods used during this period and the results should be used for comparison purposes only.

Plume Composition as Determined by 1997 – Present Data

Beginning in 1997, the pore-gas sampling and analyses methodology were greatly improved to provide quantitative analytical results that could be used to define nature and extent of contamination and track plume behavior over time. The pore-gas screening and sampling adhered to strict procedures, and stringent QA was required of analytical laboratories conducting the EPA Method TO-14 organic analysis.

The latest analytical data available for MDA L are the first quarter FY 2002 SUMMA™ canister analyses. Through the fourth quarter of 1999, the SUMMA™ samples were collected from ports with the highest detected concentrations based on field screening with the B&K. Beginning in 2000, the SUMMA™ samples were collected according to a predefined schedule developed to address data gaps regarding the nature and extent of contamination. The SUMMA™ samples after 1999 do not necessarily represent maximum plume concentrations. For maximum concentration comparison purposes, Table G-4 and G-5 show the maximum detected concentrations for each chemical and their locations for the first quarter of 1997 and fourth quarter of 1999, respectively. Table G-4 also includes a large number of compounds, whereas Table G-5 shows a fairly limited number of compounds. This difference results primarily from more rigorous data validation procedures since 1997, which limits the actual number of detected compounds. The entire set of the SUMMA™ canister data is included in Appendix D.

The SUMMA™ analytical data collected since 1997 are of sufficient quality to define the nature of the subsurface VOC contamination at MDA L. However, spatially, the SUMMA™ analytical data are limited and cannot be used to fully define extent. To define extent the pore-gas screening data are used. The pore-gas screening data have been collected from every functional port in every available pore-gas monitoring well since 1997 and provides a very extensive extent data set. As presented in Section 2 of this IWP, the B&K screening data correlates well with the SUMMA™ analytical data. Figure G-2 shows the lateral and vertical extent for TCA as defined by the B&K screening data for each quarter since 1999.

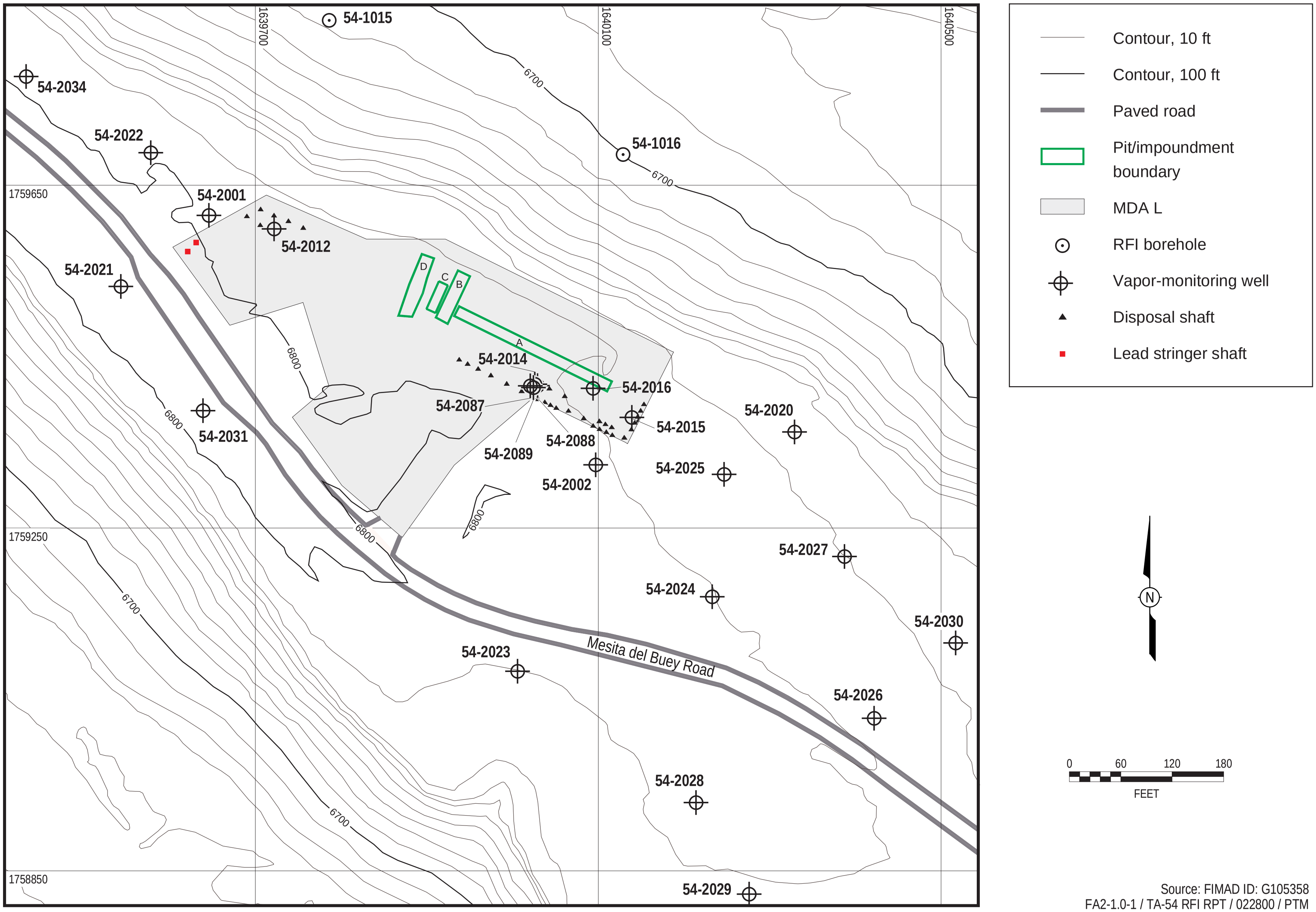
G-4.0 REFERENCES

The following list includes all references cited in this attachment. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of the actual documents at the RRES-RS Records Processing Facility.

LANL (Los Alamos National Laboratory), July 1993. “Pilot Extraction Study Plan for the Organic Vapor Plume at MDA L,” Los Alamos, New Mexico. (LANL 1993, 22430)

Neeper, D. A., February 12, 1993. "Quarterly Pore Gas Sampling at TA-54," Los Alamos National Laboratory memorandum MEE-13:93-099, Los Alamos, New Mexico. (Neeper 1993, 55533)

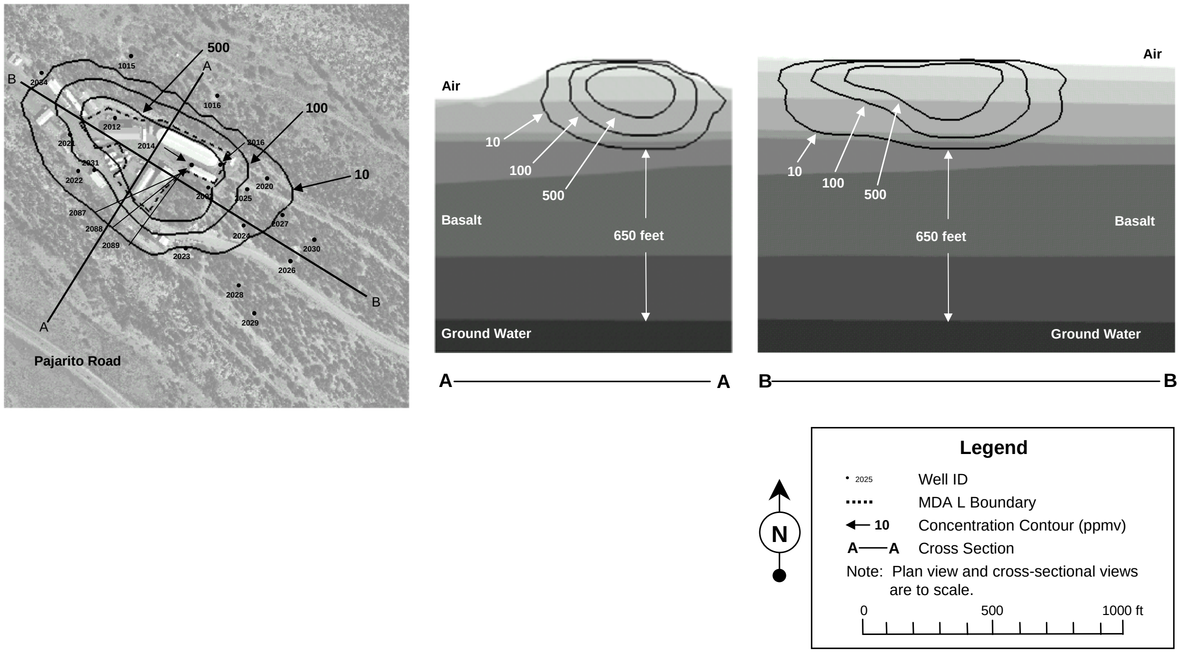
Trent, B., November 1, 1990. “Update on Analysis of Area L,” Los Alamos National Laboratory memorandum EES-5:90-718 to A. Barr, Los Alamos, New Mexico. (Trent 1990, 12557)



Source: FIMAD ID: G105358
FA2-1.0-1 / TA-54 RFI RPT / 022800 / PTM

Figure G-1. Locations of MDA L vapor-monitoring wells

MDA L Pore Gas Sampling
1st Quarter - 1999



MDA L Pore Gas Sampling
2nd Quarter - 1999

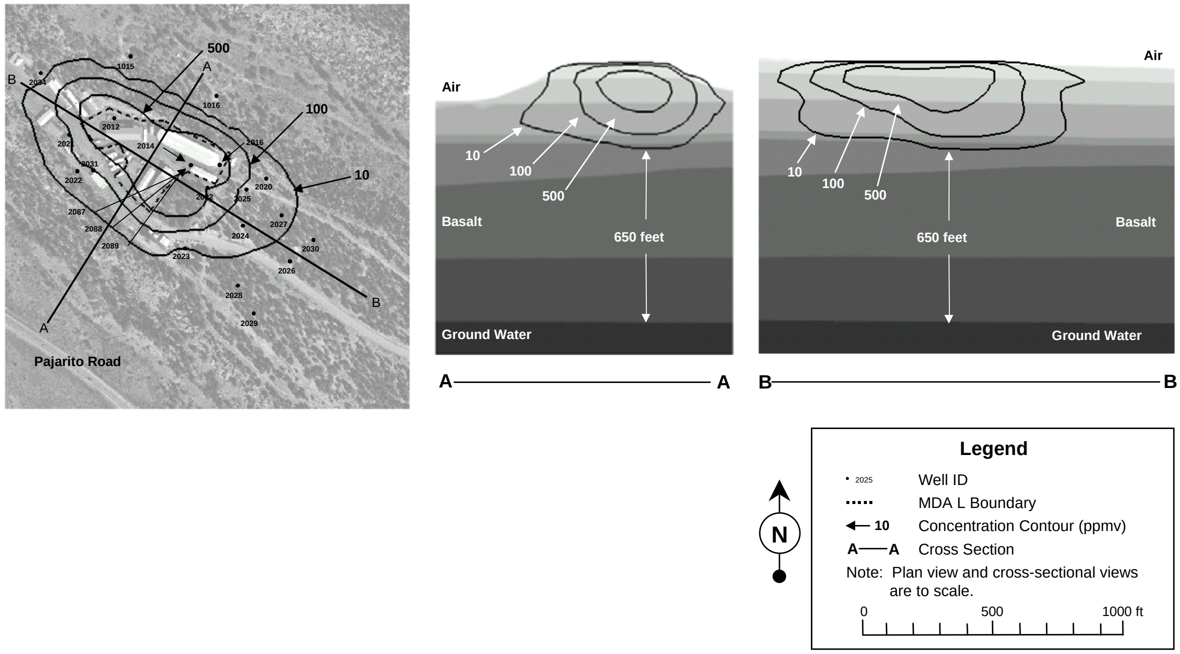
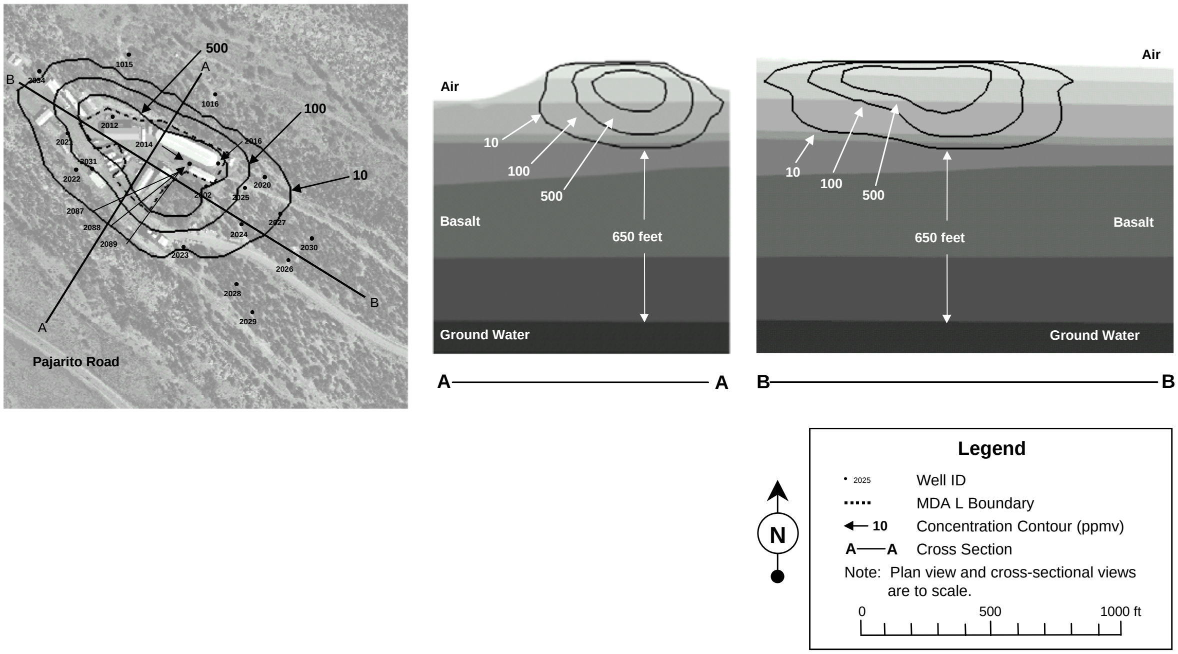


Figure G-2. **Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001**

MDA L Pore Gas Sampling
3rd Quarter - 1999



MDA L Pore Gas Sampling
4th Quarter - 1999

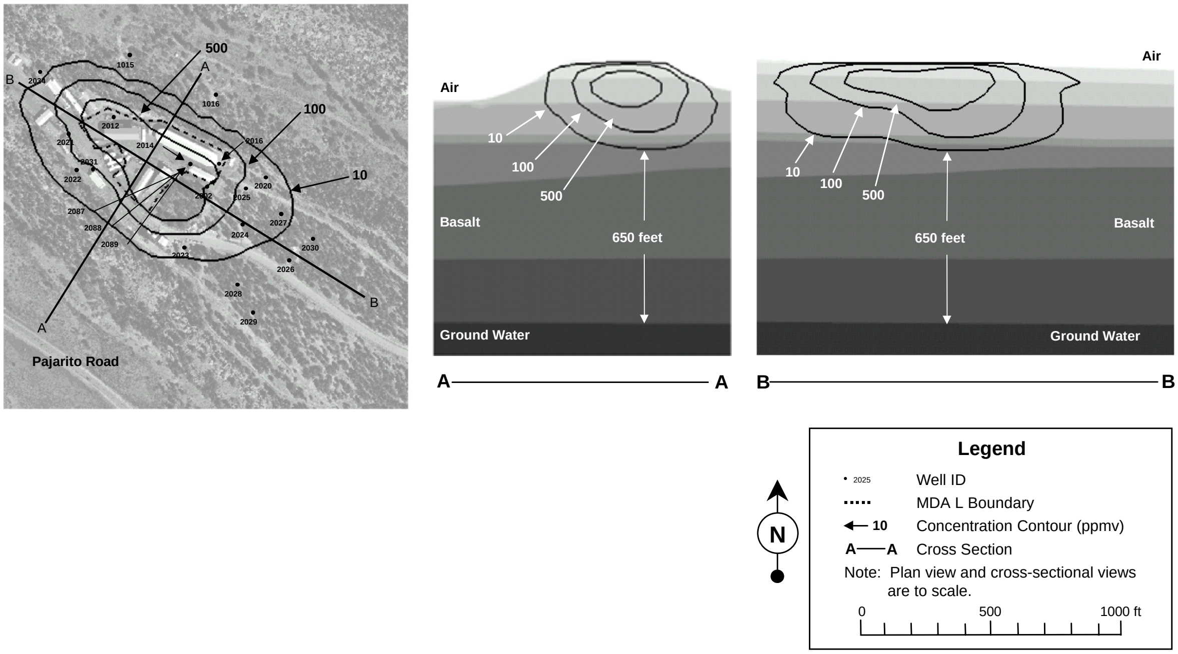
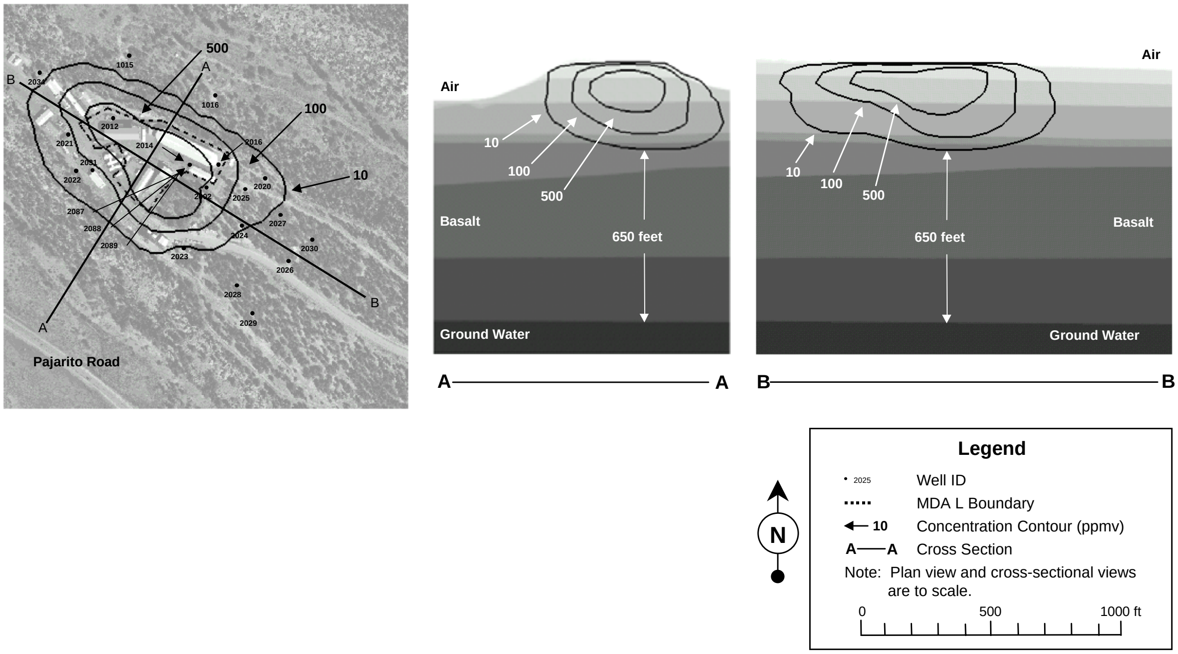


Figure G-2 (continued). **Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001**

MDA L Pore Gas Sampling
1st Quarter - 2000



MDA L Pore Gas Sampling
2nd Quarter - 2000

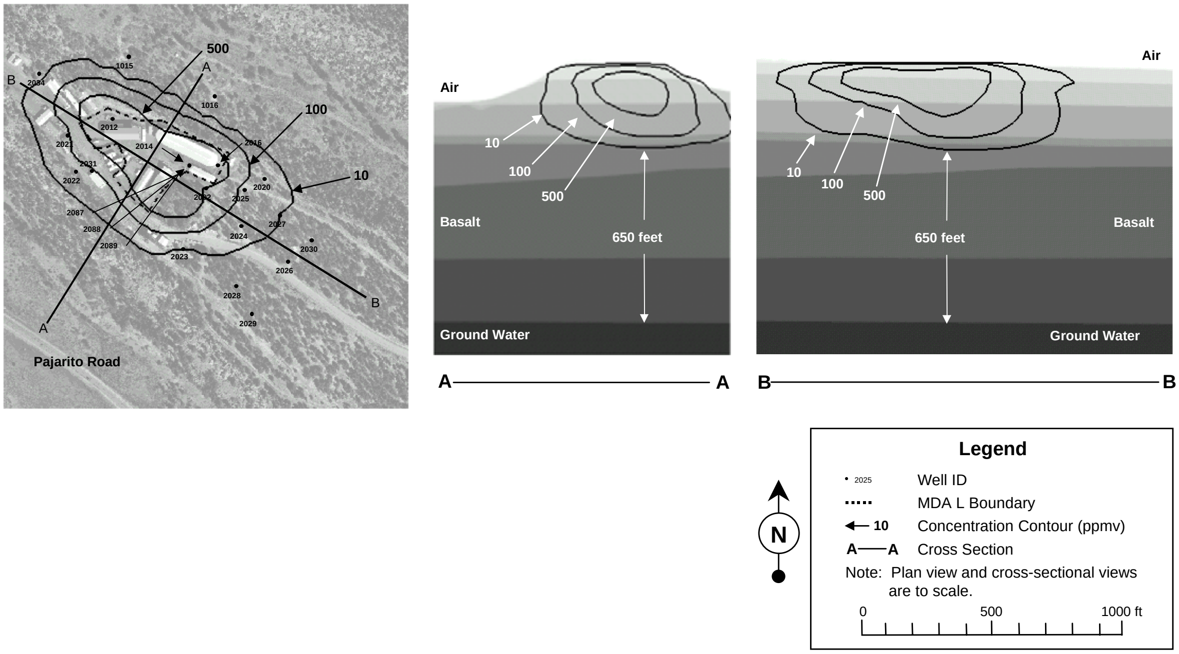
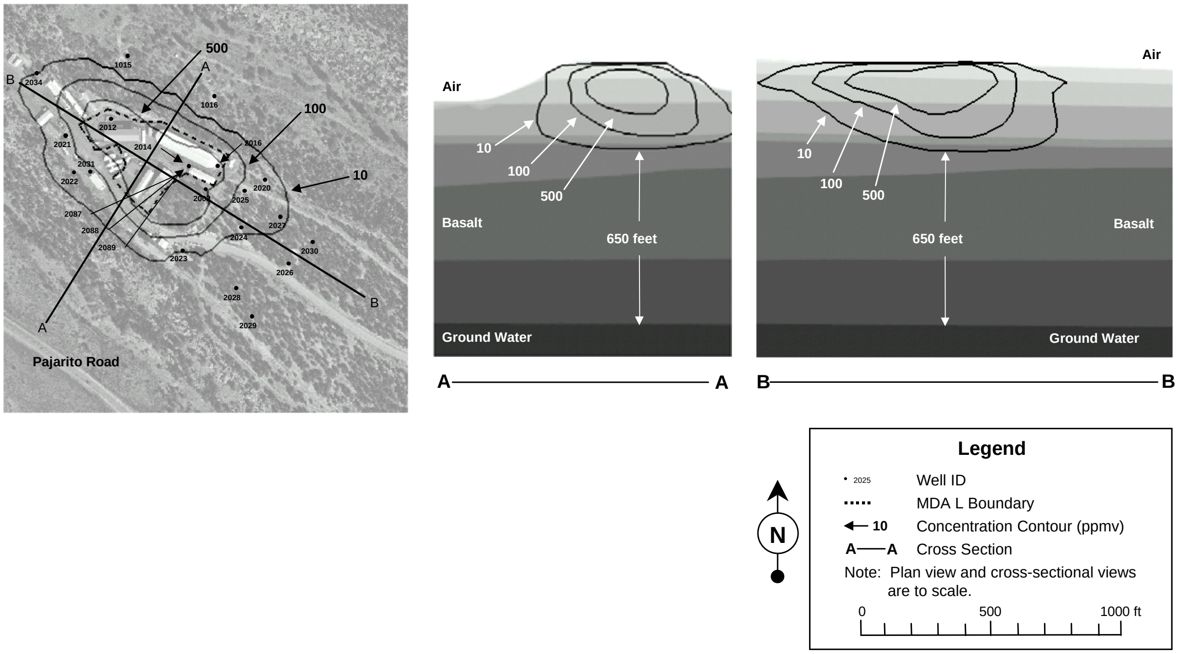


Figure G-2 (continued). **Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001**

MDA L Pore Gas Sampling
3rd Quarter - 2000



MDA L Pore Gas Sampling
4th Quarter - 2000

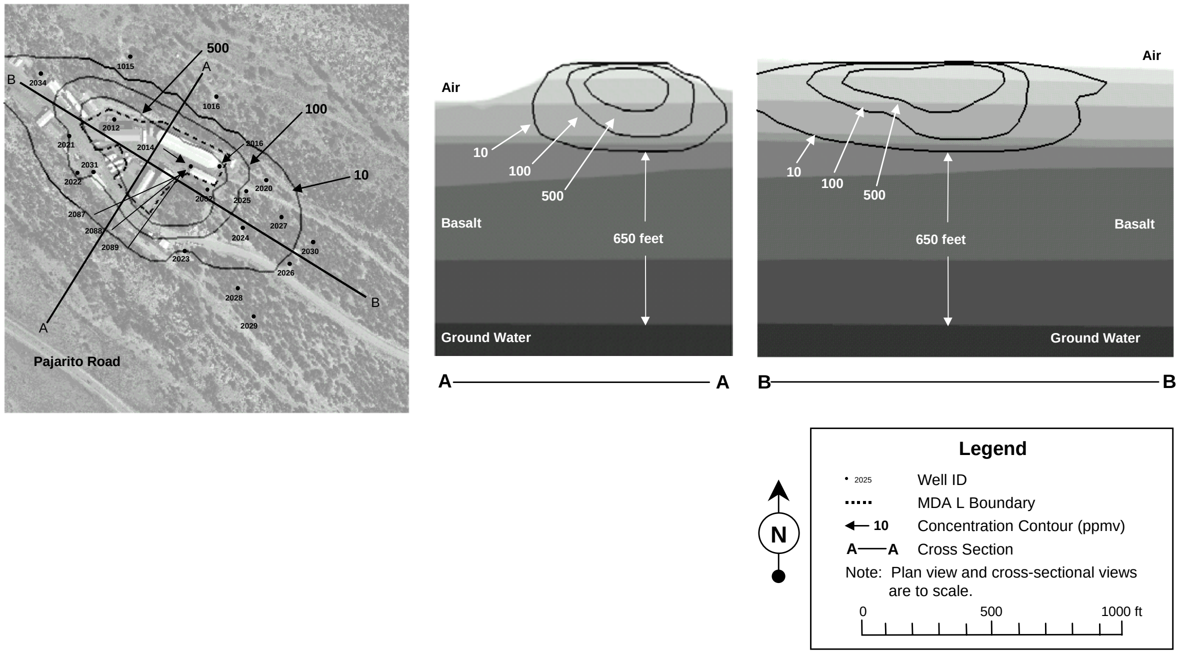
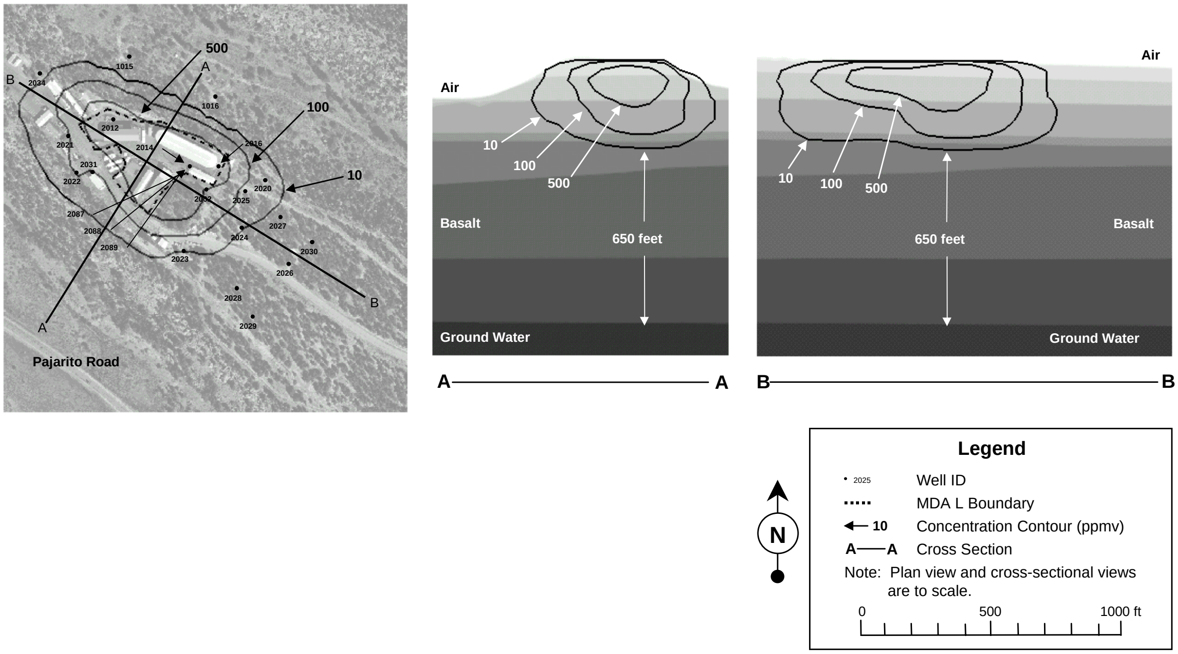


Figure G-2 (continued). Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001

MDA L Pore Gas Sampling
1st Quarter - 2001



MDA L Pore Gas Sampling
2nd Quarter - 2001

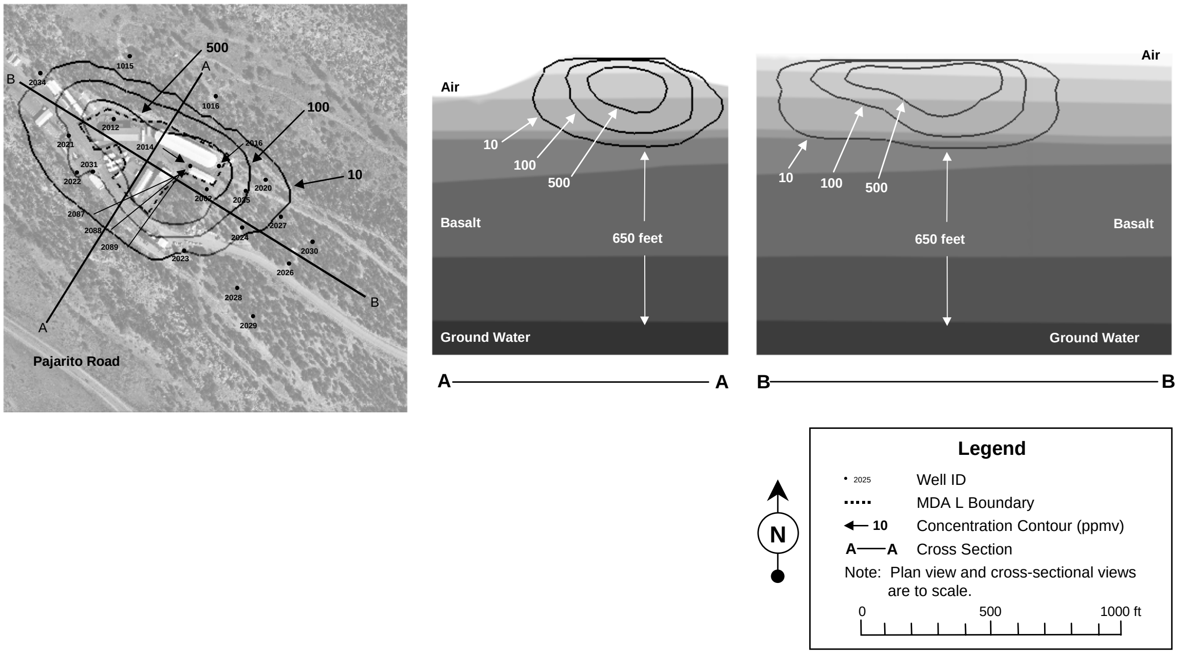
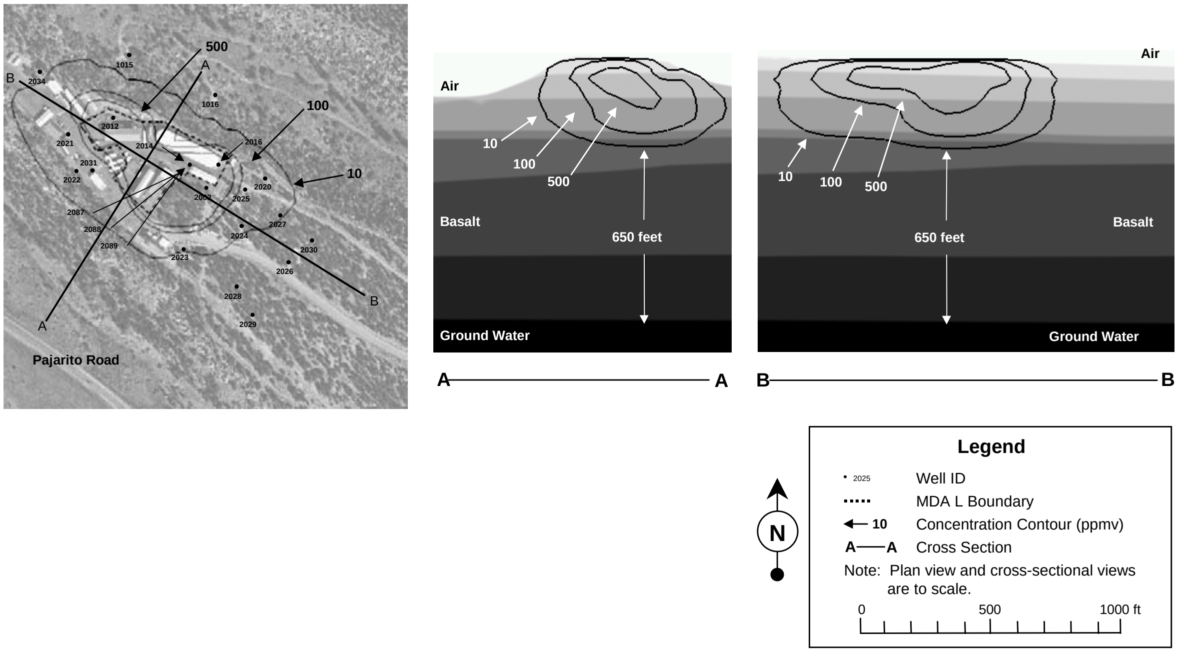


Figure G-2 (continued). **Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001**

MDA L Pore Gas Sampling
3rd Quarter - 2001



MDA L Pore Gas Sampling
4th Quarter - 2001

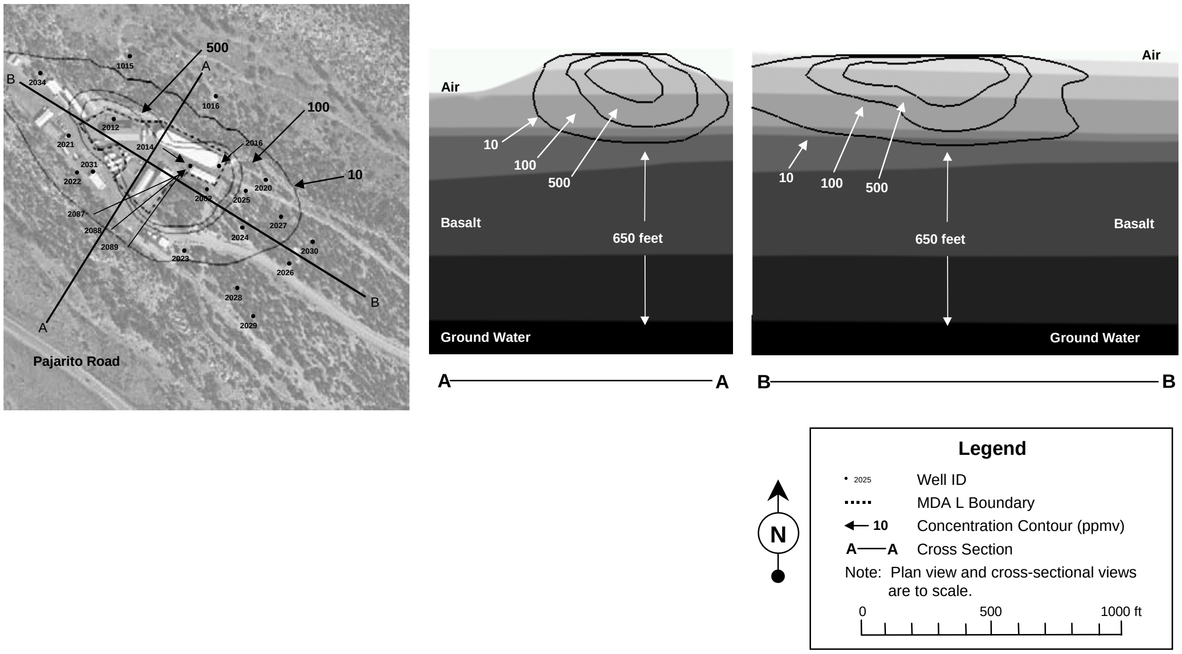


Figure G-2 (continued). Aerial and cross section views of the TCA plume at MDA L for the first quarter 1999 through fourth quarter 2001

Table G-1
Sample Port Depths in 1000- and 2000-Series Boreholes

Well Number	Sample Port Depth (ft from surface)	Well Number	Sample Port Depth (ft from surface)
54-01015 54-01016 54-02001	45, 187, 350, 385, 435, 485, 525 36, 188, 318, 390, 481, 533, 601 20, 40, 60, 80, 100, 130, 140, 160, 180, 200	54-02025	20, 60, 100, 160, 190
54-02002	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	54-02026	20, 60, 100, 160, 200, 215
54-02012	7, 27, 42,	54-02027	20, 60, 100, 160, 200, 220, 250
54-02014	13, 31, 46, 86	54-02028	20, 60, 100, 160, 200, 220, 250
54-02015	8, 31, 82	54-02029	20, 60, 100, 160, 200, 220, 260, 288
54-02016	7, 8, 31, 82	54-02030	20, 60, 100, 160, 200, 220, 243
54-02020	20, 40, 60, 80, 100, 130, 140, 160, 180, 200	54-02031	20, 60, 100, 160, 200, 220, 260
54-02021	20, 40, 60, 80, 100, 130, 140, 160, 180, 200	54-02034	60, 100, 160, 200, 220, 260, 300
54-02022	20, 40, 60, 80, 100, 120, 140, 160, 180, 197	54-02087	13, 31, 46, 86
54-02023	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	54-02088	13, 31, 46, 86
54-02024	20, 40, 60, 80, 100, 120, 140, 160, 180, 200	54-02089	13, 31, 46, 86

Table G-2
Chronology of Sampling and Analysis Methods

Time Frame	Sampling Method	Laboratory Method	Analysis Method	Analytes (number)
1988–1993	Single ampule GAC[a]	Fixed laboratory analytical method	SDGCMS[b]	12
1993–1996	Twin tube Tenax	Fixed laboratory analytical method	TDGCMS[c]	48
1993–present	Directly in real time	Field screening method	PAR[d]	5
1996–1997	Tedlar Bag	Fixed laboratory analytical method (used only once)	GCMS	60
1997–present	SUMMA™	Fixed laboratory analytical methods	EPA[e] TO-14	63

[a] GAC = granulated activated charcoal.

[b] SDGCMS = solvent desorption gas chromatograph/mass spectrometer.

[c] TDGCMS = thermal desorption gas chromatograph/mass spectrometer.

[d] PAR = photoacoustic radiometer.

[e] EPA = Environmental Protection Agency.

Table G-3
Methods for Detecting Pore-Gas Analytes

NIOSH VOST[a]		CST[b] Thermal Desorption EPA Method 8260		CST Tedlar Bag EPA Method 8260		ESE[c]/QST EPA TO-14 (SUMMA™)		TO-14 Short (SUMMA™)		TO-14 Long (SUMMA™) Current Analyte List	
Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name
		67-64-1	Acetone	67-64-1	Acetone	67-64-1	Acetone			67-64-1	Acetone
						75-05-8	Acetonitrile			75-05-8	Acetonitrile
						98-86-2	Acetophenone				
						107-02-8	Acrolein			107-02-8	Acrolein
						107-13-1	Acrylonitrile			107-13-1	Acrylonitrile
71-43-2	Benzene	71-43-2	Benzene	71-43-2	Benzene	71-43-2	Benzene	71-43-2	Benzene	71-43-2	Benzene
						100-47-0	Benzonitrile				
						100-44-7	Benzyl Chloride	100-44-7	Benzyl Chloride	100-44-7	Benzyl Chloride
108-86-1	Bromobenzene		Bromobenzene		Bromobenzene						
			Bromochloromethane		Bromochloromethane						
		75-27-4	Bromodichloromethane	75-27-4	Bromodichloromethane	75-27-4	Bromodichloromethane			75-27-4	Bromodichloromethane
		75-25-2	Bromoform	75-25-2	Bromoform	75-25-2	Bromoform			75-25-2	Bromoform
		74-83-9	Bromomethane	74-83-9	Bromomethane	74-83-9	Bromomethane	74-83-9	Bromomethane	74-83-9	Bromomethane
						106-99-0	Butadiene[1,3-]			106-99-0	Butadiene[1,3-]
						106-97-8	Butane[n-]			106-97-8	Butane[n-]
						71-36-3	Butanol[1-]			71-36-3	Butanol[1-]
		78-93-3	Butanone[2-]	78-93-3	Butanone[2-]	78-93-3	Butanone[2-]			78-93-3	Butanone[2-]
						106-98-9	Butene[1-]				
						590-18-1	Butene[cis-2-]				
						624-64-6	Butene[trans-2-]				
		75-15-0	Carbon Disulfide	75-15-0	Carbon Disulfide	75-15-0	Carbon Disulfide			75-15-0	Carbon Disulfide
56-23-5	Carbon Tetrachloride	56-23-5	Carbon Tetrachloride	56-23-5	Carbon Tetrachloride	56-23-5	Carbon Tetrachloride	56-23-5	Carbon Tetrachloride	56-23-5	Carbon Tetrachloride
						126-99-8	Chloro-1,3-butadiene[2-]				
						107-05-1	Chloro-1-propene[3-]			107-05-1	Chloro-1-propene[3-]
108-90-7	Chlorobenzene	108-90-7	Chlorobenzene	108-90-7	Chlorobenzene	108-90-7	Chlorobenzene	108-90-7	Chlorobenzene	108-90-7	Chlorobenzene

Table G-3 (continued)

NIOSH VOST[a]		CST[b] Thermal Desorption EPA Method 8260		CST Tedlar Bag EPA Method 8260		ESE[c]/QST EPA TO-14 (SUMMA^{TM})		TO-14 Short (SUMMA^{TM})		TO-14 Long (SUMMA¶) Current Analyte List	
Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name
		124-48-1	Chlorodibromomethane	124-48-1	Chlorodibromomethane	124-48-1	Chlorodibromomethane			124-48-1	Chlorodibromomethane
						75-45-6	Chlorodifluoromethane			75-45-6	Chlorodifluoromethane
		75-00-3	Chloroethane	75-00-3	Chloroethane	75-00-3	Chloroethane	75-00-3	Chloroethane	75-00-3	Chloroethane
67-66-3	Chloroform	67-66-3	Chloroform	67-66-3	Chloroform	67-66-3	Chloroform	67-66-3	Chloroform	67-66-3	Chloroform
		74-87-3	Chloromethane	74-87-3	Chloromethane	74-87-3	Chloromethane	74-87-3	Chloromethane	74-87-3	Chloromethane
						110-82-7	Cyclohexane			110-82-7	Cyclohexane
						108-94-1	Cyclohexanone				
						287-92-3	Cyclopentane				
						142-29-0	Cyclopentene				
										124-18-5	Decane[n-]
			Dibromomethane		Dibromomethane					74-95-3	Dibromomethane
						106-93-4	Dibromoethane[1,2-]	106-93-4	Dibromoethane[1,2-]	106-93-4	Dibromoethane[1,2-]
						76-14-2	Dichloro-1,1,2,2-tetrafluoroethane[1,2-]	76-14-2	Dichloro-1,1,2,2-tetrafluoroethane[1,2-]	76-14-2	Dichloro-1,1,2,2-tetrafluoroethane[1,2-]
		95-50-1	Dichlorobenzene[1,2-]	95-50-1	Dichlorobenzene[1,2-]	95-50-1	Dichlorobenzene[1,2-]	95-50-1	Dichlorobenzene[1,2-]	95-50-1	Dichlorobenzene[1,2-]
		541-73-1	Dichlorobenzene[1,3-]	541-73-1	Dichlorobenzene[1,3-]	541-73-1	Dichlorobenzene[1,3-]	541-73-1	Dichlorobenzene[1,3-]	541-73-1	Dichlorobenzene[1,3-]
		106-46-7	Dichlorobenzene[1,4-]	106-46-7	Dichlorobenzene[1,4-]	106-46-7	Dichlorobenzene[1,4-]	106-46-7	Dichlorobenzene[1,4-]	106-46-7	Dichlorobenzene[1,4-]
		75-71-8	Dichlorodifluoromethane	75-71-8	Dichlorodifluoromethane	75-71-8	Dichlorodifluoromethane	75-71-8	Dichlorodifluoromethane	75-71-8	Dichlorodifluoromethane
						75-34-3	Dichloroethane[1,1-]	75-34-3	Dichloroethane[1,1-]	75-34-3	Dichloroethane[1,1-]
		107-06-2	Dichloroethane[1,2-]	107-06-2	Dichloroethane[1,2-]	107-06-2	Dichloroethane[1,2-]	107-06-2	Dichloroethane[1,2-]	107-06-2	Dichloroethane[1,2-]
		75-35-4	Dichloroethene[1,1-]	75-35-4	Dichloroethene[1,1-]	75-35-4	Dichloroethene[1,1-]	75-35-4	Dichloroethene[1,1-]	75-35-4	Dichloroethene[1,1-]
		156-59-2	Dichloroethene[cis-1,2-]	156-59-2	Dichloroethene[cis-1,2-]	156-59-2	Dichloroethene[cis-1,2-]	156-59-2	Dichloroethene[cis-1,2-]	156-59-2	Dichloroethene[cis-1,2-]
		156-60-5	Dichloroethene [trans-1,2-]	156-60-5	Dichloroethene[trans-1,2-]	156-60-5	Dichloroethene[trans-1,2-]			156-60-5	Dichloroethene[trans-1,2-]
		78-87-5	Dichloropropane [1,2-]	78-87-5	Dichloropropane[1,2-]	78-87-5	Dichloropropane[1,2-]	78-87-5	Dichloropropane[1,2-]	78-87-5	Dichloropropane[1,2-]
		142-28-9	Dichloropropane [1,3-]	142-28-9	Dichloropropane[1,3-]	142-28-9	Dichloropropane[1,3-]				
			Dichloropropane [2,2-]		Dichloropropane[2,2-]						
			Dichloropropene [1,1-]		Dichloropropene[1,1-]						
		10061-01-5	Dichloropropene [cis-1,3-]	10061-01-5	Dichloropropene[cis-1,3-]	10061-01-5	Dichloropropene[cis-1,3-]	10061-01-5	Dichloropropene[cis-1,3-]	10061-01-5	Dichloropropene[cis-1,3-]
		10061-02-6	Dichloropropene [trans-1,3-]	10061-02-6	Dichloropropene[trans-1,3-]	10061-02-6	Dichloropropene[trans-1,3-]	10061-02-6	Dichloropropene[trans-1,3-]	10061-02-6	Dichloropropene[trans-1,3-]

Table G-3 (continued)

NIOSH VOST[a]		CST[b] Thermal Desorption EPA Method 8260		CST Tedlar Bag EPA Method 8260		ESE[c]/QST EPA TO-14 (SUMMA$^{\text{TM}}$)		TO-14 Short (SUMMA$^{\text{TM}}$)		TO-14 Long (SUMMA¶) Current Analyte List	
Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name
						60-29-7	Diethyl Ether			60-29-7	Diethyl Ether
						75-83-2	Dimethylbutane[2,2-]				
						79-29-8	Dimethylbutane[2,3-]				
						565-59-3	Dimethylpentane[2,3-]				
						123-91-1	Dioxane[1,4-]				
										112-40-3	Dodecane[n-]
						64-17-5	Ethanol				
						140-88-5	Ethyl Acrylate				
						637-92-3	Ethyl tert-Butyl Ether				
100-41-4	Ethylbenzene	100-41-4	Ethylbenzene	100-41-4	Ethylbenzene	100-41-4	Ethylbenzene	100-41-4	Ethylbenzene	100-41-4	Ethylbenzene
						142-82-5	Heptane			142-82-5	Heptane
						87-68-3	Hexachlorobutadiene	87-68-3	Hexachlorobutadiene	87-68-3	Hexachlorobutadiene
						110-54-3	Hexane			110-54-3	Hexane
						591-78-6	Hexanone[2-]			591-78-6	Hexanone[2-]
						7642-09-3	Hexene[cis-3-]				
						4050-45-7	Hexene[trans-2-]				
						75-28-5	Isobutane				
						540-84-1	Isooctane				
						78-78-4	Isopentane				
						78-79-5	Isoprene				
						98-82-8	Isopropylbenzene			98-82-8	Isopropylbenzene
						126-98-7	Methacrylonitrile				
						67-56-1	Methanol			67-56-1	Methanol
						80-62-6	Methyl Methacrylate				
						1634-04-4	Methyl tert-Butyl Ether			1634-04-4	Methyl tert-Butyl Ether
						563-45-1	Methyl-1-butene[3-]				
						763-29-1	Methyl-1-pentene[2-]				
						691-37-2	Methyl-1-pentene[4-]				
						513-35-9	Methyl-2-butene[2-]				

Table G-3 (continued)

NIOSH VOST[a]		CST[b] Thermal Desorption EPA Method 8260		CST Tedlar Bag EPA Method 8260		ESE[c]/QST EPA TO-14 (SUMMA™)		TO-14 Short (SUMMA™)		TO-14 Long (SUMMA¶) Current Analyte List	
Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name
		108-10-1	Methyl-2-pentanone [4-]	108-10-1	Methyl-2-pentanone [4-]	108-10-1	Methyl-2-pentanone [4-]			108-10-1	Methyl-2-pentanone [4-]
						108-87-2	Methylcyclohexane				
						96-37-7	Methylcyclopentane				
		75-09-2	Methylene Chloride	75-09-2	Methylene Chloride	75-09-2	Methylene Chloride	75-09-2	Methylene Chloride	75-09-2	Methylene Chloride
						592-27-8	Methylheptane[2-]				
						589-81-1	Methylheptane[3-]				
						591-76-4	Methylhexane[2-]				
						589-34-4	Methylhexane[3-]				
						107-83-5	Methylpentane[2-]				
						96-14-0	Methylpentane[3-]				
						98-83-9	Methylstyrene[alpha-]			98-83-9	Methylstyrene[alpha-]
										91-20-3	Naphthalene
						98-95-3	Nitrobenzene				
						79-46-9	Nitropropane[2-]				
						111-84-2	Nonane[1-]			111-84-2	Nonane[1-]
						111-65-9	Octane[n-]			111-65-9	Octane[n-]
						109-66-0	Pentane			109-66-0	Pentane
						109-67-1	Pentene[1-]				
						627-20-3	Pentene[cis-2-]				
						646-04-8	Pentene[trans-2-]				
						80-56-8	Pinene[alpha-]				
						127-91-3	Pinene[beta-]				
						67-63-0	Propanol[2-]				
						107-12-0	Propionitrile				
						103-65-1	Propylbenzene[1-]			103-65-1	Propylbenzene[1-]
			Propylbenzene[n-]		Propylbenzene[n-]						
						115-07-1	Propylene				
		100-42-5	Styrene	100-42-5	Styrene	100-42-5	Styrene	100-42-5	Styrene	100-42-5	Styrene
			Tetrachloroethane [1,1,1,2-]		Tetrachloroethane [1,1,1,2-]			630-20-6	Tetrachloroethane [1,1,1,2-]		

Table G-3 (continued)

NIOSH VOST[a]		CST[b] Thermal Desorption EPA Method 8260		CST Tedlar Bag EPA Method 8260		ESE[c]/QST EPA TO-14 (SUMMA™)		TO-14 Short (SUMMA™)		TO-14 Long (SUMMA¶) Current Analyte List	
Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name	Analyte Code	Analyte Name
		79-34-5	Tetrachloroethane [1,1,2,2-]	79-34-5	Tetrachloroethane [1,1,2,2-]	79-34-5	Tetrachloroethane [1,1,2,2-]	79-34-5	Tetrachloroethane [1,1,2,2-]	79-34-5	Tetrachloroethane [1,1,2,2-]
127-18-4	Tetrachloroethene	127-18-4	Tetrachloroethene	127-18-4	Tetrachloroethene	127-18-4	Tetrachloroethene	127-18-4	Tetrachloroethene	127-18-4	Tetrachloroethene
						109-99-9	Tetrahydrofuran				
108-88-3	Toluene	108-88-3	Toluene	108-88-3	Toluene	108-88-3	Toluene	108-88-3	Toluene	108-88-3	Toluene
			Trichlorotrifluoroethane		Trichlorotrifluoroethane						
						76-13-1	Trichloro-1,2,2-trifluoroethane[1,1,2-]	76-13-1	Trichloro-1,2,2-trifluoroethane[1,1,2-]	76-13-1	Trichloro-1,2,2-trifluoroethane[1,1,2-]
						120-82-1	Trichlorobenzene [1,2,4-]	120-82-1	Trichlorobenzene [1,2,4-]	120-82-1	Trichlorobenzene [1,2,4-]
71-55-6	Trichloroethane[1,1,1-]	71-55-6	Trichloroethane [1,1,1-]	71-55-6	Trichloroethane[1,1,1-]	71-55-6	Trichloroethane[1,1,1-]	71-55-6	Trichloroethane[1,1,1-]	71-55-6	Trichloroethane[1,1,1-]
		79-00-5	Trichloroethane [1,1,2-]	79-00-5	Trichloroethane[1,1,2-]	79-00-5	Trichloroethane[1,1,2-]	79-00-5	Trichloroethane[1,1,2-]	79-00-5	Trichloroethane[1,1,2-]
79-01-6	Trichloroethene	79-01-6	Trichloroethene	79-01-6	Trichloroethene	79-01-6	Trichloroethene	79-01-6	Trichloroethene	79-01-6	Trichloroethene
		75-69-4	Trichlorofluoromethane	75-69-4	Trichlorofluoromethane	75-69-4	Trichlorofluoromethane	75-69-4	Trichlorofluoromethane	75-69-4	Trichlorofluoromethane
95-63-6	Trimethylbenzene [1,2,4-]	95-63-6	Trimethylbenzene [1,2,4-]	95-63-6	Trimethylbenzene [1,2,4-]	95-63-6	Trimethylbenzene [1,2,4-]	95-63-6	Trimethylbenzene [1,2,4-]	95-63-6	Trimethylbenzene [1,2,4-]
		108-67-8	Trimethylbenzene [1,3,5-]	108-67-8	Trimethylbenzene [1,3,5-]	108-67-8	Trimethylbenzene [1,3,5-]	108-67-8	Trimethylbenzene [1,3,5-]	108-67-8	Trimethylbenzene [1,3,5-]
						565-75-3	Trimethylpentane [2,3,4-]				
										1120-21-4	Undecane[n-]
						108-05-4	Vinyl Acetate			108-05-4	Vinyl Acetate
		75-01-4	Vinyl Chloride	75-01-4	Vinyl Chloride	75-01-4	Vinyl Chloride	75-01-4	Vinyl Chloride	75-01-4	Vinyl Chloride
						95-47-6	Xylene[1,2-]	95-47-6	Xylene[1,2-]	95-47-6	Xylene[1,2-]
						108-38-3	Xylene[1,3-]				
1330-20-7	Xylene, mixed									1330-20-7	Xylene (Total)
			Xylene[m-]		Xylene[m-]						
			Xylene[o-]		Xylene[o-]						
			Xylene[p-]		Xylene[p-]						
								Xylene 1314	Xylene[1,3-] +Xylene[1,4-]		

[a] NIOSH VOST = National Institute of Occupational Safety and Health Volatile Organic Sample Train.
[b] CST = Chemical Science and Technology (Laboratory division).
[c] ESE = Environmental Science Engineering.

Table G-4
Maximum Contaminant Concentrations in the First Quarter of Fiscal Year 1997 (Tedlar Bag GCMS Method)

Compound	Well Number	Depth (ft)	Concentration (ppmv)
Trichloroethane[1,1,1-]	54-2088	31	6970
Trichloroethene	54-2087	31	367
Trichloro-1,2,2-trifluoroethane[1,1,2-]	54-2087	31	267
Dichloropropane[1,2-]	54-2088	31	90.8
Methylene Chloride	54-2014	13	74.4
Trichlorofluoromethane	54-2088	31	40.4
Dichloroethene[1,1-]	54-2088	31	39.1
Dichloroethane[1,2-]	54-2088	31	31.5
Dichloroethane[1,1-]	54-2089	31	20.1
Chloroform	54-2088	31	18.6
Diethyl Ether	54-2089	31	14.6
Cyclohexane	54-2088	31	12.1
Tetrachloroethene	54-2089	31	10.6
Trimethylbenzene[1,2,4-]	54-2014	13	7.92
Carbon Tetrachloride	54-2088	31	6.73
Toluene	54-2014	13	5.34
Chloromethane	54-2088	31	5.08
Benzene	54-2014	13	4.61
Hexane	54-2089	31	4.56
Methylcyclohexane	54-2088	31	3.53
Propylene	54-2089	31	3.48
Butane[n-]	54-2089	31	3.18
Methylcyclopentane	54-2088	31	3.18
Isobutane	54-2089	31	3.12
Butene[1-]	54-2089	31	2.68
Pentane	54-2089	31	2.68
Methylpentane[2-]	54-2088	31	2.33
Isooctane	54-2088	31	2.23
Dichlorodifluoromethane	54-2089	31	1.96
Chlorobenzene	54-2089	31	1.58
Heptane	54-2089	31	1.32
Methylhexane[3-]	54-2088	31	0.79
Xylene[1,2-]	54-2014	13	0.757
Isopentane	54-2088	31	0.68
Dimethylbutane[2,2-]	54-2088	31	0.44

Table G-4 (continued)

Compound	Well Number	Depth (ft)	Concentration (ppmv)
Butene[cis-2-]	54-2088	31	0.4
Dimethylbutane[2,3-]	54-2088	31	0.38
Methylheptane[3-]	54-2088	31	0.27
Cyclopentane	54-2014	13	0.221
Pentene[1-]	54-2014	13	0.217
Vinyl Chloride	54-2088	31	0.19
Ethylbenzene	54-2014	13	0.178
Octane[n-]	54-2014	13	0.165
Chloroethane	54-2014	13	0.162
Dichloroethene[trans-1,2-]	54-2087	31	0.162
Methylheptane[2-]	54-2088	31	0.15
Nonane[1-]	54-2088	31	0.14
Butene[trans-2-]	54-2088	31	0.12
Dichloroethene[cis-1,2-]	54-2088	31	0.11
Methyl-1-pentene[2-]	54-2087	31	0.108
Dichlorobenzene[1,4-]	54-2088	31	0.08
Methyl-2-butene[2-]	54-2088	31	0.07
Methylhexane[2-]	54-2088	31	0.07
Pentene[cis-2-]	54-2087	31	0.066
Methyl-1-butene[3-]	54-2087	31	0.062
Acetophenone	54-2014	13	0.052
Methyl-1-pentene[4-]	54-2087	31	0.048
Trimethylbenzene[1,3,5-]	54-2014	13	0.045
Chlorodifluoromethane	54-2014	13	0.038
Pentene[trans-2-]	54-2014	13	0.03
Isoprene	54-2087	31	0.02
Trichlorobenzene[1,2,4-]	54-2087	31	0.02
Pinene[alpha-]	54-2014	13	0.017
Bromomethane	54-2087	31	0.014
Tetrachloroethane[1,1,2,2-]	54-2014	13	0.012
Trimethylpentane[2,3,4-]	54-2014	13	0.012
Hexene[cis-3-]	54-2014	13	0.01
Isopropylbenzene	54-2014	13	0.009
Propylbenzene[1-]	54-2014	13	0.009
Dibromoethane[1,2-]	54-2014	13	0.007

Table G-5
Maximum Contaminant Concentrations in the Fourth Quarter of Fiscal Year 1999 (TO-14 Method) at MDA L

Compound	Well Number	Depth (ft)	Concentration (ppmv)
1,1,1-Trichloroethane	54-2012	28	2600
Trichloroethene	54-2012	28	2100
Methylene Chloride	54-2012	28	190
Trichloro-1,2,2-trifluoroethane[1,1,2-]	54-2089	31	160
Tetrachloroethene	54-2012	28	120
Dichloroethane[1,1-]	54-2012	28	82
Trichlorofluoromethane	54-2002	180	36
Chloroform	54-2002	180	14
Toluene	54-2002	180	9.9
Dichlorodifluoromethane	54-2034	160	0.044

Appendix H

Borehole Profiles and Logs

APPENDIX H BOREHOLE PROFILES AND LOGS

This appendix presents logs of boreholes 54-01001 through 54-01018 and profiles of boreholes 54-01001 through 54-01016 (Figures H-1 to H-16) drilled at Material Disposal Area L. The profiles depict the subsurface trajectories of the boreholes relative to adjacent subsurface disposal units, the stratigraphic units encountered during drilling, the location of samples taken from the core, and the pore-gas sample and monitoring port locations, where applicable.

Footages on the logs are the length along each borehole.

Figure H-17 presents a diagram showing pore-gas sampling port construction.

REFERENCE

The following list includes all references cited in this document. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of actual documents at the RRES-RS Records Processing Facility.

Broxton, D. E., and S. L. Reneau, August 1995. “Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory,” Los Alamos National Laboratory report LA-13010-MS, Los Alamos, New Mexico. (Broxton and Reneau 1995, 49726)

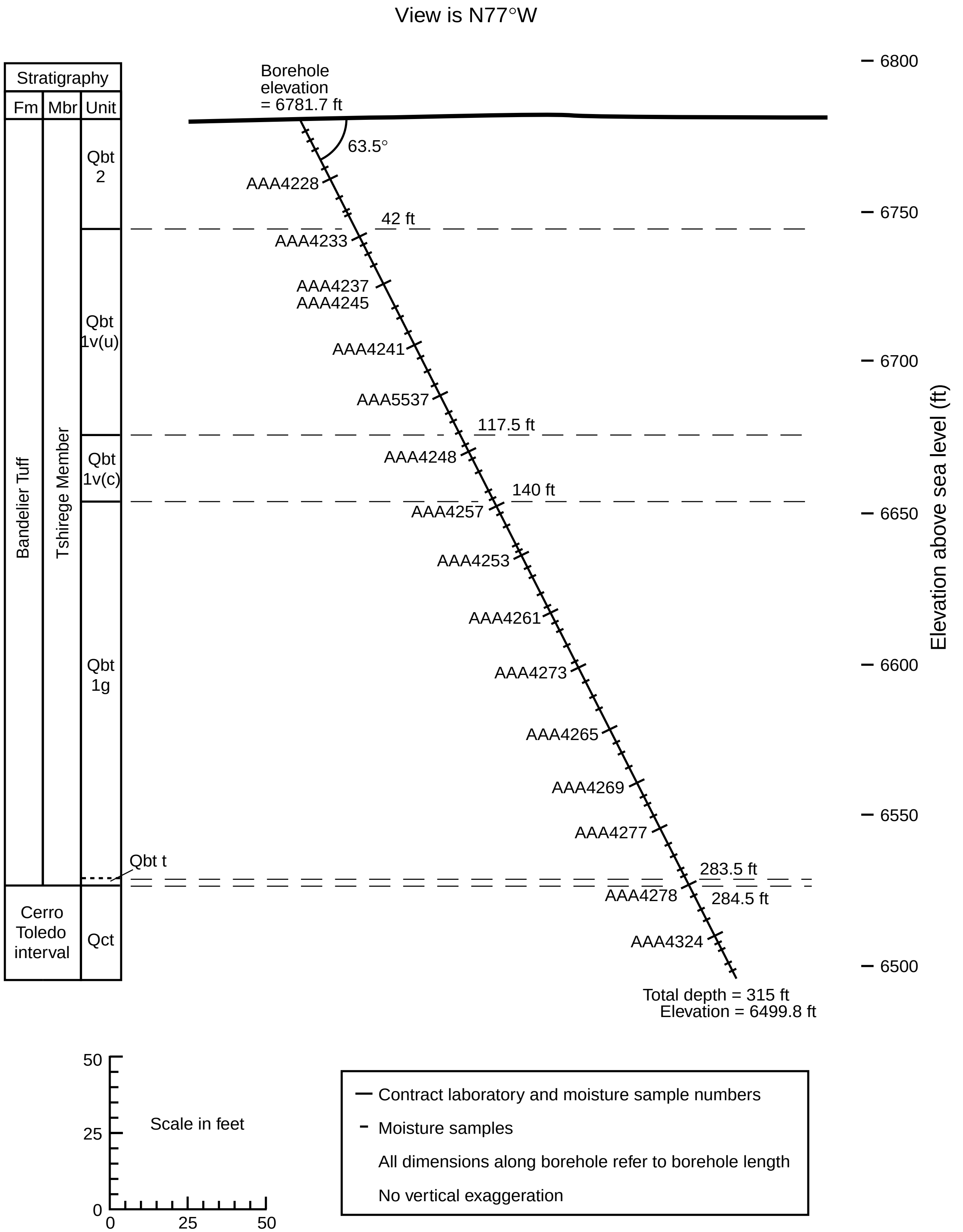
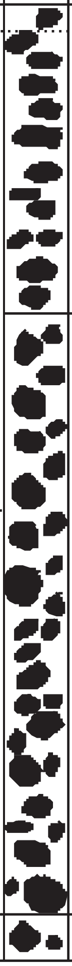


Figure H-1. **Profile of borehole 54-01001 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1001	TA/OU:	54/1148	MDA:	L	Page:	1 of 3
Drilling Co.:	Stewart Bros. Drilling	Core Box #(s)	39	Start Date:	9/9/93	End Date:	9/16/93
				Time:	15:45	Time:	14:55
Drilling Equip./Method:	Failing F-10/Hollow Stem Auger			Sampling Method:	Continuous 5.0 ft core barrel		
Driller:	Paul Garcia	Geologist:	Val Rhodes, Jon Marin, ERM/Golder	Declination:	63.5°	Bearing:	S 13.0° E
TD:	315.0 ft						

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100% 2/100%			1/0–6.2 ft 2/6.2–11.3 ft	0–1.1 ft TOPSOIL, brown organic clay 1.1–3.5 ft TUFF, oxidized, weathered 3.5–42.0 ft TUFF, pinkish gray 5 YR 8/1, moderately indurated, slightly welded, devitrified rhyolite ash flow tuff. Pumice lapilli are medium gray, 10–20%, 0.1–3.0 cm, avg. = 0.8 cm, sugary texture from minute quartz and sanidine crystals on relict tube structures. Pumice phenocrysts are euhedral quartz, 5–10%, 0.5–2.5 mm, avg. = 1.5 mm. Matrix phenocrysts are quartz (5%) and sanidine (5%) with Schiller blue iridescence, 0.5–1.0 mm. Lithics are rare, <1.0 cm, intermediate composition lavas (dacite).		Unit 2, Tshirege Member, Bandelier Tuff	Borehole is open below capped surface casing, capable of hosting Seamist flexible liner	Borehole 54-1001 is located in the formerly proposed MDA G development area east of MDA L. Surface casing set at 30.0 ft.
10	3/100% 4/100%			3/11.3–16.6 ft					
20	5/100% 6/100%	AAA4228		4/16.6–22.4 ft 5/22.4–27.8 ft					
30	7/100% 8/100%		1.5	6/27.8–35.0 ft 7/35.0–41.9 ft					At 3.0 ft, clay and decomposed roots on oxidized fracture; at 18.6 ft clay on oxidized fracture; at 20.2 ft and 22.6 ft weak limonite on fractures; at 32.5 ft moderate limonite and weak goethite on fracture; at 37.0 ft, moderate limonite on fracture; at 44.8 ft fresh fracture
40	9/70% 10/26%	AAA4233	0.2	8/41.9–52.0 ft	42.0–117.5 ft TUFF, light pinkish gray 5 YR 8/1, slightly indurated, non-welded devitrified ash flow tuff. Pumice lapilli are 10–15%, brownish gray, largest with light gray cores, 1.0 mm to 5.0 cm, sugary texture, 3% are finely devitrified light gray pumice lapilli, lithics are rare. Local light pinkish white fibrous clay alteration in pumice.		42.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff		
50	11/100% 12/100%	AAA4237	0.1	9/52.0–58.3 ft					
60	13/40% 14/50%	AAA4245	1.7 1.5	10/58.3–70.7 ft	At 65.0 ft TUFF, same as above (SAA), matrix is grayish pink 5 YR 8/2				
70	15/70% 16/50%		0.8 0.6	11/70.7–80.0 ft					
80	17/70% 18/70%	AAA4241	0.2 0.1	12/80.0–91.0 ft	At 87.0 ft TUFF, SAA, 90% of pumice lapilli are pale brown.				
90	19/100% 20/100%			13/91.0–100.0 ft					
100	21/100% 22/100% 23/100%	AAA5537	0.2	14/100.0–107.5 ft 15/107.5–112.5 ft					Multiple fractures are steeply dipping and fresh.
110	24/100% 25/100%		0.2 0.3	16/112.5–117.5 ft 17/117.5–123.5 ft	117.5–140.0 ft TUFF, moderately indurated		117.5 ft		
120									

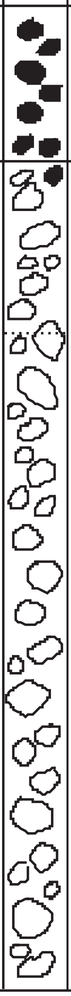
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1001 TA/OU: 54/1148 MDA: L Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 39 Start Date: 9/9/93 Time: 15:45 End Date: 9/16/93 Time: 14:55

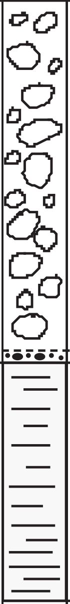
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, Jon Marin, ERM/Golder Declination: 63.5° Bearing: S 13.0° E TD: 315.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
120 130 140 150 160 170 180 190 200 210 220 230 240	26/80% 27/100% 28/90% 29/100% 30/100% 31/100% 32/100% 33/100% 34/100% 35/100% 36/40% 37/50% 38/30% 39/40% 40/80% 41/60% 42/50% 43/80% 44/60% 45/40% 46/80% 47/80% 48/60% 49/60% 50/80% 51/80% 52/80% 53/80% 54/60% 55/80% 56/80% 57/80% 58/80% 59/60% 60/40% 61/60% 62/40% 63/60%	AAA4248 AAA4257 AAA4253 AAA4261 AAA4273 AAA4265	1.7 0.1 0.1 3.1 0.1 0.1 0.1 0.4 0.1 0.1 0.2 0.2 0.1 0.1 0.2 0.2 0.1 0.2 0.1 0.1 0.2 0.1 0.1 0.1 0.1	17/Cont. 18/123.5–130.0 ft 19/130.0–134.8 ft 20/134.8–140.0 ft 21/140.0–145.3 ft 22/145.3–151.8 ft 23/151.8–157.5 ft 24/157.5–172.5 ft 25/172.5–189.5 ft 26/189.5–201.0 ft 27/201.0–210.0 ft 28/210.0–218.5 ft 29/218.5–227.5 ft 30/227.5–237.5 ft 31/237.5–245.5 ft	117.5–140.0 ft (continued) TUFF, light pinkish gray 5 YR 8/1, moderately indurated, nonwelded, devitrified ash flow, iron-rich chocolate brown pumice lapilli are 10–15%, 1.0–3.0 cm, dacite lithics are 5–10%, 1.0–3.0 cm. 140.0–161.0 ft TUFF grayish orange pink 5 YR 7/2, moderately indurated, nonwelded, vitric ash-flow tuff. Light olive gray 5 Y 5/2 vitric pumice lapilli are 10–15%, 0.5–2.0 cm with fully inflated tube structures, glassy resinous luster and up to 15% broken quartz phenocrysts to 1.0 mm. Quartz phenocrysts in matrix are 3%, up to 1.0 mm. Dacite lithics are 5–20%, 1.0 mm to 6.0 cm. 161.0–283.5 ft TUFF, SAA, vitric ash flow tuff, nonindurated to slightly indurated. Pumice lapilli contain minute magnetite crystals up to 1%. At 181.0 ft Pumices losing magnetite. At 185.0 ft TUFF, light brown 5 YR 6/4 nonindurated to slightly indurated, nonwelded to slightly welded, vitric ash-flow tuff. Pumice lapilli are very pale orange 10 YR 8/2, 0.1–4.0 cm, slightly deformed around 0.5–2.0 mm quartz. At 200.2 ft Pinkish gray 5YR 8/1 SAA vitric ash-flow tuff.		Unit 1v(c) 140.0 ft Unit 1g, Tshirege Member, Bandelier Tuff	Borehole is open below capped surface casing, capable of hosting Seamist flexible liner	At 117.5 ft, colonnade subunit of Broxton and Reneau (1995, 49726). At 136.8 ft, fracture coated with amorphous dessicated clay 2.0 mm thick; minute magnetite crystals 10% in tuff matrix to 0.3 mm from fracture. Vapor-phase notch at 140.0 ft. From 160.0–272.0 ft core recovery averages 62% due to non-indurated tuff. Fractures are not preserved if present.

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1001 TA/OU: 54/1148 MDA: L Page: 3 of 3
Drilling Co.: Stewart Bros. Drilling Core Box #(s) 39 Start Date: 9/9/93 Time: 15:45 End Date: 9/16/93 Time: 14:55
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel
Driller: Paul Garcia Geologist: Val Rhodes, Jon Marin, ERM/Golder Declination: 63.5° Bearing: S 13.0° E TD: 315.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
240	64/60%	AAA4269		31/Cont.	161.0–283.5 ft (continued)	TUFF, pinkish gray 5 YR 8/1, nonindurated, nonwelded, vitric, rhyolite ash flow tuff. Pumice lapilli are 10%, 0.1–4.0 cm, average 1.5 cm, light olive gray 5 Y 5/2 perpendicular to the fully inflated tube structures and resinous very pale orange 10 YR 8/2 parallel to the tube structures, quartz phenocrysts in pumice, 5%, 0.5–1.0 mm. Lithics are rare.		Unit 1g, Tshirege Member, Bandelier Tuff	Borehole is open below capped surface casing, capable of hosting Seamist flexible liner	Minute dark brown anhedral iron crystals in pumice lapilli are more visible perpendicular than parallel to the vitric tube structures.
	65/80%									
	66/75%			32/245.5–253.5 ft						
	67/83%		0.1							
250	68/80%		0.1							
	69/80%									
	70/60%			33/253.5–262.5 ft						
260	71/60%									
	72/60%	AAA4277								
	73/80%		0.1	34/262.5–270.4 ft						
	74/60%									
	75/100%									
270	76/80%									
	77/100%		0.3	35/270.4–280.0 ft						
	78/80%		0.1							
	79/100%									
280	80/80%		0.2							
	81/81%	AAA4278	0.2	36/280.0–291.2 ft	283.5–284.5 ft	Pumice BED, light gray, 100% vitric pumice, 0.1–4 cm		283.5 ft		At 283.5–284.5 ft Tsankawi Pumice Bed, Qbt t
	82/100%		0.2		284.5–315.0 ft	SEDIMENTS, pale yellowish brown 10 YR 6/2 to moderate yellowish brown 10 YR 5/4 nonindurated reworked ash with 10% white vitric pumice up to 1.0 cm		284.5 ft Cerro Toledo Interval		
290	83/100%		0.2							
	84/80%		0.1	37/291.2–300.5 ft	At 292.5 ft	SAND AND GRAVEL, light brownish gray 5 YR 6/1 medium- to coarse-grained rounded sand and fine gravel with 20% medium gray subrounded dacite pebbles				
	85/40%		0.2							
	86/60%				At 295.6 ft	SILT, pinkish gray 5 YR 8/1 poorly sorted, nonindurated, reworked ash with white vitric nonwelded pumice, 5–10%, up to 1 cm				
	87/60%		0.1							
300	88/40%	AAA4324	0.2	38/300.5–311.5 ft						
	89/100%		0.2							
	90/40%		0.1							
	91/80%									
310	92/60%		0.2	39/311.5–315.0 ft						
	93/60%		0.1		313.8–315.0 ft	COBBLES, medium light gray aphanitic dacite, 6.0 cm, 5% feldspar crystals up to 2.0 mm, pinkish gray rounded weakly oxidized quartzite, 6.0 cm				TD = 315.0 ft
320										
330										
340										
350										
360										

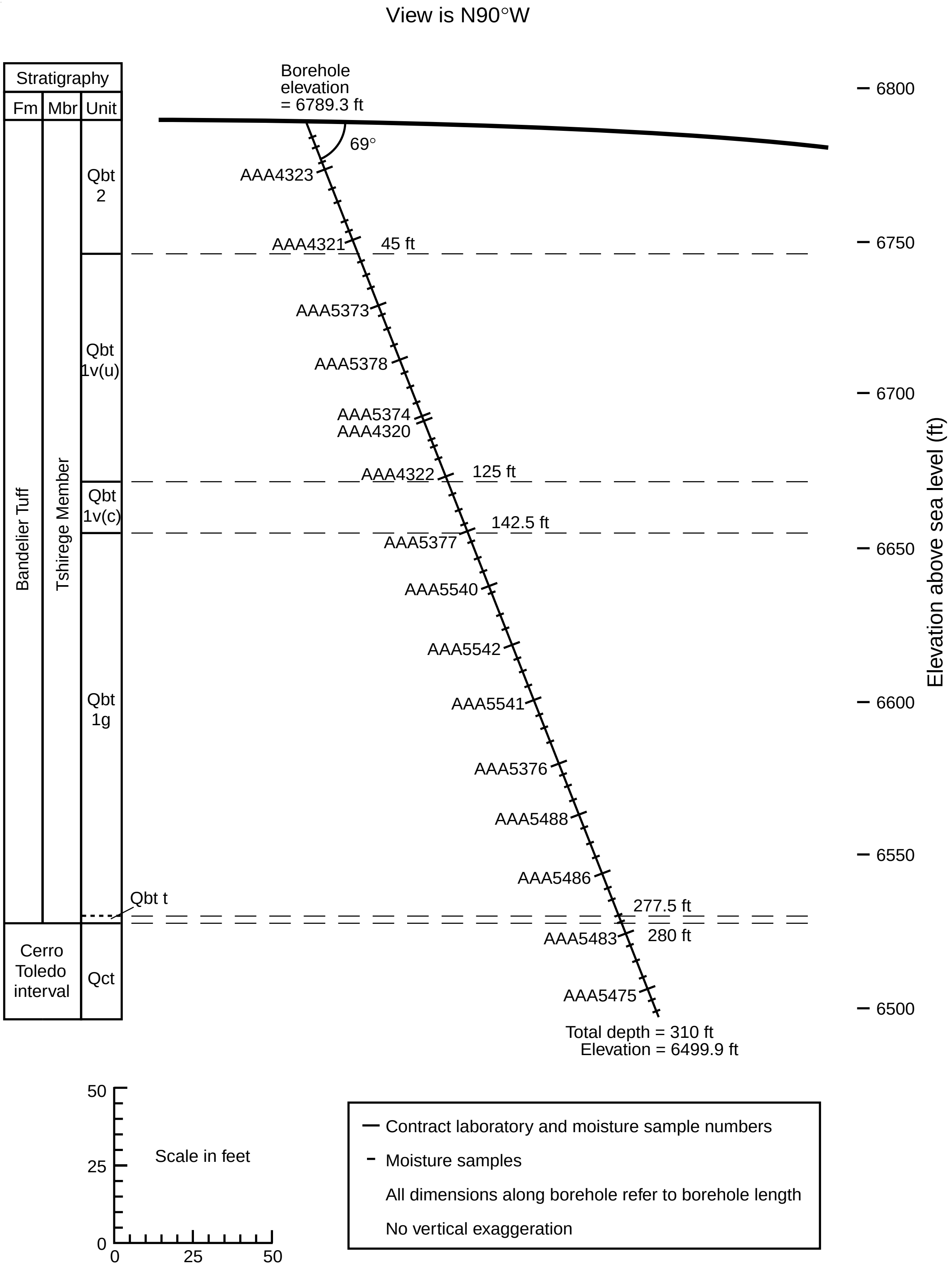


Figure H-2. **Profile of borehole 54-01002 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1002 TA/OU: 54/1148 MDA: L Page: 1 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 43 Start Date: 9/20/93 Time: 08:10 End Date: 9/23/93 Time: 17:00

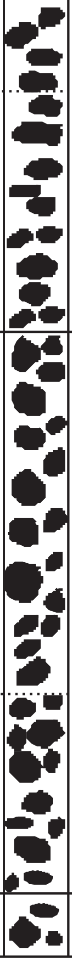
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 69.0° Bearing: South TD: 310.0 ft

Depth (feet)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (feet)
0	1/100%		2.2	1/0–6.2 ft
	2/100%			2/5.0–10.8 ft
10	3/100%		0.3	3/10.8–20.0 ft
	4/30%	AAA4323	0.1	
20	5/100%		0.4	4/20.0–25.4 ft
	6/100%		0.4	5/25.4–30.0 ft
30	7/100%			6/30.0–36.1 ft
	8/100%		0.2	7/36.1–41.3 ft
40	9/36%	AAA4321	0.1 0.1	8/41.3–50.0 ft
	10/100%		0.1	
50	11/100%			9/50.0–55.4 ft
	12/100%			10/55.4–61.0 ft
60	13/80%	AAA5373	0.2	11/61.0–68.2 ft
	14/100%		0.2	12/68.2–73.6 ft
70	15/100%			
	16/100%		0.1	13/73.6–79.8 ft
80	17/90%	AAA5378	0.1	14/79.8–86.3 ft
	18/100%			15/86.3–93.0 ft
90	19/100%		0.1 0.2	
	20/90%		0.2	16/93.0–99.0 ft
100	21/70%	AAA5374 AAA4320		17/99.0–107.5 ft
	22/100%		0.1	18/107.5–133.3 ft
110	23/100%		0.2	
	24/100%			19/113.3–119.4 ft
120				

Lithology	
0–2.0 ft	TOPSOIL, clay loam.
2.0–15.5 ft	TUFF, pinkish gray 5 YR 8/1, friable, fractured, nonwelded to slightly welded, devitrified ash flow, elongate pumice lapilli are 5–15%, 0.5–5.0 cm, sugary texture.
15.5–45.0 ft	TUFF, same as above (SAA), light grayish brown 5 YR 6/1, pumice lapilli are brown with gray cores, phenocrysts are quartz (20%) up to 1.0 mm and K-spar (15%) up to 0.3 mm with Schiller blue iridescence, dacite lithics rare (<2%).
45.0–90.0 ft	TUFF, moderate brown, nonwelded, devitrified, ash flow, pumice lapilli are brown with gray stripes, 5–12%, 1.0–10.0 cm, some pumice lapilli contain dark gray hornblende, relict tube structures are fully inflated, phenocrysts and lithics are SAA.
At 61.0 ft	Pumice SWARM, lapilli to 25%
At 62.0 ft	TUFF, SAA, light brownish gray 5 YR 6/1, some pumice are mottled light brown and pink
90.0–112.3 ft	TUFF, SAA, dull white to pinkish gray 5 YR 8/1, non-welded, light brown devitrified pumice lapilli are mottled, sugary, and friable with some spherulites, phenocrysts are 30% total, quartz and K-spar.
112.3–137.5 ft	TUFF, SAA, 30% pumice bombs to 7.0 cm, fractures

Graphic Log



Lithologic Unit	Seamist Monitor Well Construction	Notes
Unit 2, Tshirege Mbr, Bandelier Tuff	Seamist flexible liner	Borehole 54-1002 is located in the formerly proposed MDA G development area east of MDA L. Surface casing set at 30.0 ft
45.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff		Seamist vapor port at 57.8 ft Seamist vapor ports at 78.9 ft and 97.5 ft; at 112.3 ft, colonnade subunit of Broxton and Reneau (1995, 49726);
112.3 ft Qbt 1v(c)		Seamist vapor port at 117.0 ft

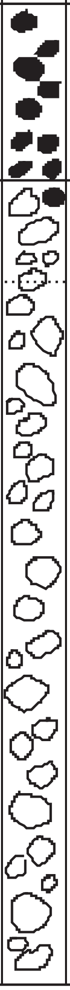
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1002　TA/OU: 54/1148　MDA: L　Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling　Core Box #(s) 43　Start Date: 9/20/93 Time: 08:10　End Date: 9/23/93 Time: 17:00

Drilling Equip./Method: Failing F-10/Hollow Stem Auger　Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia　Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder　Declination: 69.0°　Bearing: South　TD: 310.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist“ Monitor Well Construction	Notes
120 130 140 150 160 170 180 190 200 210 220 230 240	25/50% 26/100% 27/100% 28/100% 29/50% 30/100% 31/100% 32/80% 33/80% 34/30% 35/20% 36/60% 37/60% 38/80% 39/72% 40/80% 41/80% 42/80% 43/72% 44/80% 45/80% 46/100% 47/100% 48/60% 49/80% 50/100% 51/80% 52/60% 53/80% 54/60% 55/80% 56/100% 57/80% 58/100% 59/80% 60/68% 61/80% 62/68% 63/80%	AAA4322 AAA5377 AAA5540 AAA5542 AAA5541 AAA5376	0.2 0.7 0.1 0.5 0.2 0.1 0.2 0.2 0.1 0.1 0.2 0.3 0.1 0.2 0.2 0.4 0.3 0.2 0.1 0.2 0.1 0.3 0.4 0.4 0.3 1.2 0.1	20/119.4–128.6 ft 21/–133.5 ft 22/133.5–139.0 ft 23/139.0–147.8 ft 24/147.8–153.0 ft 25/153.0–159.0 ft 26/159.0–171.0 ft 27/171.0–181.0 ft 28/181.0–188.7 ft 29/188.7–197.5 ft 30/197.5–209.5 ft 31/209.5–218.5 ft 32/218.5–226.2 ft 33/226.2–234.5 ft 34/234.5–241.0 ft	112.4–142.5 ft (continued) TUFF, SAA, lithics <1%. TUFF, SAA, pumice lapilli are brown to orange, mottled, phenocrysts are iron stained, dacite lithics are 2–5%. At 137.5 ft TUFF, SAA, pale grayish orange pink 10 YR 8/2 142.5–155.0 ft TUFF, vitric, grayish orange pink 10 YR 8/2, nonwelded, ash flow, pumice lapilli are vitreous and silky, 20% total 155.0–277.5 ft in two types, (1) dark green brown, crystal rich, 2.0–12.0 cm, (2) olive gray, crystal poor, 0.5–3.0 cm, phenocrysts are euhedral, quartz and K-spar with Schiller blue iridescence, 25% total, dacite lithics are 1–5%. TUFF, SAA, nonindurated, moderate orange pink 5 YR 8/4 to light brown 5 YR 6/4, pumice lapilli decrease to 5–10%, phenocrysts are SAA, 35–40%, dacite lithics are 2–5%. At 205.0 ft TUFF, SAA, very pale orange 10 YR 8/2 to pale yellowish brown 10 YR 6/2 At 212.5 ft TUFF, SAA, grayish orange pink to very pale orange 10 YR 8/2, pumice are light tan to white		Unit 1v(c), Tshirege Mbr. 142.5 ft Unit 1g, Tshirege Member, Bandelier Tuff	Seamist flexible liner	Seamist vapor port at 128.8 ft Seamist vapor port at 140.8 ft; vapor-phase notch at 142.5 ft Seamist vapor port at 157.8 ft Seamist vapor port at 178.8 ft; From 155.0–277.5 ft, core recovery averages 73% due to non-indurated tuff Seamist vapor ports at 201.7 ft and 224.6 ft

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1002 TA/OU: 54/1148 MDA: L Page: 3 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 43 Start Date: 9/20/93 Time: 08:10 End Date: 9/23/93 Time: 17:00

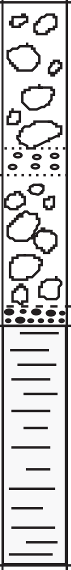
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 69.0° Bearing: South TD: 310.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
240	64/60%			
	65/60%	AAA5488		35/241.0–248.5 ft
	66/60%		0.1	
	67/80%			
250	68/72%		0.2	36/248.5–255.6 ft
	69/80%		0.2	
	70/60%		0.1	
	71/60%		0.1	37/255.6–263.0 ft
260	72/60%	AAA5486	0.1	
	73/60%			38/263.0–270.6 ft
	74/80%		0.2	
	75/100%		0.1	
270	76/60%			39/270.6–277.5 ft
	77/60%		0.1	
	78/80%		0.2	
	79/80%		0.2	40/277.5–282.5 ft
280	80/100%		0.1	
	81/60%	AAA5483	0.1	41/282.5–291.1 ft
	82/68%		1.4	
	83/52%			
290	84/80%		0.5	
	85/60%		0.3	42/291.1–305.0 ft
	86/0%		0.1	
	87/60%		0.2	
300	88/60%	AAA5475		
	89/0%		0.4	
	90/80%		0.3	43/305.0–310.0 ft
	91/80%		0.2	
310				
320				
330				
340				
350				
360				

Lithology		Lithologic Unit	Seamist“ Monitor Well Construction	Notes
155.0–277.5 ft (continued)	TUFF, SAA, nonindurated, nonwelded, ash flow, pumice lapilli are 5%, phenocrysts are 20%, lithics are 2%.	Unit 1g, Tshirege Mbr., Bandelier Tuff	Seamist flexible liner	
At 258.0 ft	Pumice SWARM, bombs up to 7.0 cm, 12%			
At 261.0 ft	TUFF, SAA, nonindurated, nonwelded			
	Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm,			Seamist vapor port at 274.4 ft,
277.5–280.0 ft	some interlayered ash	277.5 ft Qbt t 280.0’		at 277.5–280.0 ft Tsankawi Pumice Bed, Qbt t
280.0–310.0 ft	SEDIMENTS, silt, sand, laminated, interlayered poorly to well sorted, moderate brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel-sized reworked phenocrysts and lithics from 0–40%, local cobbles and boulders	Cerro Toledo Interval		Seamist vapor port at 304.3 ft
TD = 310.0 ft				

Graphic Log



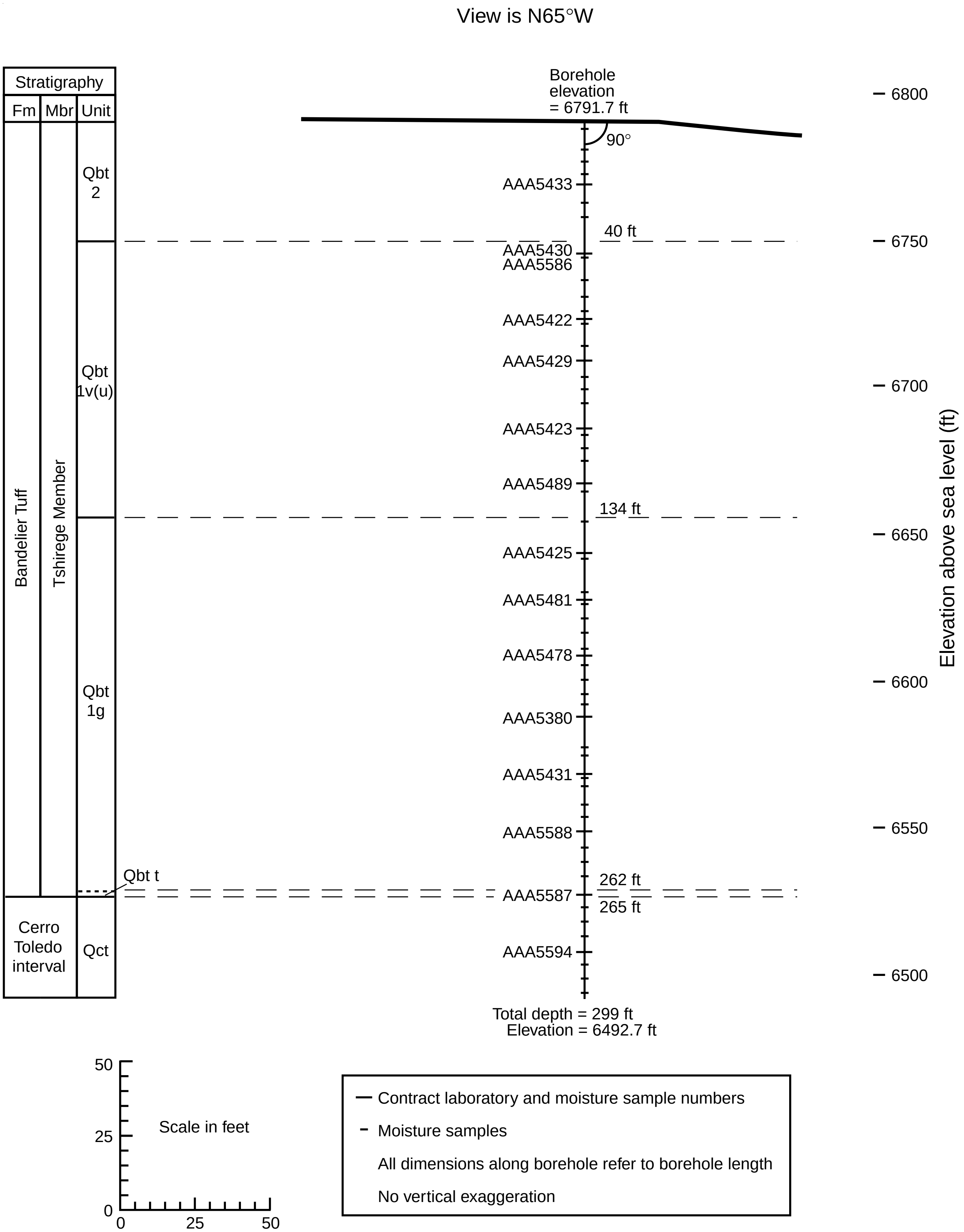


Figure H-3. Profile of borehole 54-01003 showing subsurface sample locations

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1003	TA/OU: 54/1148	MDA: L	Page: 1 of 3
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 37	Start Date: 10/4/93 Time: 09:10	End Date: 10/7/93 Time: 17:30
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Paul Garcia	Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination: 90.0° Bearing: NA	TD: 299.0 ft

Depth (ft): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120

Core Run # / Core Recovery %
1/60%
2/100%
3/100%
4/100%
5/100%
6/100%
7/60%
8/100%
9/100%
10/100%
11/100%
12/100%
13/100%
14/100%
15/50%
16/50%
17/90%
18/100%
19/100%
20/100%
21/100%
22/100%
23/100%
24/100%

Field Analytical Sample Number
AAA5433
AAA5430 AAA5586
AAA5422
AAA5429
AAA5423

Field Screening VOCs (ppm) > Background
9.1
1.4
0.2
0.1
0.3
0.1
0.4
0.3
0.3
2.0
0.8
1.0
0.7
0.6
0.6
0.8
0.7
0.3
0.4
0.4
0.5
0.4
0.6
0.8

Core Box # From - To (ft)
1/0–8.1 ft
2/8.1–13.4 ft
3/13.4–18.6 ft
4/18.6–24.5 ft
5/24.5–29.0 ft
6/29.0–40.3 ft
7/40.3–47.0 ft
8/47.0–52.5 ft
9/52.5–57.6 ft
10/57.6–64.2 ft
11/64.2–71.3 ft
12/71.3–84.5 ft
13/84.5–92.0 ft
14/92.0–97.5 ft
15/97.5–103.1 ft
16/103.1–109.0 ft
17/109.0–113.5 ft
18/113.5–119.0 ft

Lithology	
0–2.1 ft	SOIL, unconsolidated tuff
2.1–40.0 ft	TUFF, pinkish gray 5 YR 8/1, fractured, stained, devitrified ash flow, pumice lapilli are medium dark gray, 1.0 mm to 1.5 cm, 20–25%, relict tubes structures preserved with sugary texture, phenocrysts are quartz and K-spar, 20–25% total (15%), dacite lithics rare (<1%).
40.0–114.0 ft	TUFF, very light gray N8, devitrified ash flow, pumice lapilli are same as above (SAA) and light to dark gray, phenocrysts and lithics are SAA.
At 57.0 ft	TUFF, SAA, pinkish gray to light brownish gray 5 YR 6/1 ash flow, pumice lapilli are gray, 35–40%, 1.5 to 6.0 cm, mottled light to dark green, some faint light blue cores.
At 60.0 ft	TUFF, SAA, unconsolidated (nonindurated), some pumice lapilli contain light pink clay on relict tube structures
At 90.0 ft	TUFF, SAA, heavily fractured, some clay in weathered fractures, pumice lapilli are brown, mottled blue and light to dark greenish grays.
At 105.0 ft	TUFF, SAA, very friable (nonindurated), lapilli are 35–40%, 1.5 to 5.0 cm, brown orange, mottled light to dark gray.
114.0–134.0 ft	TUFF, slightly indurated, clay in fracture at 117.2–117.5 ft

Graphic Log

Lithologic Unit
Unit 2, Tshirege Mbr, Bandelier Tuff
40.0 ft
Unit 1v, Tshirege Member, Bandelier Tuff
114.0 ft
Qbt 1v(c)

Seamist“ Monitor Well Construction: Seamist“ flexible liner

Notes
Borehole 54-1003 is located in the formerly proposed MDA G development area east of MDA L.
Surface casing set at 30.0 ft
Seamist vapor port at 35.8 ft
Seamist vapor port at 48.3 ft
Seamist vapor port at 62.4 ft
Seamist vapor port at 79.4 ft
Seamist vapor port at 94.4 ft, Seamist vapor port at 116.6 ft, at 114.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726)

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1003 TA/OU: 54/1148 MDA: L Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 37 Start Date: 10/4/93 End Date: 10/7/93

Time: 09:10 Time: 17:30

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 90.0° Bearing: NA TD: 299.0 ft

Depth (ft)
120
130
140
150
160
170
180
190
200
210
220
230
240

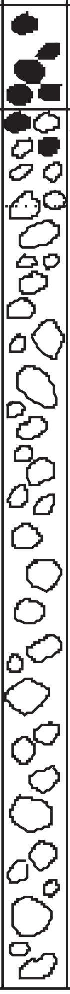
Core Run # Core Recovery %
25/100%
26/100%
27/0%
28/40%
29/100%
30/0%
31/100%
32/40%
33/100%
34/100%
35/100%
36/100%
37/80%
38/90%
39/100%
40/100%
41/80%
42/100%
43/100%
44/100%
45/100%
46/100%
47/80%
48/100%
49/0%
50/100%
51/100%
52/100%
53/100%
54/100%
55/60%
56/80%
57/96%
58/100%
59/52%
60/72%

Field Analytical Sample Number
AAA5489
AAA5425
AAA5481
AAA5478
AAA5380
AAA5431

Field Screening VOCs (ppm) > Background
0.6
0.7
0.6
0.5
1.7
1.5
4.1
2.5
3.7
2.3
2.3
2.2
3.6
2.7
2.6
2.5
2.2
1.6
1.3
1.4
1.5
1.3
1.1
1.0
1.1
0.9
0.7
0.6
0.4

Core Box # From - To (ft)
19/119.0–124,4 ft
20/124.4–134.0 ft
21/134.0–146.5 ft
22/146.5–157.0 ft
23/157.0–164.0 ft
24/164.0–172.5 ft
25/172.5–180.8 ft
26/180.8–190.0 ft
27/190.0–197.5 ft
28/197.5–210.0 ft
29/210.0–218.5 ft
30/218.5–227.5 ft
31/227.5–238.5 ft

Lithology	
114.0–134.0 ft (continued)	TUFF, pinkish gray 5 YR 8/1 to grayish pink 5 YR 8/2 devitrified ash flow, pumice lapilli are brown to orange, 20–25%, phenocrysts are 20% and iron stained, lithics are 2–7%.
134.0–145.0 ft	TUFF, SAA, vitric, moderate orange pink 5 YR 8/4, pumice lapilli are crystal rich, 20–25%, 1.5 to 3.0 cm, tan, brown, and gray, tube structures are inflated, phenocrysts are 30%, lithics are 5–7%.
145.0–262.0 ft	TUFF, vitric, light brown 5 YR 6/4, unconsolidated (non-indurated) ash flow, pumice lapilli are 20%, phenocrysts are 25%, lithics are 5–10%.
At 198.0 ft	TUFF, SAA, grayish orange pink to lt. brown

Graphic Log


Lithologic Unit
Qbt 1v(c)
134.0 ft
Unit 1g, Tshirege Member, Bandelier Tuff

Seamist Monitor Well Construction
Seamist flexible liner

Notes
Seamist vapor port at 124.0 ft
Seamist vapor port at 136.0 ft, vapor-phase notch at 142.5 ft
Seamist vapor port at 155.8 ft
Seamist vapor port at 173.8 ft
Seamist“ vapor port at 225.5 ft.

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1003	TA/OU: 54/1148	MDA: L	Page: 3 of 3
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 37	Start Date: 10/4/93 Time: 09:10	End Date: 10/7/93 Time: 17:30
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Paul Garcia	Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination: 90.0° Bearing: NA	TD: 299.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
240	61/60%	AAA5588	0.2	
	62/72%		0.2	32/238.5–250.0 ft
	63/72%		0.2	
250	64/72%		0.5	
	65/64%		0.2	33/250.0–257.5 ft
	66/92%		0.8	
	67/80%			
260	68/60%		0.9	34/257.5–270.5 ft
	69/68%	AAA5587	1.0	
	70/60%		1.0	
	71/100%		0.9	
270	72/60%			
	73/75%		0.8	35/270.5–282.5 ft
	74/70%		0.7	
	75/80%		0.6	
280	76/80%			
	77/60%		0.5	
	78/84%	AAA5594	0.6	36/282.5–292.5 ft
	79/60%		0.5	
290	80/64%		0.5	
	81/72%		0.4	37/292.5–296.5 ft
	82/92%		0.3	
	83/60%			
300	84/0%			
310				
320				
330				
340				
350				
360				

Lithology

145.0–262.0 ft (continued) TUFF, SAA, grayish pink 5 R 8/2 ash flow, pumice lapilli are 10%, phenocrysts are 25–30%, lithics are <1%.

262.0–265.0 ft Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm, some interlayered ash.

265.0–299.0 ft SEDIMENTS, laminated, interlayered poorly to well-sorted, moderate brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel-sized reworked phenocrysts and lithics, 0–40%, local cobbles and boulders

TD = 299.0 ft

Graphic Log

Lithologic Unit

Unit 1g

262.0 ft

Qbt t

265.0 ft

Cerro Toledo Interval

Seamist Monitor Well Construction

Seamist flexible liner

Notes

At 262.0–265.0 ft Tsankawi Pumice Bed, Qbt t

Seamist vapor port at 295.2 ft

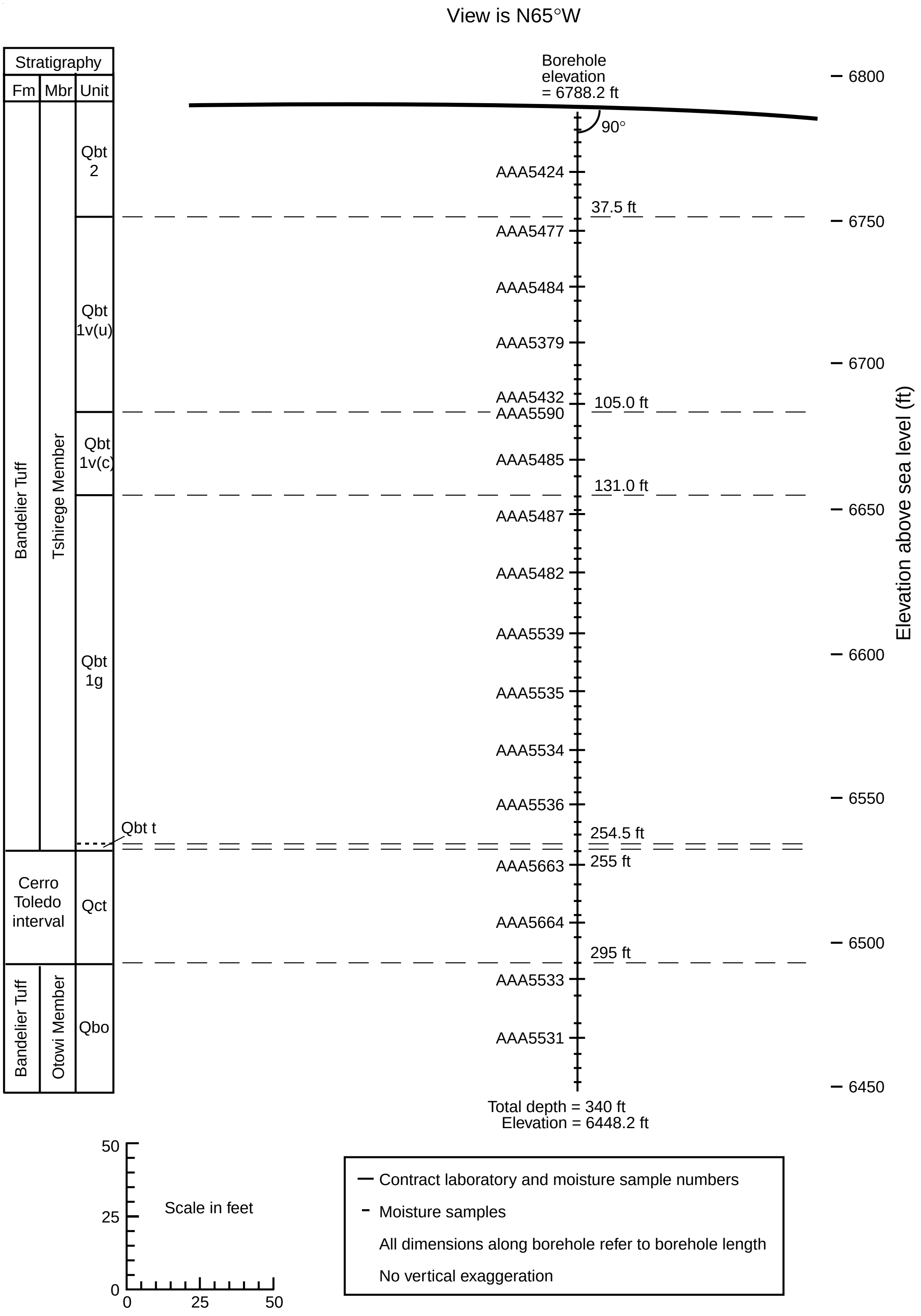


Figure H-4. **Profile of borehole 54-01004 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1004	TA/OU:	54/1148	MDA:	L	Page:	1 of 3
Drilling Co.:	Stewart Bros. Drilling	Core Box #(s)	36	Start Date:	10/8/93	End Date:	10/14/93
				Time:	13:15	Time:	11:45
Drilling Equip./Method:	Failing F-10/Hollow Stem Auger			Sampling Method:	Continuous 5.0 ft core barrel		
Driller:	Paul Garcia	Geologist:	Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination:	90.0°	Bearing:	NA
TD:	340.0 ft						

Depth (ft): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120

Core Run # / Core Recovery %
1/100%
2/100%
3/100%
4/100%
5/100%
6/100%
7/50%
8/60%
9/64%
10/100%
11/0%
12/0%
13/40%
14/80%
15/80%
16/40%
17/60%
18/80%
19/100%
20/100%
21/75%
22/100%
23/100%
24/60%
25/100%
26/100%
27/80%
28/80%
29/100%
30/80%
31/60%
32/100%
33/80%
34/80%
35/60%
36/80%

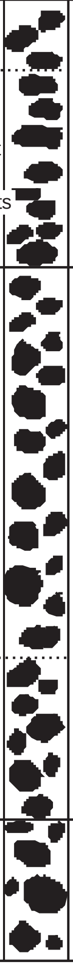
Field Analytical Sample Number
AAA5424
AAA5477
AAA5484
AAA5379
AAA5432
AAA5590

Field Screening VOCs (ppm) > Background
0.5
9.1
3.6
2.1
10.6
4.1
3.8
7.3
3.1
18.1
9.2
19.6
5.0
7.1
6.7
3.9
14.4
6.7
5.2
7.0
17.5

Core Box # From - To (ft)
1/0–5.8 ft
2/5.8–12.5 ft
3/12.5–18.7 ft
4/18.7–25.0 ft
5/25.0–30.0 ft
6/30.0–37.8 ft
7/37.8–47.5 ft
8/47.5–60.8 ft
9/60.8–70.0 ft
10/70.0–78.3 ft
11/78.3–87.5 ft
12/87.5–95.0 ft
13/95.0–105.8 ft
14/105.8–114.5 ft
15114.5–125.0 ft
16/125.0–135.0 ft

Lithology	
0–1.5 ft	SOIL, moderate brown, with tuff.
1.5–12.5 ft	TUFF, light gray, crystal rich, fractured, slightly welded, devitrified ash flow, elongate pumice lapilli are 5–15%, 1.0–10.0 cm, sugary texture.
12.5–37.5 ft	TUFF, same as above (SAA), light pinkish brown, pumice lapilli are brown with gray cores, phenocrysts are quartz and K-spar (20–25%) up to 1.0 mm, lithics <1%.
37.5–85.0 ft	TUFF, light pinkish brown to light brownish gray 5 YR 6/1, nonwelded, devitrified, ash flow, pumice lapilli are brown with gray to blue patches, 5–12%, 0.5–6.0 cm, relict tube structures are preserved as a sugary texture, phenocrysts are quartz (1.0 cm) and sanidine (0.2 cm), 20–25% total, lithics are dacite 1.0–6.0 cm, 2–10%.
At 61.5 ft	Pumice SWARM, lapilli to 40%
At 62.5 ft	TUFF, SAA, light brownish gray 5 YR 6/1, some pumice lapilli are mottled light brown and pink.
85.0–105.0 ft	TUFF, SAA, dull white to gray, nonwelded, unconsolidated (nonindurated), light brown devitrified pumice lapilli are mottled, sugary, and friable.
105.0–131.0 ft	TUFF, SAA, pinkish gray 5 YR 8/1 to grayish orange pink 5 YR 7/2, pumice lapilli are chocolate brown, phenocrysts are iron stained, lithics 2–3%.

Graphic Log



Lithologic Unit
Unit 2, Tshirege Mbr., Bandelier Tuff
37.5 ft
Unit 1v(u), Tshirege Member, Bandelier Tuff
105.0 ft
Unit 1v(c)

Seamist Monitor Well Construction

Seamist flexible liner

Notes

Borehole 54-1004 is located in the formerly proposed MDA G development area east of MDA L.

Surface casing set at 30.0 ft

Seamist vapor port at 57.8 ft

Seamist vapor port at 78.9 ft, Seamist vapor port at 97.5 ft, at 105.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726), Seamist vapor port at 117.0 ft

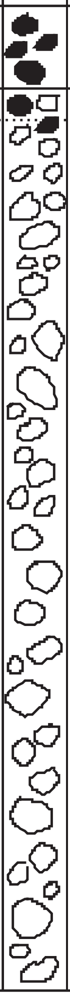
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1004 TA/OU: 54/1148 MDA: L Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 36 Start Date: 10/8/93 Time: 13:15 End Date: 10/14/93 Time: 11:45

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 90.0° Bearing: NA TD: 340.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
120 130 140 150 160 170 180 190 200 210 220 230 240	37/80% 38/100% 39/100% 40/40% 41/0% 42/100% 43/80% 44/100% 45/60% 46/60% 47/60% 48/60% 49/80% 50/60% 51/60% 52/80% 53/40% 54/60% 55/60% 56/60% 57/76% 58/80% 59/60% 60/88% 61/80% 62/60% 63/68% 64/60% 65/68% 66/80% 67/84% 68/60% 69/80% 70/60% 71/68% 72/60% 73/59% 74/80% 75/60% 76/80% 77/100% 78/100% 79/60% 80/80% 81/72% 82/100% 83/60% 84/60%	AAA5485 AAA5487 AAA5482 AAA5539 AAA5535 AAA5534	5.1 6.2 6.5 10.1 11.5 2.5 9.5 9.7 11.5 10.2 9.0 8.3 4.2 10.1 11.3 9.3 9.6 7.6 3.2 10.5 9.8 9.6 7.0 10.4 5.1 6.1 6.3 5.0 6.3 4.4 1.6 5.8 4.3 3.9 3.9 4.0	16 Cont. 17/135.0–145.0 ft 18/145.0–155.0 ft 19/155.0–167.5 ft 20/167.5–180.0 ft 21/180.0–192.0 ft 22/192.5 ft 23/205.0–215.0 ft 24/215.0–225.0 ft 25/225.0–235.0 ft 26/235.0–247.5 ft	37.5–131.0 ft (continued) TUFF, SAA, lithics 2–3% at 127.5 ft TUFF, SAA, pinkish orange gray matrix 131.0–135.0 ft TUFF, vitric, moderate orange pink 10 YR 8/2, nonwelded, ash flow, pumice lapilli are vitreous and silky, light olive gray, 1.0–8.0 cm, tube structures are fully inflated, phenocrysts are euhedral, quartz and K-spar, 20–25% total, accessory minerals are 1–2% amphibole, lithics are intermediate composition volcanics and obsidian clasts, 1–3%. 135.0–254.5 ft TUFF, SAA, unconsolidated (nonindurated), moderate orange pink 5 YR 8/4 to light brown 5 YR 6/4, pumice lapilli decrease to 5–10%, phenocrysts are SAA, 35–40%, lithics are 2–5%.		Qbt 1v(c) 131.0 ft Unit 1g, Tshirege Member, Bandelier Tuff	Seamist flexible liner	Seamist vapor port at 124.3 ft, vapor-phase notch at 131.0 ft Seamist vapor port at 140.0 ft Seamist vapor port at 179.8 ft From 140.0–250.0 ft core recovery averages 70% due to non-indurated tuff Seamist vapor port at 222.3 ft

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1004 TA/OU: 54/1148 MDA: L Page: 3 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 36 Start Date: 10/8/93 Time: 13:15 End Date: 10/14/93 Time: 11:45

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 90.0° Bearing: NA TD: 340.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
240	85/60%	AAA5536		26/Cont.	135.0–254.5 ft (continued) TUFF, SAA, nonindurated, nonwelded, ash flow, pumice lapilli are 5%, phenocrysts are 20%, lithics are 2%		Unit 1g		
	86/80%		3.3						
	87/80%		1.9						
	88/80%		2.2	27/247.5–255.0 ft					Seamist vapor port at 253.7 ft, at 277.5–280.0 ft Tsankawi Pumice Bed, Qbt t
250	89/100%								
	90/100%						277.5 ft		
	91/72%		2.5	28/255.0–270.0 ft	254.5–255.0 ft Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm, some interlayered ash		280.0 ft		
260	92/80%		1.0						
	93/88%	AAA5663			255.0–295.0 ft SEDIMENTS, laminated silt and sand, interlayered poorly to well sorted, moderate brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel-sized reworked phenocrysts and lithics, 0–40%, local cobbles and boulders		Cerro Toledo Interval		
	94/80%		0.8						
	95/0%		2.5						
270	96/80%		2.2						
	97/68%		1.9	29/270.0–280.0 ft					
	98/80%								
	99/80%		2.2						
	100/100%		1.5					Seamist flexible liner	
280	101/80%		1.0	30/280.0–290.7 ft					
	102/60%	AAA5664	1.1						
	103/80%								
290	104/80%		1.1						
	105100%		0.6	31/290.7–304.0 ft					
	106/68%		0.5						
	107/60%						295.0 ft		
300	108/60%		0.4		295.0–340.0 ft TUFF, massive, nonwelded, vitric, ash flow, pumice lapilli and bombs are gray to yellow brown, 20%, 2.0–7.0 cm, tube structures are fully inflated and intact, phenocrysts are quartz and K-spar, both 1.0 mm to 0.5 cm, 10% total, accessory mafic minerals are minute and rare, clinopyroxene and amphibole, lithics are 0.2 cm aphanitic dacite, <2%.		Otowi Member, Bandelier Tuff		
	109/80%	AAA5533	0.3						
	110/100%		0.1						
	111/80%		0.2	32/304.0–312.5 ft					
	112/100%								
310	113/60%		0.1						
	114/100%		0.1	33/312.5–320.0 ft					Seamist vapor port at 313.0 ft
	115/100%		0.1						
	116/100%		0.2						
320	117/80%		0.3						
	118/84%	AAA5531	0.1	34/320.0–330.0 ft					
	119/92%								
330	120/100%		0.2						
	121/100%			35/330.0–337.5 ft					
	122/100%		0.2						
	123/100%		0.2	36/337.5–340.0 ft					Seamist vapor port at 338.0 ft
340	124/100%								
					TD = 340.0 ft				
350									
360									

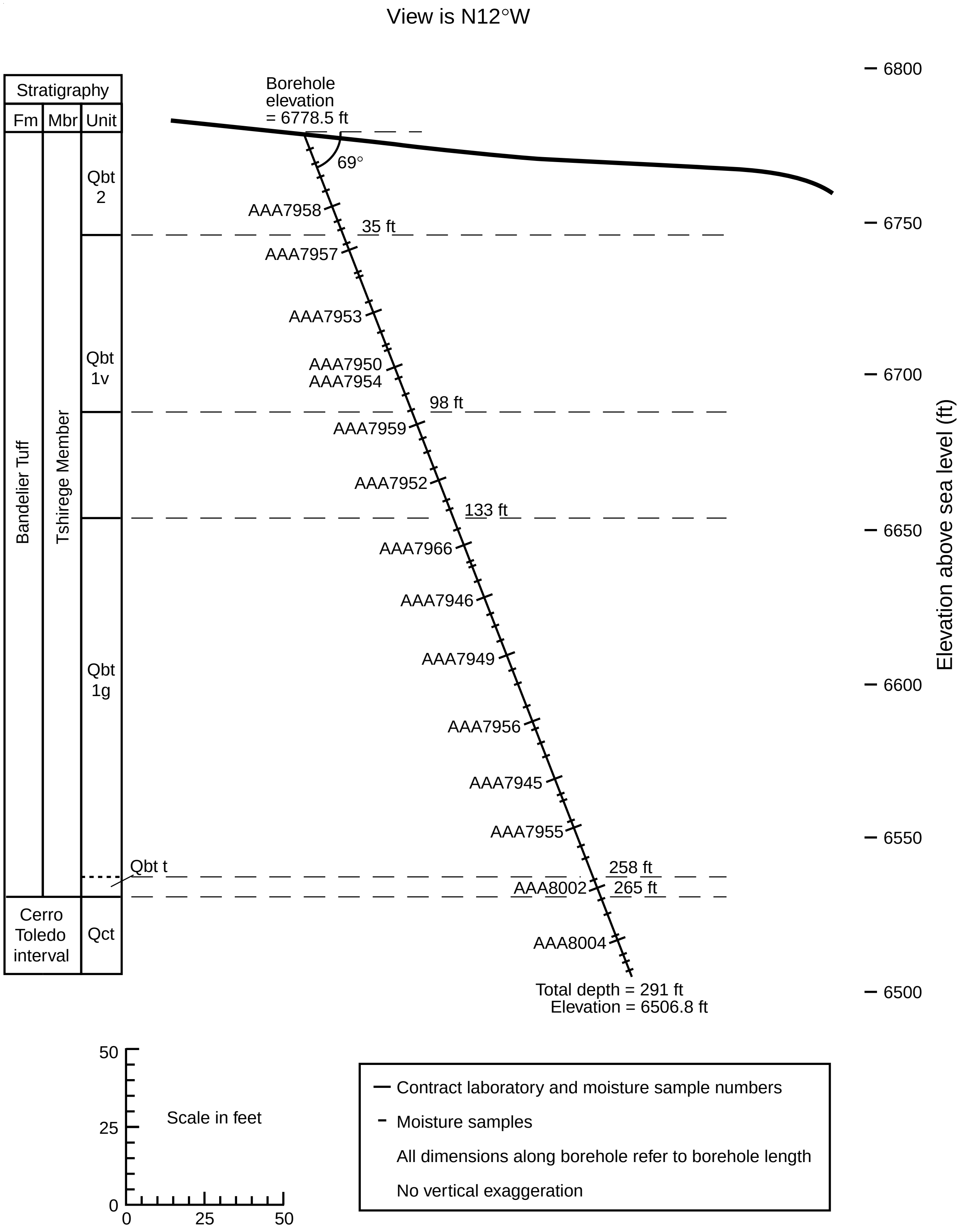
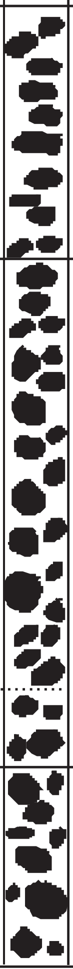


Figure H-5. Profile of borehole 54-01005 showing subsurface sample locations

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1005	TA/OU: 54/1148	MDA: L	Page: 1 of 3
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 43	Start Date: 12/1/93 Time: 10:00	End Date: 12/8/93 Time: 15:07
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Paul Garcia	Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination: 69.0°	Bearing: N 78.0° E TD: 291.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
0	1/100%			1/0–5.8 ft	0–1.0 ft	TOPSOIL			Seamist flexible liner	Borehole 54-1005 is located in the formerly proposed MDA G development area east of MDA L.
10 20 30	2/100% 3/100% 4/100% 5/100% 6/100% 7/100%	AAA7958	0.3 0.2	2/6.0–11.9 ft 3/11.9–17.8 ft 4/17.8–23.1 ft 5/23.1–29.0 ft 6/29.0–34.0 ft	1.0–35.0 ft	TUFF, light brownish gray 5 YR 6/1, devitrified, ash flow, fractured, elongate pumice lapilli are 15–20%, 0.5–2.0 cm, medium to dark gray, sugary texture on relict tube structures, phenocrysts are 25%, lithics are <1%.		Unit 2, Tshirege Mbr., Bandelier Tuff		Surface casing set at 30.0 ft
40 50 60	8/100% 9/100% 10/100% 11/100% 12/100% 13/100% 14/100%	AAA7957 AAA7953	0.5 1.2 0.8 0.5 0.5	7/34.0–40.4 ft 8/40.4–45.8 ft 9/45.8–51.1 ft 10/51.5–56.9 ft 11/56.9–63.0 ft 12/63.0–68.0 ft	35.0–88.0 ft	TUFF, same as above (SAA), pinkish gray 5 YR 8/1, pumice lapilli are 20%, some have light blue alteration along relict tube structures, phenocrysts 20–25%, lithics <1%.		35.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff	▬ ▬	Seamist vapor port at 43.3 ft Seamist vapor port at 55.0 ft
70 80	15/100% 16/100% 17/100% 18/70%	AAA7950 AAA7954	0.6 0.2 0.2 0.2	13/68.0–75.0 ft 14/75.0–81.6 ft 15/81.6–88.4 ft	At 68.0 ft	TUFF, SAA, very fractured, pinkish gray, pumice lapilli are mottled with medium to dark gray, pink to brown and light blue alteration, phenocrysts are quartz and K-spar (20%), lithics <1%.			▬	Seamist vapor port at 70.5 ft Seamist vapor port at 96.3 ft; at 98.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726); clay-filled fractures at 105.5–108.0 ft, 110.5–110.9 ft, and 114.5–115.0 ft
90	19/40% 20/50%		0.1	16/88.4–100.5 ft	88.0–98.0 ft	TUFF, SAA, unconsolidated (nonindurated), devitrified, ash flow, pumice lapilli are brown.			▬	
100 110 120	21/100% 22/100% 23/100% 24/100% 25/100%	AAA7959 AAA7952	1.2 1.4 0.9 0.6 0.3	17/100.5–105.9 ft 18/105.9–111.4 ft 19/111.4–118.0 ft 20/118.0–	98.0–133.0 ft	TUFF, slightly indurated, pinkish gray, devitrified, friable ash flow, pumice lapilli are medium to dark chocolate brown, iron stained phenocrysts, lithics 2–5%.		98.0 ft Unit 1v(c)		

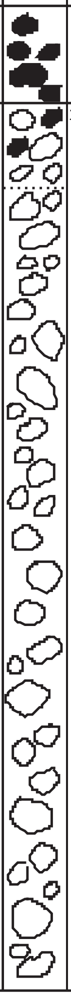
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1005 TA/OU: 54/1148 MDA: L Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 43 Start Date: 12/1/93 Time: 10:00 End Date: 12/8/93 Time: 15:07

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 69.0° Bearing: N 78.0° E TD: 291.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
120	25 Cont. 26/100%		0.6 0.7	124.4 ft 21/124.4–130.5 ft	98.0–133.0 ft (continued) TUFF, SAA, pumice lapilli are brown to orange, mottled, phenocrysts are iron stained, dacite lithics are 2–5%.		Qbt 1v		Seamist vapor port at 120.2 ft
130	27/100% 28/100% 29/100%		0.5 0.4	22/130.5–136.6 ft 23/136.6–143.0 ft	133.0–143.0 ft TUFF, SAA, moderate orange pink, vitric, nonwelded, ash flow, pumice lapilli are crystal rich, light gray to olive brown, 1.0–10.0 cm, 20–25%, tube structures are fully inflated and intact with silky texture, dacite lithics are 1–5%.		133.0 ft		Vapor-phase notch at 133.0 ft
140	30/100%	AAA7966	0.3 0.2	24/143.0–149.0 ft	143.0–258.0 ft TUFF, SAA, nonindurated, moderate orange pink 5 YR 8/4 to light brown 5 YR 6/4, pumice lapilli decrease to 5–10%, phenocrysts are SAA, 35–40%, lithics are 2–3%.		Unit 1g, Tshirege Member, Bandelier Tuff		Seamist vapor port at 145.0 ft
150	31/100% 32/100% 33/100%		0.3 1.0	25/149.0–156.0 ft					
160	34/100% 35/100% 36/100%	AAA7946	0.7	26/156.0–164.0 ft 27/164.0–172.0 ft					Seamist vapor port at 165.0 ft
170	37/100% 38/100% 39/80%		0.6 0.6	28/172.0–180.5 ft					
180	40/100% 41/100% 42/100%	AAA7949	0.5	29/180.5–188.0 ft	At 180.5 ft TUFF, SAA, very pale orange 10 YR 8/2 to pale yellowish brown 10 YR 6/2, unconsolidated (non-indurated), dacite and latite lithics are 1–5%, 0.5–10 cm.			Seamist flexible liner	
190	43/100% 44/100%		0.5 0.4	30/188.0–196.0 ft 31/196.0–203.0 ft					
200	45/100% 46/100%	AAA7956	0.4	32/203.0–210.5 ft	At 193.0 ft TUFF, SAA, light tan gray to pinkish gray, unconsolidated (nonindurated), pumice lapilli are vitric and gray, 35–40%, phenocrysts are 20%, lithics are 2%.				
210	47/100% 48/100% 49/100%		0.4 0.5	33/210.5–218.0 ft					Seamist vapor port at 209.8 ft
220	50/90% 51/100%	AAA7945	0.4 0.4	34/218.0–228.0 ft					Seamist vapor port at 219.8 ft
230	52/100% 53/100%		0.5 0.5	35/228.0–235.5 ft 36/235.5–243.0 ft					
240	54/100%	AAA7955							

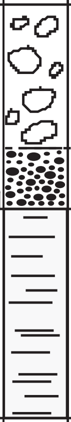
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1005 TA/OU: 54/1148 MDA: L Page: 3 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 43 Start Date: 12/1/93 Time: 10:00 End Date: 12/8/93 Time: 15:07

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 69.0° Bearing: N 78.0° E TD: 291.0 ft

Depth (feet)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (feet)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
240	54 Cont. 55/100%		0.3	36/Cont. 37/243.0–250.0 ft	143.0–258.0 ft (continued) TUFF, SAA, nonindurated, nonwelded, ash flow, pumice lapilli are 5%, phenocrysts are 20%, lithics are 2%.		Qbt 1g	Seamist flexible liner	Seamist vapor port at 241.7 ft
250	56/100% 57/100%			38/250.0–257.2 ft			258.0 ft		
260	58/100% 59/100% 60/50%	AAA8002		39/257.2–264.0 ft	258.0–265.0 ft Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm, some interlayered ash		Qbt t		Tsankawi Pumice Bed, Qbt t, Seamist vapor port at 262.7 ft
270	61/100% 62/100% 63/80%			40/264.0–272.0 ft 41/272.0–281.3 ft	265.0–291.0 ft SEDIMENTS, laminated silt and sand, interlayered poorly to well sorted, moderate brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel sized reworked phenocrysts and lithics from 0–40%, local cobbles and boulders		265.0 ft Cerro Toledo Interval		
280	64/80% 65/80% 66/60% 67/100%	AAA8004		42/281.3–287.3 ft					Seamist vapor port at 284.0 ft
290	68/80%			43/287.3–290.5 ft	TD = 291.0 ft				
300									
310									
320									
330									
340									
350									
360									

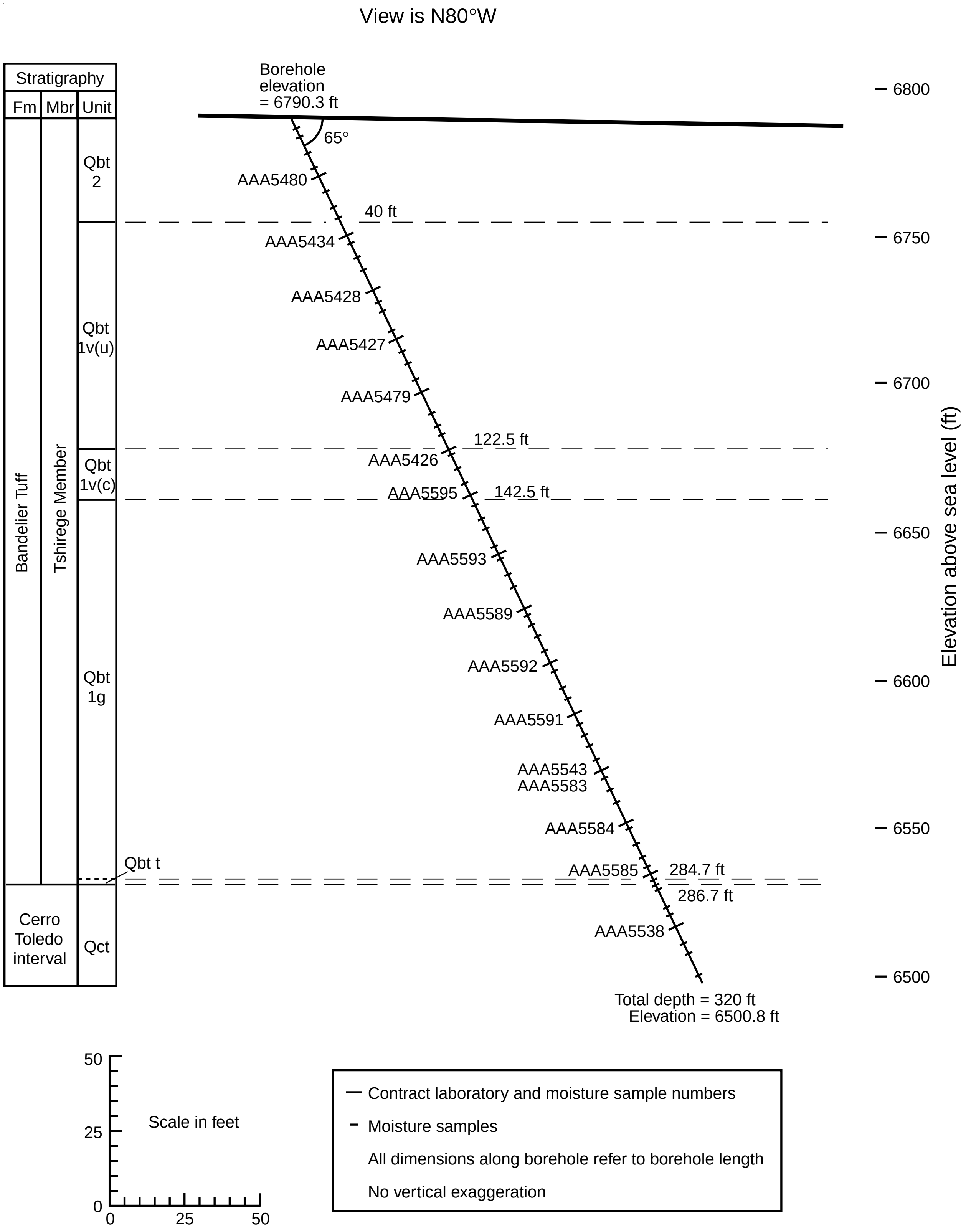
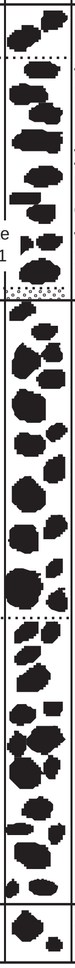


Figure H-6. **Profile of borehole 54-01006 showing subsurface sample locations**

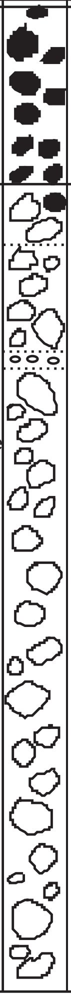
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1006	TA/OU: 54/1148	MDA: L	Page: 1 of 3
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 47	Start Date: 9/24/93 Time: 14:50	End Date: 10/1/93 Time: 11:45
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Paul Garcia	Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination: 65° Bearing: S 10° E	TD: 323.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
0 10 20 30 40 50 60 70 80 90 100 110 120	1/100% 2/100% 3/100% 4/100% 5/70% 6/100% 7/100% 8/100% 9/100% 10/100% 12/80% 13/100% 14/100% 15/100% 16/90% 17/100% 18/100% 19/100% 20/90% 21/100% 22/100% 23/50% 24/50% 25/0% 26/100% 27/100% 28/100%	AAA5480 AAA5434 AAA5428 AAA5427 AAA5479	2.5 2.5 2.8 3.7 2.1 1.5 1.3 1.2 7.0 9.4 6.4 6.3 2.7 11.1 8.2 11.6 9.2 6.7 5.4 5.1 18.2 2.0 7.1 8.0 9.3	1/0–5.8 ft 2/5.1–10.0 ft 3/10.0–15.0 ft 4/15.0–20.7 ft 5/20.7–25.0 ft 6/25.0–30.0 ft 7/30.0–35.0 ft 8/35.0–40.0 ft 9/40.0–47.0 ft 10/47.0–53.0 ft 11/53.0–58.8 ft 12/58.8–65.0 ft 13/65.0–70.0 ft 14/70.0–77.1 ft 15/77.1–83.0 ft 16/83.0–88.8 ft 17/88.8–94.0 ft 18/94.0–102.0 ft 19/102.0–112.0 ft 20/112.0–117.5 ft 21/117.5–124.5 ft	0–1.2 ft SOIL, brown with tuff cobbles 1.2–10.0 ft TUFF, light gray N6, fractured, slightly welded, devitrified ash 10.0–40.0 ft flow, elongated pumice lapilli are dark gray to brown, 5–20%, 1.0–1.5 cm, sugary texture, phenocrysts are quartz (20%) up to 1.0 mm and K-spar (15%) up to 0.3 mm. TUFF, same as above (SAA), moderate pink tan to light brownish gray 5 YR 6/1 At 38.8 ft Base SURGE, 60% phenocrysts in banded layers 40.0–80.0 ft TUFF, light pink gray, nonwelded, devitrified, ash flow, pumice lapilli are moderate gray brown, 0.5–5.0 cm, light blue alteration along fully inflated relict tube structures, phenocrysts are SAA, lithics are intermediate composition lavas, <1% . At 62.5 ft Pumice SWARM, lapilli to 40% At 65.0 ft TUFF, SAA 80.0–115.3 ft TUFF, SAA, dull white to pinkish gray 5 YR 8/1, nonwelded, friable (nonindurated), brown devitrified pumice lapilli are mottled, sugary, phenocrysts are 20–25% total, euhedal quartz and K-spar, lithics <1%. 115.3–142.5 ft TUFF, light pink gray, slightly indurated with fractures.		Unit 2, Tshirege Mbr., Bandelier Tuff 40.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff 115.3 ft	Seamist flexible liner	Borehole 54-1006 is located in the formerly proposed MDA G development area east of MDA L. Surface casing set at 30.0 ft Seamist vapor port at 39.1 ft Seamist vapor port at 57.3 ft Seamist vapor port at 79.3 ft Seamist vapor port at 98.4 ft, at 115.3 ft, colonnade subunit of Broxton and Reneau (1995, 49726)

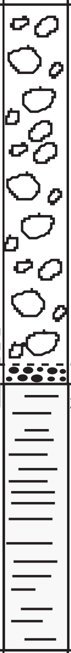
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1006 TA/OU: 54/1148 MDA: L Page: 2 of 3
Drilling Co.: Stewart Bros. Drilling Core Box #(s) 47 Start Date: 9/24/93 Time: 14:50 End Date: 10/1/93 Time: 11:45
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel
Driller: Paul Garcia Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder Declination: 65° Bearing: S 10° E TD: 323.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
120 130 140 150 160 170 180 190 200 210 220 230 240	29/0% 30/100% 31/30 32/100% 33/100% 34/100% 35/100% 36/100% 37/67% 38/100% 39/100% 40/100% 41/80% 42/100% 43/100% 44/100% 45/100% 46/100% 47/100% 48/100% 49/50% 50/100% 51/80% 52/100% 53/100% 54/100% 55/50% 56/100% 57/80% 58/100% 59/100% 60/100% 61/100%	AAA5426 AAA5595 AAA5593 AAA5589 AAA5592 AAA5591	9.1 8.1 6.2 10.7 22.5 8.4 9.5 8.0 3.7 12.2 14.6 5.3 10.1 8.6 17.7 24.1 9.6 26.4 25.7 10.4 13.8 6.5 10.6 13.3 7.0 12.5 5.1 2.8 6.9 8.2 8.7 10.8	21 Cont. 22/124.5–132.5 ft 23/132.5–138.5 ft 24/138.5–142.4 ft 25/142.4–147.8 ft 26/147.8–153.2 ft 27/153.2–159.2 ft 28/159.2–166.2 ft 29/166.2–172.5 ft 30/172.5–179.0 ft 31/179.0–186.8 ft 32/186.8–196.5 ft 33/196.5–203.2 ft 34/203.2–210.5 ft 35/210.5–218.2 ft 36/218.2–226.8 ft 37/226.8–234.4 ft 38/234.4–242.5 ft	115.3–142.5 ft TUFF, SAA, tan to pinkish gray, pumice lapilli are red brown due to dendritic iron oxides and contain some spherulites, lithics are 2–5%. At 138.5 ft TUFF, SAA, moderate orange 142.5–150.0 ft TUFF, SAA, medium orange, vitric, nonwelded, ash flow, pumice lapilli are crystal-rich, light gray to olive brown, 1.0–10.0 cm, 20–25%, tube structures are fully inflated and intact with silky texture, dacite lithics are 1–5%. 150.0–284.7 ft TUFF, SAA, unconsolidated (nonindurated), moderate orange pink 5 YR 8/4 to light brown 5 YR 6/4, pumice lapilli, silky texture, 10–20%, 1.0–10.0 cm, phenocrysts are SAA, 35–40%, lithics are dacite and latite, 2–3%. At 162.0 ft TUFF, SAA, rare hornblende-rich pumice lapilli At 163.0 ft Pumice SWARM, lapilli are 40%. At 165.0 ft TUFF, SAA, nonindurated At 180.0 ft TUFF, SAA, matrix is tan gray, pumice lapilli are light olive gray. At 215.0 ft TUFF, SAA, light tan gray to grayish orange pink, unconsolidated (non-indurated), pumice lapilli are vitric and gray, 35–40%, phenocrysts are 20%, lithics are 2%.		Unit 1v(c) 142.5 ft Unit 1g, Tshirege Member, Bandelier Tuff	Seamist flexible liner	Seamist vapor port at 124.3 ft Vapor-phase notch at 142.5 ft, Seamist vapor port at 145.3 ft and 159.0 ft Seamist vapor port at 159.0 ft At 163.0–165.0 ft, pumice lapilli 40% Seamist vapor port at 188.2 ft Seamist vapor port at 205.0 ft

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1006	TA/OU: 54/1148	MDA: L	Page: 3 of 3	
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 47	Start Date: 9/24/93 Time: 14:50	End Date: 10/1/93 Time: 11:45	
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel		
Driller: Paul Garcia	Geologist: Val Rhodes, F.A. Caporuscio, ERM/Golder	Declination: 65°	Bearing: S 10° E	TD: 323.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Seamist Monitor Well Construction	Notes
240 250 260 270 280 290 300 310 320 330 340 350 360	62/80% 63/100% 64/100% 65/100% 66/100% 67/100% 68/40% 69/100% 70/100% 71/100% 72/80% 73/100% 74/100% 75/100% 76/60% 77/60% 78/80% 79/18% 80/60% 81/80% 82/40% 83/60% 84/60% 85/60%	AAA5543 AAA5583 AAA5584 AAA5585 AAA5538	4.3 3.7 4.5 4.3 5.1 2.6 5.5 1.6 3.9 3.5 5.1 3.9 0.9 2.9 2.5 2.1 1.5 1.7 1.6 2.3 1.2	38/cont. 39/242.5–250.0 ft 40/250.0–256.7 ft 41/256.7–263.9 ft 42/263.9–273.5 ft 43/273.5–281.2 ft 44.281.2–288.5 ft 45/288.5–299.5 ft 46/299.5–310.0 ft 47/310.0–320.0 ft	150.0–284.7 ft (continued) TUFF, SAA, unconsolidated (nonindurated), nonwelded, grayish orange pink to very pale orange 10 YR 8/2, vitric ash flow, pumice lapilli are 5%, phenocrysts are 20%, lithics are 2%. 284.7–286.7 ft Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm, some interlayered ash. 286.7–320.0 ft SEDIMENTS, laminated silt and sand, interlayered poorly to well sorted, moderate brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel-sized reworked phenocrysts and lithics from 0–40% local cobbles and boulders. TD = 320.0 ft		Unit 1g, Tshirege Member, Bandelier Tuff 284.7 ft Qbt t 286.7 ft Cerro Toledo Interval	Seamist flexible liner	Seamist vapor port at 249.8 ft At 284.7–286.7 ft Tsankawi Pumice Bed, Qbt t, Seamist vapor port at 283.8 ft Seamist vapor port at 314.5 ft

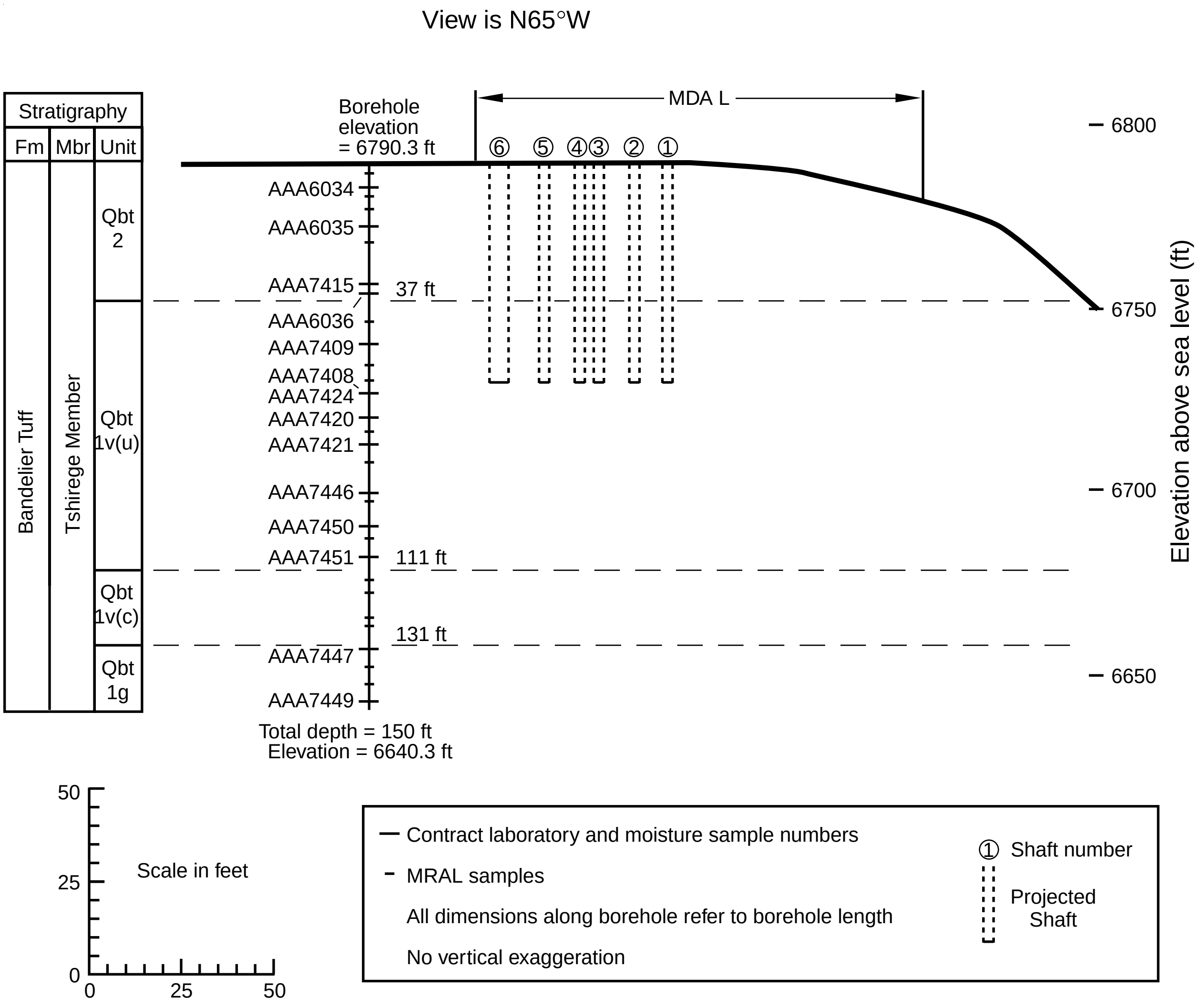


Figure H-7. **Profile of borehole 54-01007 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1007 TA/OU: 54/1148 MDA: L Page: 1 of 2

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 23 Start Date: 11/22/93 Time: 10:00 End Date: 11/30/93 Time: 09:15

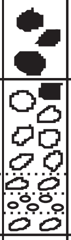
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Albert Chavez Geologist: F.A. Caporuscio, ERM/Golder Declination: 90.0° Bearing: NA TD: 150.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0 10 20 30 40 50 60 70 80 90 100 110 120	1/100% 2/80% 3/88% 4/100% 5/100% 6/100% 7/100% 8/0% 9/100% 10/100% 11/100% 12/100% 13/100% 14/0% 15/100% 16/100% 17/0% 18/60% 19/100% 20/0% 21/100% 22/100% 23/100% 24/100% 25/100% 26/100% 27/0% 28/60% 29/100% 30/0% 31/100% 32/80% 33/100% 34/100%	AAA6034 AAA6035 AAA7415 AAA6036 AAA7409 AAA7408 AAA7424 AAA7420 AAA7421 AAA7446 AAA7450 AAA7451	0.9 2.0 1.5 1.9 2.7 6.6 9.1 24.9 34.3 26.6 29.6 24.4 50.8 45.3 24.1 16.7 21.2 44.4 42.6 28.6 16.7 29.4 23.4 19.4 14.9 35.3 23.7 28.1 22.7 26.8	1/0–5.0 ft 2/5.0–12.0 ft 3/12.0–19.0 ft 4/19.0–25.0 ft 5/25.0–35.0 ft 6/35.0–43.0 ft 7/43.0–51.6 ft 8/51.6–60.0 ft 9/60.0–70.0 ft 10/70.0–77.5 ft 11/–82.5 ft 12/82.5–87.5 ft 13/–90.0 ft 14/90.0–95.0 ft 15/95.0–100.8 ft 16/100.8–105.5 ft 17/105.5–112.5 ft 18/112.5–188.3 ft 19/–123.1 ft	0–0.1 ft SOIL 0.1–11.0 ft TUFF, medium light gray N6, slightly indurated and welded, devitrified, ash flow 11.0–37.0 ft TUFF, same as above (SAA), pale brown 5 YR 5/2, pumice lapilli are gray 10–15%, 1.2–2.5 cm with local vapor-phase alteration clay, phenocrysts are 25–30%, iron-stained quartz to 0.5 cm and K-spar to 1.0 mm, lithics are rare. 37.0–70.0 ft TUFF, SAA, nonindurated, nonwelded, pumice lapilli (<3.0 cm) are dark brown with blue streaked interiors, 50%, rest are pumice bombs (>3.0 cm) up to 10 cm, lithics and phenocrysts are SAA. 70.0–111.0 ft TUFF, SAA, grayish orange pink 10 R 8/2 to pinkish gray 5 YR 8/1, nonindurated, nonwelded ash flow, pumice lapilli are mottled chocolate brown, 20–25%, 0.5–10.0 cm, avg. = 4.0 cm, local swarms up to 60%, minute sugary tridymite and sanidine, and blue gray alteration clay, along relict tube structures, lithics are dark gray, intermediate composition lava (dacite), 1–4%, up to 0.5 cm. 111.0–131.0 ft TUFF, SAA, large friable chocolate brown pumice lapilli 25–30%, dacite lithics 5–10%		Unit 2, Tshirege Member, Bandelier Tuff 37.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff 111.0 ft Qbt 1v(c)	NA	Borehole 54-1007 is located in the formerly proposed MDA G development area east of MDA L. Oxidized fracture with caliche and clay at 4.2–4.7 ft, 5.0–7.0 ft, clay lined 14.0–15.0 ft, at 20.0 ft borehole deviated from fracture. Clay-lined fracture at 50.4–52.7 ft. Weathered fracture at 100.0–103.0 ft At 111.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726)

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1007	TA/OU: 54/1148	MDA: L	Page: 2 of 2
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 23	Start Date: 11/22/93 Time: 10:00	End Date: 11/30/93 Time: 09:15
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Paul Garcia	Geologist: Val Rhodes, ERM/Golder	Declination: 90.0° Bearing: NA	TD: 150.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
120	35/100%		39.1	19/Cont.	111.0–131.0 ft (continued) TUFF, grayish orange pink, pumice lapilli are 15%, iron-stained phenocrysts are 25–30%, lithics are light brown, 10–15%.		Qbt 1v(c)	NA	Vapor-phase notch at 131.0 ft, weathered fracture at 137.0–138.2 ft
	36/10%			20/123.1–132.8 ft					
130	37/92%	AAA7447	18.6						
	38/100%		15.1	21/132.8–137.9 ft	131.0–143.0 ft TUFF, moderate orange pink, pumice are light gray to tan, vitric, 20%, tube structures are fully inflated, iron-stained phenocrysts are 20–25%, lithics are 10–15%.		131.0 ft Qbt 1g		
	39/100%		8.3						
			19.3	22/137.9–143.9 ft					
140	40/100%		26.7						
	41/83%	AAA7449	12.9	23/143.9–150.0 ft	143.0–150.0 ft TUFF, SAA, nonindurated, vitric At 145.0 ft Pumice BED, unconsolidated At 147.5 ft TUFF, SAA, nonindurated				
150	42/100%		38.8						
160									
170					TD = 150.0 ft				
180									
190									
200									
210									
220									
230									
240									

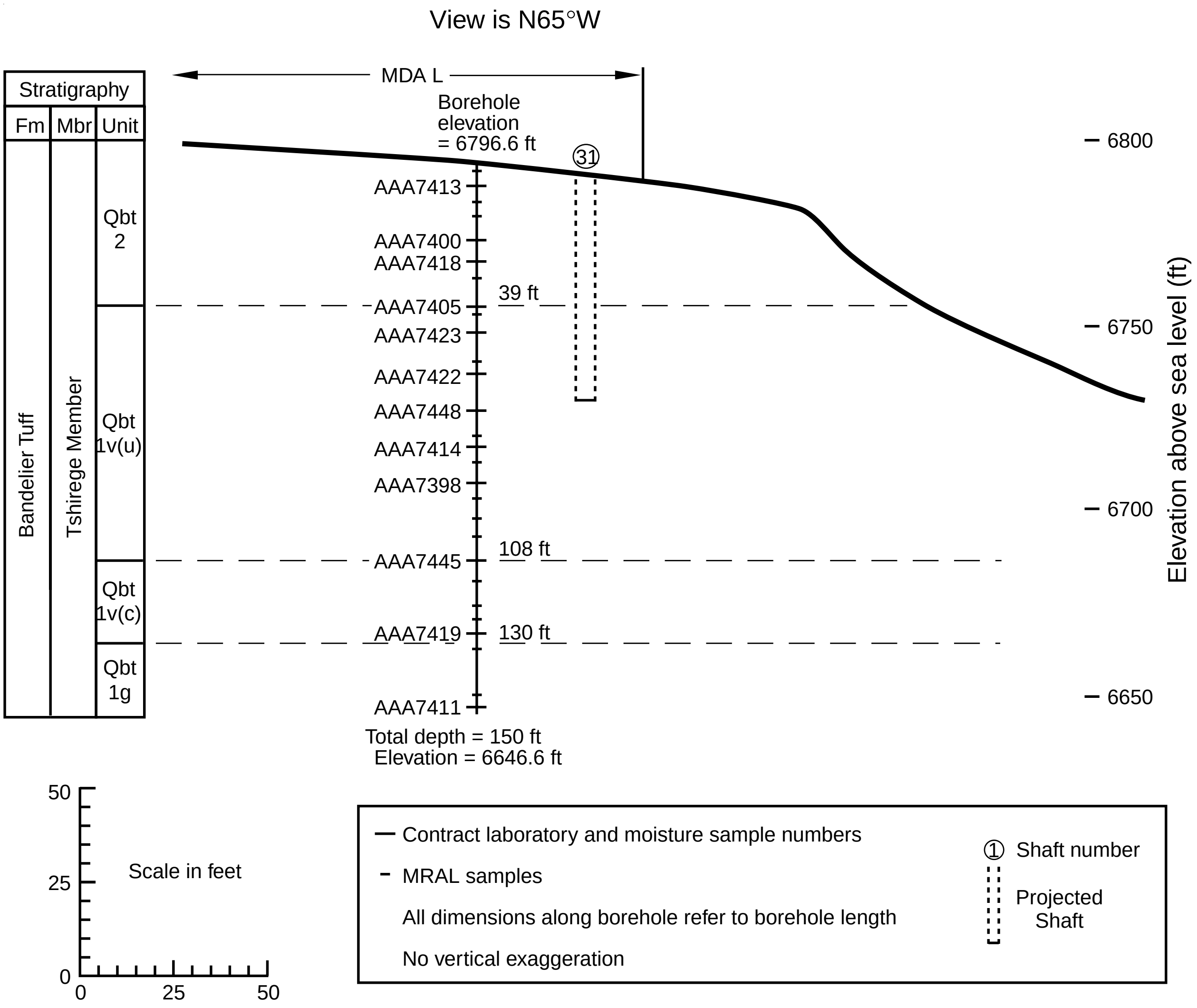


Figure H-8. Profile of borehole 54-01008 showing subsurface sample locations

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1008 TA/OU: 54/1148 MDA: L Page: 1 of 2

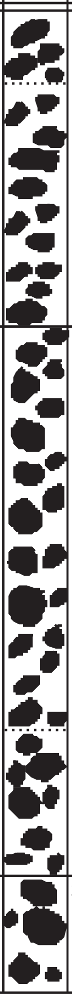
Drilling Co.: Stewart Bros. Drilling Core Box #(s) 22 Start Date: 11/18/93 Time: 15:05 End Date: 11/19/93 Time: 16:35

Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Albert Chavez Geologist: Val Rhodes, ERM/Golder Declination: 90.0° Bearing: NA TD: 150.0 ft

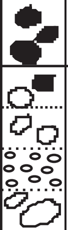
Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
0 10 20 30 40 50 60 70 80 90 100 110 120	1/100% 2/100% 3,4/100% 5/100% 6/100% 7/100% 8/100% 9/100% 10/100% 11/100% 12/100% 13/100% 14/80% 15/100% 16/100% 17/100% 18/100% 19/100% 20/100% 21/100% 22/100% 23/63% 24/0% 25/100% 26/80% 27/100% 28/100% 29/100% 30/100% 31/100% 32/35% 33/100% 34/100%	AAA7413 AAA7400 AAA7418 AAA7405 AAA7423 AAA7422 AAA7448 AAA7414 AAA7398 AAA7445	0.9 14.9 9.3 39.9 13.8 11.8 17.1 11.7 32.4 29.1 59.5 73.3 16.9 64.4 67.2	1/0–5.0 ft 2/5.0–11.2 ft 3/11.2–22.0 ft 4/22.0–26.9 ft 5/26.9–33.3 ft 6/33.3–41.3 ft 7/41.3–47.5 ft 8/47.5–53.1 ft 9/53.1–60.8 ft 10/60.8–66.0 ft 11/66.0–72.5 ft 12/72.5–80.5 ft 13/80.5–87.5 ft 14/87.5–93.2 ft 15/93.2–100.0 ft 16/100.0–106.0 ft 17/106.0–113.5 ft 18/113.5–119.0 ft 19/–124.5 ft

Lithology	
0–1.0 ft	TOPSOIL, tuff mixture
1.0–39.0 ft At 10.0 ft	TUFF, grayish orange pink 10 YR 8/2 devitrified ash flow tuff, pumice lapilli are medium dark gray, 15%, sugary texture, phenocrysts are 25–30%, lithics are <1%.
	TUFF, same as above (SAA), pinkish gray 5 YR 8/1, pumice lapilli are 15–25%, 5.0 mm to 2.5 cm, with light blue gray alteration clay along relict tube structures.
39.0–90.0 ft	TUFF, SAA, light brownish gray 5 YR 8/1, very friable (non-indurated), pumice lapilli are 30%, phenocrysts are 20%.
At 55.0 ft	TUFF, SAA, pumice bombs are up to 10.0 cm, 40%, with blue and pink alteration clay along relict tube structures, phenocrysts are 10–15%, lithics are <1%.
At 68.0 ft	TUFF, SAA, minor brown mottling in some pumice lapilli
At 75.0 ft 90.0–108.0 ft	TUFF, SAA, pinkish gray to light brownish gray, pumice lapilli are light to dark gray, 20–25%, 2.5 mm to 2.5 cm, some blue alteration and pink/brown mottling, phenocrysts are 20%, lithics are 1%.
	TUFF, SAA, very light gray N8 to pinkish gray 5 YR 8/1, pumice lapilli are 25%, lithics <1%.
108.0–130.0 ft	TUFF, SAA, pumice are light brown orange, lithics 2–10%.

Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
	Unit 2, Tshirege Member, Bandelier Tuff 39.0 ft Unit 1v(u), Tshirege Member, Bandelier Tuff 108.0 ft Qbt 1v(c)	NA	Borehole 54-1008 was located adjacent to a shaft field in the northwestern portion of MDA L. At 108.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726)

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1008	TA/OU:	54/1148	MDA:	L	Page:	2 of 2
Drilling Co.:	Stewart Bros. Drilling	Core Box #(s)	22	Start Date:	11/18/93	End Date:	11/19/93
				Time:	15:05	Time:	16:35
Drilling Equip./Method:	Failing F-10/Hollow Stem Auger			Sampling Method:	Continuous 5.0 ft core barrel		
Driller:	Albert Chavez	Geologist:	Val Rhodes, ERM/Golder	Declination:	90.0°	Bearing:	NA
TD:	150.0 ft						

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
120	35/100% 36/100%		0.9 14.2	19/Cont.	108.0–130.0 ft (continued)	TUFF, SAA, phenocrysts are 20–25% and iron-stained.		Qbt 1v(c)	NA	
	37/13%	AAA7419	4.7	20/ 124.5–134.1 ft	At 120.0 ft	TUFF, SAA, pinkish gray, lithics are 10–15%.				Vapor-phase notch at 130.0 ft
130	38/100% 39/100%		3.8 4.9		130.0–135.0 ft	TUFF, vitric, grayish orange pink 5 YR 7/2 to moderate orange pink, ash flow, pumice lapilli are 15–20%, chocolate brown with tans and grays, phenocrysts are 30–35% and iron-stained, lithics are 5–10%.		130.0 ft Qbt 1g		Weathered fracture at 137.0–138.2 ft
	40/0%			21/134.1–145.0 ft	135.0–150.0 ft	TUFF, SAA, no recovery, probably nonindurated				
140	41/100%		17.2		At 140.0 ft	Pumice BED, unconsolidated				
	42/100% 43/100%	AAA7411	4.7 9.6	22/145.0–150.0 ft	At 145.0 ft	TUFF, SAA, light brown matrix, pumice lapilli are 30%, vitric, phenocrysts are 15–20%, lithics are 3–5%.				
150										
160										
170										
180										
					TD = 150.0 ft					
190										
200										
210										
220										
230										
240										

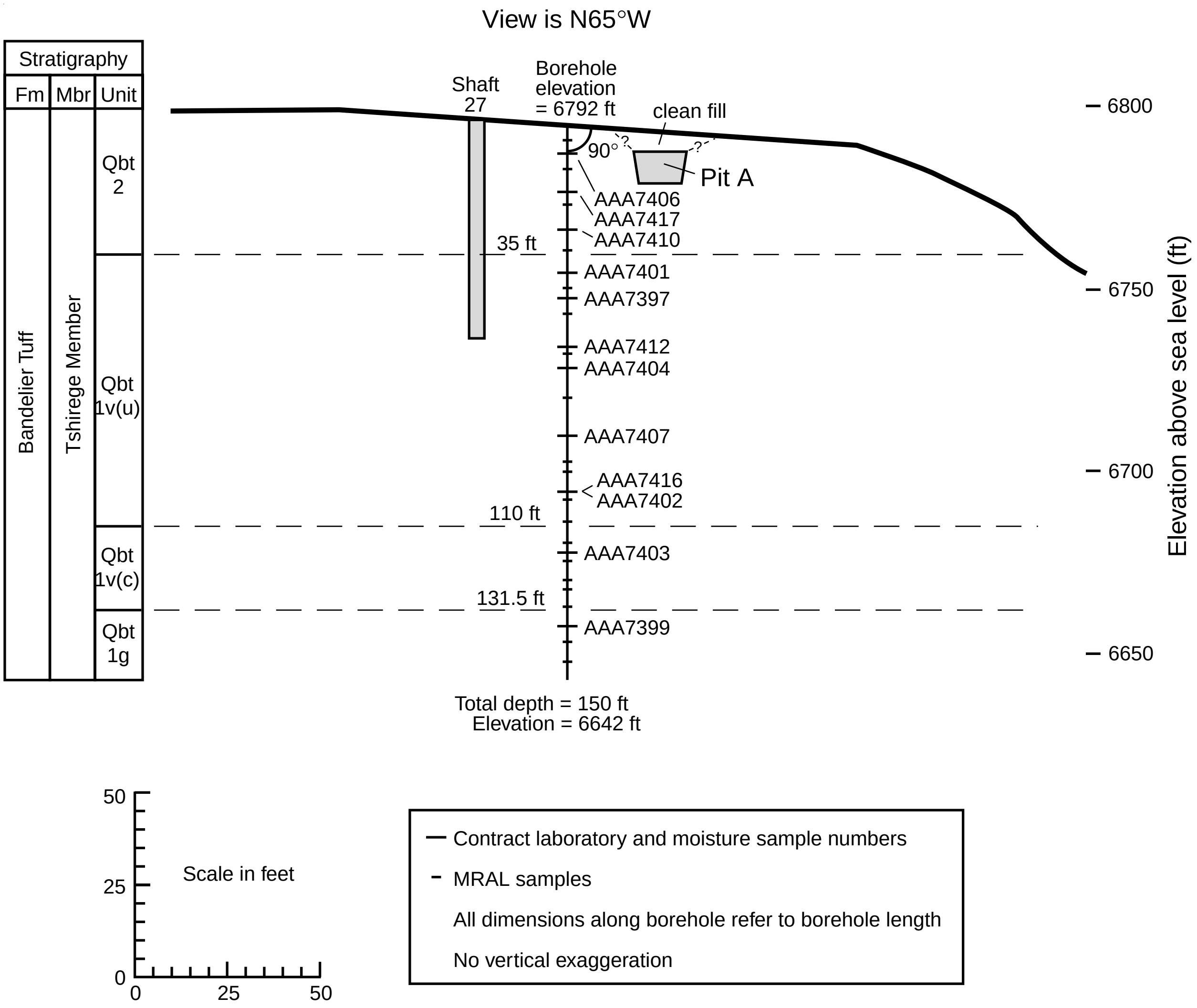


Figure H-9. **Profile of borehole 54-01009 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1009 TA/OU: 54/1148 MDA: L Page: 1 of 2

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 21 Start Date: 11/16/93 Time: 09:45 End Date: 11/17/93 Time: 16:25

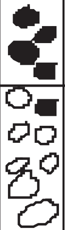
Drilling Equip./Method: Failing F-10/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Albert Chavez Geologist: Val Rhodes, ERM/Golder Declination: 90.0° Bearing: NA TD: 150.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100%			1/0–7.5 ft	0–1.0 ft 1.0–1.5 ft	ASPHALT TOPSOIL		Unit 2, Tshirege Mbr., Bandelier Tuff	NA	Borehole 54-1009 was located adjacent to disposal pit A within MDA L.
	2/100%	AAA7406			1.5–35.0 ft	TUFF, light brownish gray 5 YR 6/1, devitrified ash flow, pumice lapilli are 10–15%, medium dark gray, 3.0 mm to 1.5 cm, phenocrysts are 30–35%, lithics <1%, relict tube structures poorly preserved.				
10	3/100%			2/7.5–14.1 ft						
	4/100%	AAA7417		3/14.1–20.5 ft						
20	5/100%			4/20.5–25.5 ft						
	6/56%	AAA7410		5/25.5–34.0 ft						
30	7/100%									
	8/50%	AAA7401		6/34.0–40.0 ft	35.0–110.0 ft	TUFF, same as above (SAA), nonindurated, coarsely devitrified grayish orange pink ash flow, pumice lapilli are 20–25%, grays with light to dark blue and green alteration, friable, 3.0 mm to 1.5 cm, phenocrysts are 15–20%, lithics are <1%.		35.0 ft		Stained fracture at 37.0–37.5 ft
40	9/100%			7/40.0–45.3 ft				Unit 1v(u), Tshirege Member, Bandelier Tuff		
	10/100%	AAA7397		8/45.3–51.6 ft						
50	11/100%			9/51.6–56.7 ft						Fractures at 50.7–51.0 ft, 51.3 ft, and 54.0–54.5 ft
	12/100%			10/–62.5 ft						
60	13/100%	AAA7412		11/62.5–82.5 ft	At 45.0 ft	TUFF, SAA, relict tube structures well preserved with sugary texture				
	14/20%	AAA7404								
70	15/10%		19.3		At 82.5 ft	TUFF, pinkish gray 5 YR 8/1, pumice lapilli are 25–20%, 0.3–3.0 cm, relict tube structures well preserved with sugary texture, local green gray and dark gray to pink and blue mottling, phenocrysts are 15–20%, lithics are 1%.				Poor recovery 66.0–82.5 ft
	16/0%		0.4							
80	17/0%									Used 300 pound hammer for runs 19 and 20
	18/80%		10.9							
	19/100%	AAA7407		12/82.5–95.0 ft						
	20/67%		9.3							
90	21/100%		10.7							
	22/83%	AAA7416			At 90.0 ft	TUFF, SAA, pinkish gray matrix, very friable (non-indurated), lithics are 1%.				
	23/100%	AAA7402	8.5	13/95.0–103.1 ft						
100	24/100%									
	25/100%		8.4	14/103.1–109.2 ft	110.0–131.5 ft	TUFF, SAA, pinkish gray to grayish orange pink, pumice lapilli are 25%, brown to orange, 0.3–3.3 cm, iron-stained phenocrysts are 25%.				Colonnade subunit of Broxton and Reneau (1995, 1320)
110	26/100%		4.4	15.109.2–115.0 ft				110.0 ft		
	27/100%	AAA7403	1.6					Qbt 1v(c)		
120	28/83%		1.6	16/115.0–121.2 ft						
			3.8							

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1009	TA/OU: 54/1148	MDA: L	Page: 2 of 2
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 21	Start Date: 11/16/93 Time: 09:45	End Date: 11/17/93 Time: 16:25
Drilling Equip./Method: Failing F-10/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Albert Chavez	Geologist: Val Rhodes, ERM/Golder	Declination: 90.0° Bearing: NA	TD: 150.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
120	29/100%		3.7	17/121.2–126.8 ft	110.0–131.5 ft (continued) TUFF, SAA, pumice lapilli have well preserved relict tube structures, light gray to white mottling, glassy phenocrysts 25–30%, lithics are 5–10%. At 125.0 ft TUFF, SAA, moderate orange pink		Qbt 1v(c)	NA	Stained fracture at 122.8–123.1 ft, clay-filled fractures at 127.5–130.0 ft and 130.0–131.2 ft
	30/100%		1.2	18/126.8–133.0 ft					
130	31/100%		1.6				131.5 ft		
	32/100%	AAA7399	1.7	19/133.0–140.0 ft	131.5–150.0 ft TUFF, moderate orange pink to light brown, vitric, very competent (well indurated), pumice lapilli are 15%, phenocrysts are 25–30%, lithics are 10–15%. At 140.0 ft TUFF, SAA, unconsolidated (nonindurated) TD = 150.0 ft		Qbt 1g		Vapor-phase notch at 131.5 ft
	33/100%		2.9						
140	34/100%		4.4	20/140.0–145.6 ft					
	35/100%		6.7	21/145.6–150.0 ft					
	36/100%		1.8						
150									
160									
170									
180									
190									
200									
210									
220									
230									
240									

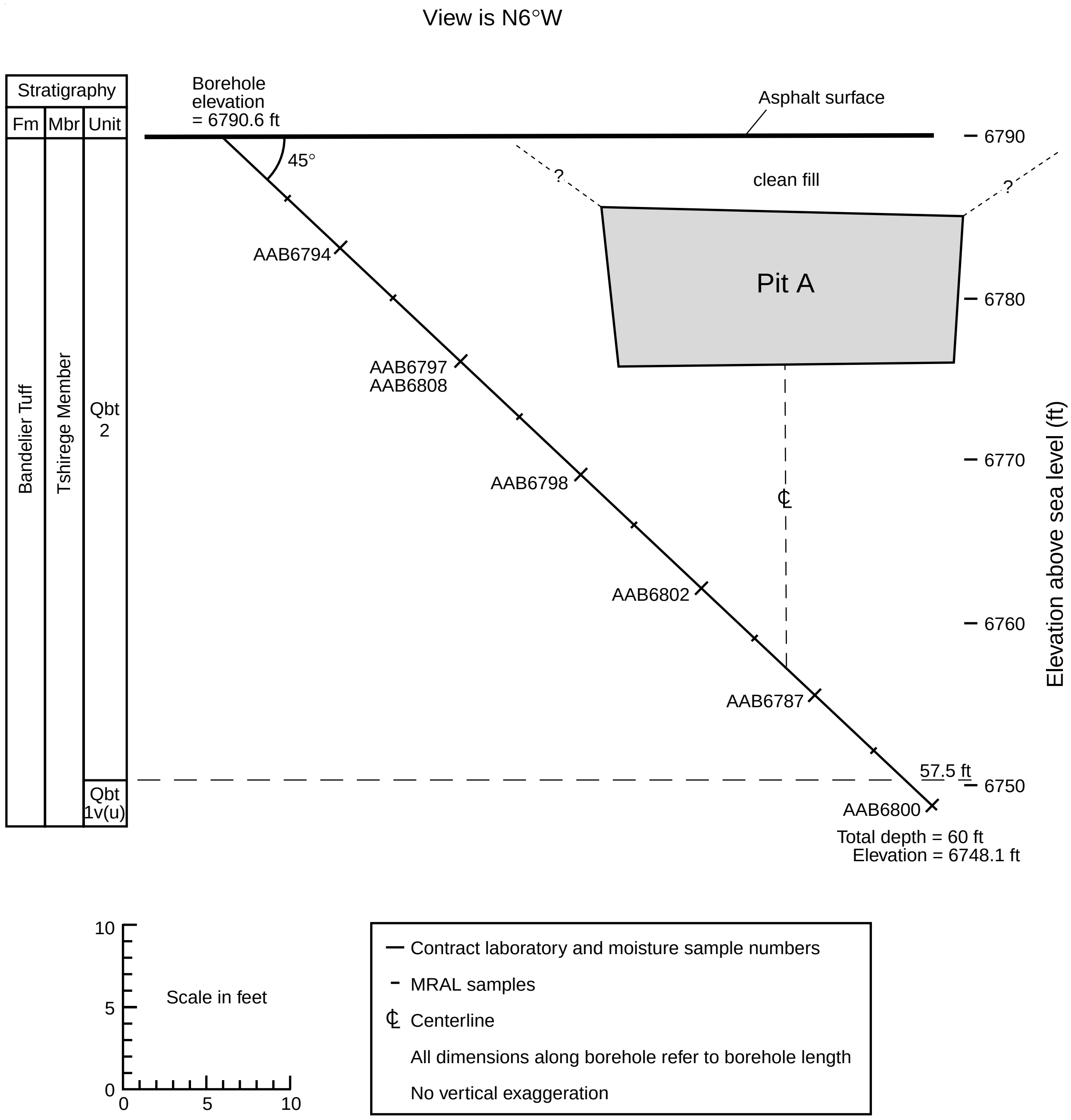


Figure H-10. Profile of borehole 54-01010 showing subsurface sample locations

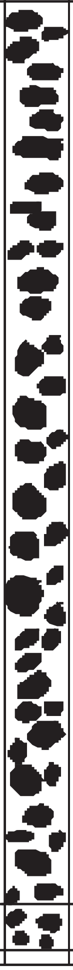
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1010 TA/OU: 54/1148 MDA: L Page: 1 of 1

Drilling Co.: Layne Western Drilling Core Box #(s) 12 Start Date: 7/28/94 Time: 11:01 End Date: 8/1/94 Time: 12:20

Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Split spoon/barrel sampling

Driller: Jim Hayle Geologist: Vince Trujillo LANL Declination: 45.0° Bearing: N 84° E TD: 60.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100%			1/ 0–5.0 ft	0–1.2 ft 1.2–57.5 ft	BACKFILL, brown with gravel TUFF, light gray, nonindurated to slightly indurated, ash flow tuff. Pumice lapilli are slightly lighter in color than matrix and up to 2.5 cm across.		Unit 2, Tshirege Member, Bandelier Tuff	NA	Borehole 54-1010 was located adjacent to and angled beneath disposal pit A.
	2/0%									
5	3/100%			2/ 5.0–10.0 ft						
	4/56%	AAB6794								
10	5/100%			3/ 10.0–15.0 ft						
	6/100%									
15	7/100%			4/ 15.0–20.0 ft						
	8/52%	AAB6797			At 18.7 ft	TUFF, same as above (SAA), slightly indurated to moderately indurated, medium gray brown				
20	9/100%	AAB6808	0.1	5/ 20.0–25.0 ft	At 20.0 ft	TUFF, SAA, light gray, nonindurated to slightly indurated				
	10/80%									
25	11/100%		4.3	6/ 25.0–30.0 ft						
	12/48%									
30	13/60%	AAB6798	0.3	7/ 30.0–35.0 ft	At 30.0 ft	TUFF, SAA, matrix very light gray, nonindurated				
	14/100%									
35	15/100%		0.1	8/ 35.0–40.0 ft						
	16/100%	AAB6802			At 37.5 ft	TUFF, SAA, pinkish brown, nonindurated to slightly indurated, moist				
40	17/0%		2.9	9/ 40.0–45.0 ft						
	18/100%				At 42.5 ft	TUFF, SAA, dark brown, nonindurated to slightly indurated				
45	19/100%		5.7	10/ 45.0–50.0 ft						
	20/100%				At 47.5 ft	TUFF, SAA, light grayish brown, slightly indurated				
50	21/100%	AAB6787		11/ 50.0–55.0 ft	At 50.0 ft	TUFF, SAA, dark gray, moderately indurated				At 51.5 ft, roots observed in fracture
	22/100%									
55	23/100%			12/ 55.0–60.0 ft				57.5 ft		
	25/100%	AAB6800			57.5–60.0 ft	TUFF, light gray, non-indurated.		Qbt 1v		
60										TD = 60.0 ft

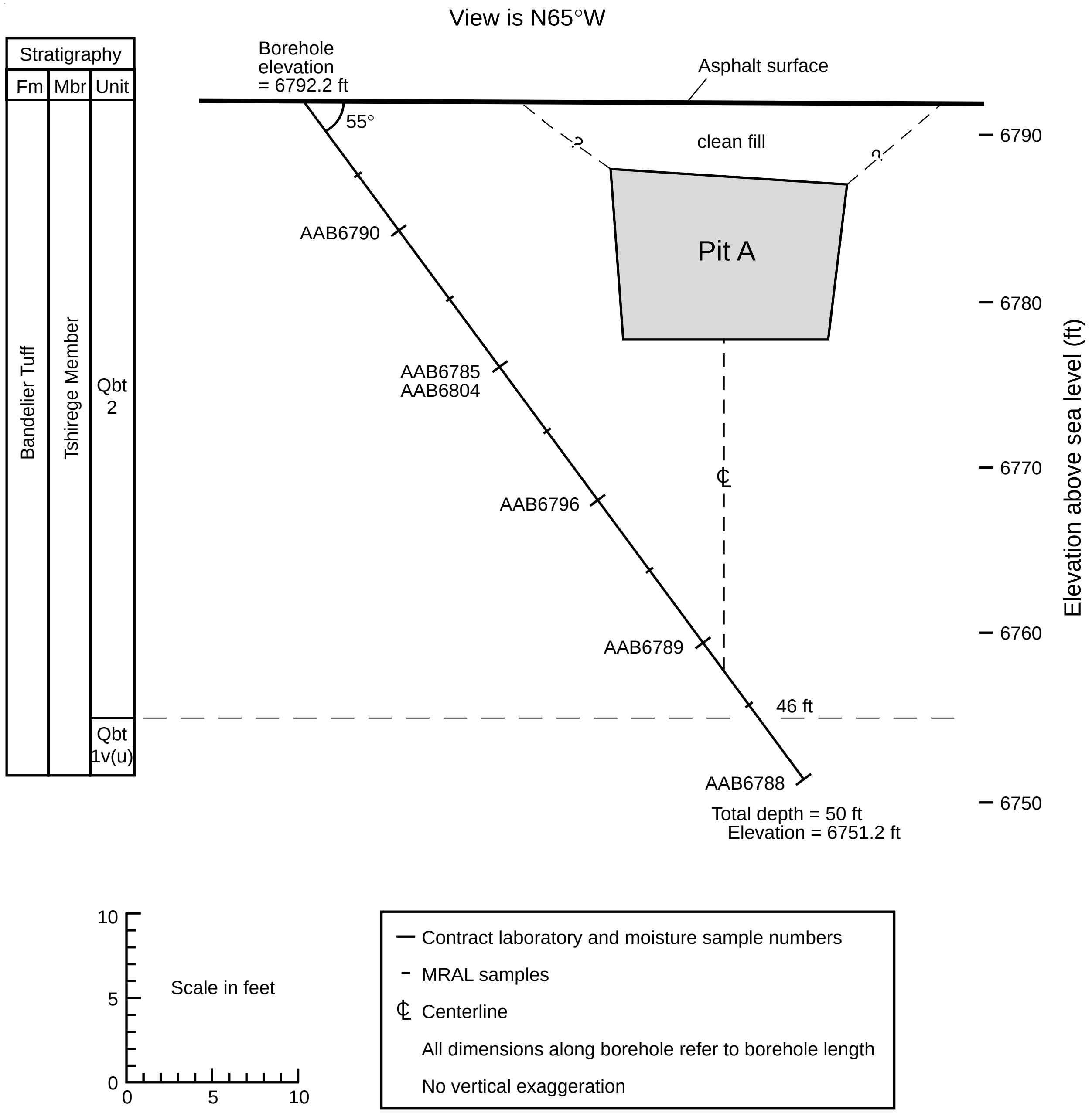


Figure H-11. Profile of borehole 54-01011 showing subsurface sample locations

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

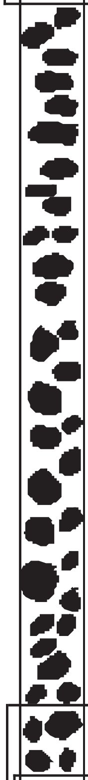
BOREHOLE ID: 54-1011 TA/OU: 54/1148 MDA: L Page: 1 of 1

Drilling Co.: Layne Western Drilling Core Box #(s) 10 Start Date: 7/26/94 Time: 15:40 End Date: 7/26/94 Time: 09:20

Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Split spoon/barrel sampling

Driller: Jim Hayle Geologist: Vince Trujillo LANL Declination: 55.0° Bearing: N 25° E TD: 50.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
0	1/100%			1/ 0–5.0 ft
	2/0%			
5	3/100%		0.2	2/ 5.0–10.0 ft
	4/48%			
10	5/100%	AAB6790		3/ 10.0–15.0 ft
	6/100%			
15	7/76%			4/ 15.0–20.0 ft
	8/100%		0.1	
20	9/80%	AAB6785 AAB6804		5/ 20.0–25.0 ft
	10/60%		0.1	
25	11/100%			6/ 25.0–30.0 ft
	12/60%			
30	13/100%	AAB6796		7/ 30.0–35.0 ft
	14/60%			
35	15/100%			8/ 35.0–40.0 ft
	16/48%	AAB6789		
40	17/100%			9/ 40.0–45.0 ft
	18/100%			
45	19/100%			10/ 45.0–50.0 ft
	20/100%	AAB6788		
50				
55				
60				

	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0–2.2 ft	BACKFILL, moist			NA	Borehole 54-1011 was located adjacent to and angled beneath disposal pit A at MDA L.
2.2–46.0 ft	TUFF, dark gray, nonindurated to slightly indurated, devitrified ash flow, moist		Unit 2, Tshirege Member, Bandelier Tuff		
At 10.0 ft	TUFF, same as above (SAA), medium gray, not as moist				
At 15.0 ft	TUFF, SAA, light gray, slightly indurated to moderately indurated, small dark fragments (lithics)				
At 22.5 ft	TUFF, SAA, dark gray, nonindurated to slightly indurated, dark fragments to 0.5 in.				At 25.0 ft, weak dark staining
At 30.0 ft	TUFF, SAA, dark spots present, moderately indurated, dry				
At 33.6 ft	TUFF, dark reddish brown, with clay				
At 34.0 ft	TUFF, gray, with dark spots				
At 37.5 ft	TUFF, dark gray with dark spot and 1.5 cm fragments				At 36.2–36.5 ft, fracture with reddish material oxidation or clay) at 45 degrees to core axis
At 40.0 ft	TUFF, SAA, dark reddish brown, nonindurated to slightly indurated				
At 42.5 ft	TUFF, SAA, light gray, moderately indurated, with fragments		46.0 ft		
46.0–50.0 ft	TUFF, medium gray, non-indurated		Qbt 1v		
TD = 50.0 ft					

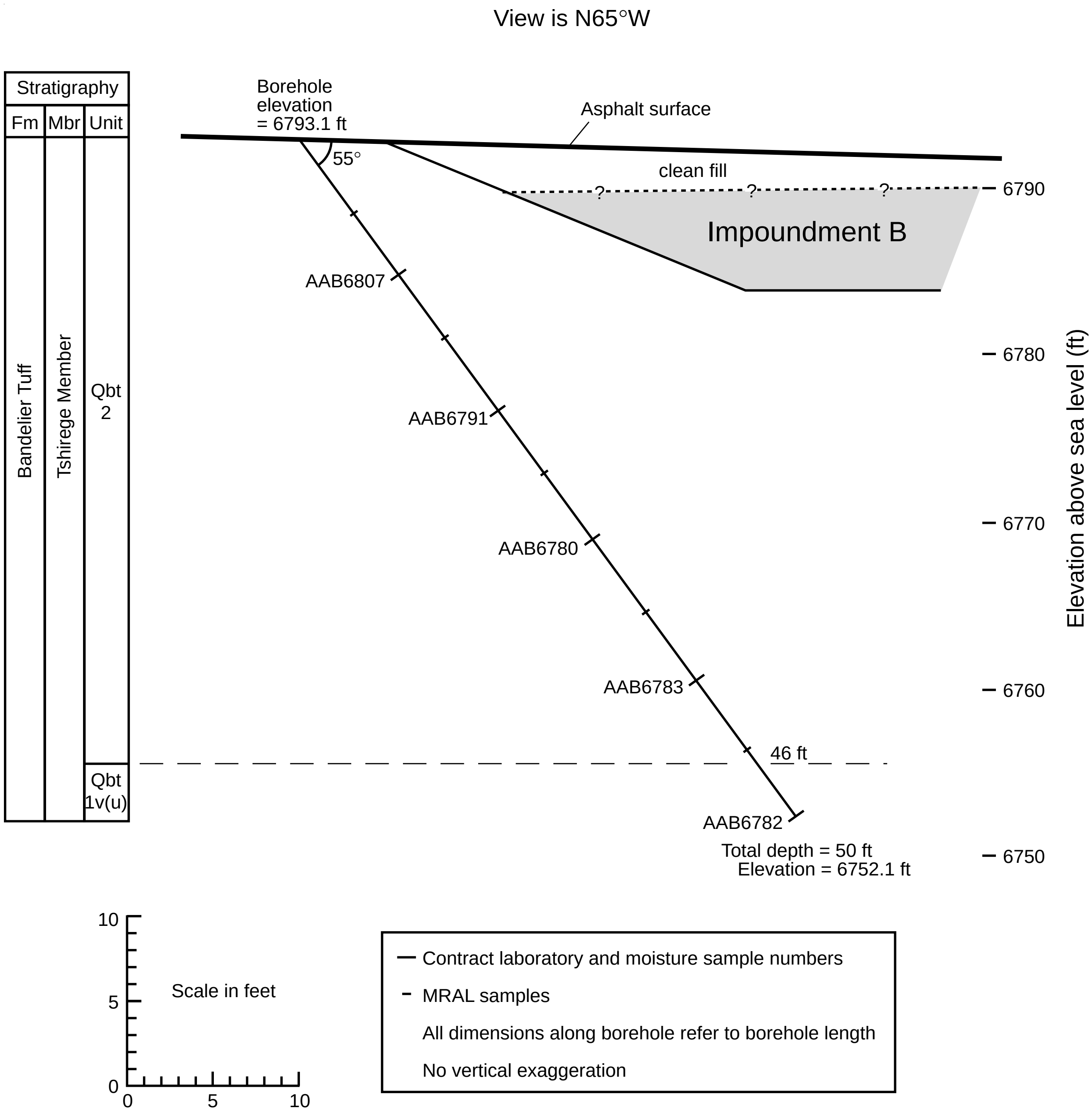


Figure H-12. Profile of borehole 54-01012 showing subsurface sample locations

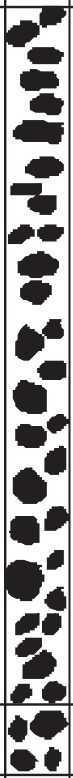
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1012 TA/OU: 54/1148 MDA: L Page: 1 of 1

Drilling Co.: Layne Western Drilling Core Box #(s) 10 Start Date: 7/25/94 Time: 13:08 End Date: 7/25/94 Time: 16:46

Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Split spoon/barrel sampling

Driller: Jim Hayle Geologist: Vince Trujillo LANL Declination: 55.0° Bearing: N 25° E TD: 50.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100%			1/ 0–5.0 ft	0–2.4 ft	BACKFILL, brown, gravel			NA	Borehole 54-1012 was located adjacent to and angled beneath disposal pit B at MDA L. Brown staining at 7.0–7.5 ft.
	2/0%				2.4–46.0 ft	TUFF, light gray, nonindurated to slightly indurated, devitrified ash flow.		Unit 2, Tshirege Member, Bandelier Tuff		
5	3/100%			2/ 5.0–10.0 ft	At 7.0 ft	TUFF, same as above (SAA), brown staining				
	4/100%									
10	5/100%	AAB6807		3/ 10.0–15.0 ft						
	6/100%				At 15.0 ft	TUFF, SAA, medium gray, slightly indurated to moderately indurated				
15	7/100%			4/ 15.0–20.0 ft						
	8/100%									
20	9/100%	AAB6791		5/ 20.0–25.0 ft	At 20.0 ft	TUFF, SAA, dark gray, nonindurated to slightly indurated				
	10/100%									
25	11/100%			6/ 25.0–30.0 ft	At 27.5 ft	TUFF, SAA, moderately indurated, dark fragments up to 0.5 in.				
	12/100%									
30	13/100%	AAB6780		7/ 30.0–35.0 ft	At 30.0 ft	TUFF, SAA, light gray with dark speckles, moderately indurated				
	14/100%									
35	15/100%			8/ 35.0–40.0 ft						
	16/100%									
40	17/100%	AAB6783		9/ 40.0–45.0 ft	At 40.5 ft	TUFF, dark reddish brown with clay				
	18/100%				At 42.0 ft	TUFF, light gray brown, moderately indurated				
45	19/100%			10/ 45.0–50.0 ft	46.0–50.0 ft	TUFF, SAA, light greenish gray, moderately indurated		46.0 ft Qbt 1v		
	20/60%	AAB6782			At 48.5 ft	TUFF, SAA, light gray, moderately indurated, with fragments				
50					TD = 50.0 ft					
55										
60										

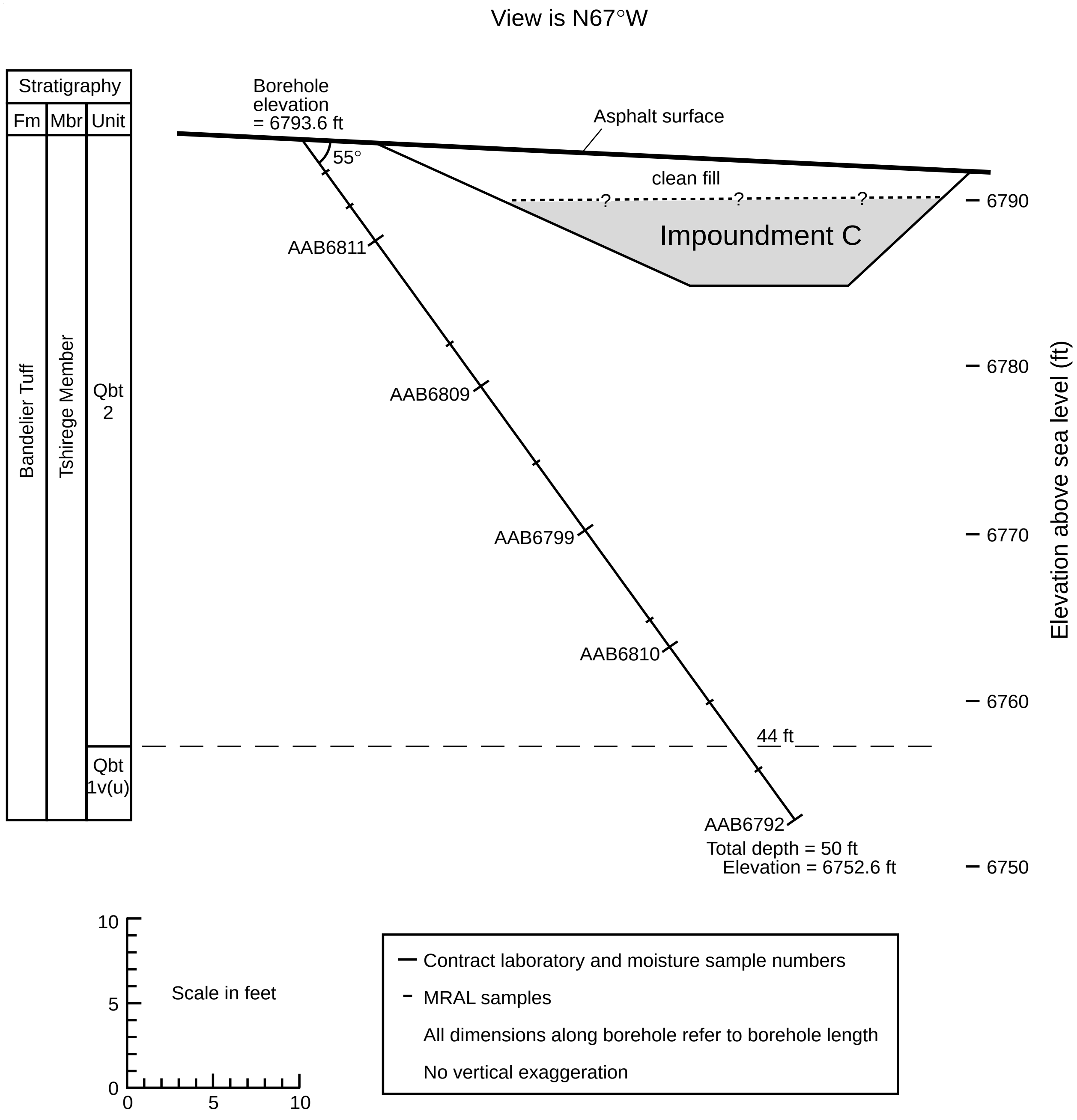


Figure H-13. Profile of borehole 54-01013 showing subsurface sample locations

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1013 TA/OU: 54/1148 MDA: L Page: 1 of 1

Drilling Co.: Layne Western Drilling Core Box #(s) 10 Start Date: 7/15/94 Time: 11:00 End Date: 7/20/94 Time: 14:30

Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Split spoon/barrel sampling

Driller: Jim Hayle Geologist: Vince Trujillo LANL Declination: 55.0° Bearing: N 23° E TD: 50.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100%			1/ 0–5.0 ft	0–0.8 ft ASPHALT 0.8–2.5 ft BACKFILL			NA	Borehole 54-1013 was located adjacent to and angled beneath disposal pit C at MDA L. At 8.5 ft fracture with roots.
	2/100%				2.5–3.0 ft SOIL, dark brown clay 3.0–44.0 ft TUFF, light gray, nonindurated to slightly indurated, ash flow		Unit 2, Tshirege Member, Bandelier Tuff		
5	3/50%			2/ 5.0–10.0 ft					
	4/100%	AAB6811							
10	5/100%			3/ 10.0–15.0 ft	At 10.0 ft TUFF, same as above (SAA), slightly indurated to moderately indurated				
	6/100%								
15	7/10%			4/ 15.0–20.0 ft					
	8/100%	AAB6809			At 17.5 ft TUFF, SAA, light brown, nonindurated to slightly indurated				
20	9/100%			5/ 20.0–25.0 ft					At 19.2 ft light reddish brown staining
	10/100%				At 22.5 ft TUFF, SAA, light gray specks in matrix				
25	11/100%			6/ 25.0–30.0 ft	At 25.0 ft TUFF, SAA, medium brown gray, moderately indurated				
	12/100%	AAB6799							
30	13/100%			7/ 30.0–35.0 ft	At 32.0 ft TUFF, SAA, reddish brown				
	14/100%				At 33.1 ft TUFF, SAA, light gray, loose sandy texture				At 32.0 ft possible oxidized fracture along core axis
35	15/100%			8/ 35.0–40.0 ft					
	16/50%	AAB6810							
40	17/100%			9/ 40.0–45.0 ft	At 40.75 ft TUFF, SAA, light gray brown, moderately indurated				
	18/0%								
45	19/70%			10/ 45.0–50.0 ft	44.0–50.0 ft TUFF, SAA, dark gray, moist		44.0 ft Qbt 1v		
	20/100%	AAB6792			At 47.5 ft TUFF, SAA, medium gray				
50					TD = 50.0 ft				
55									
60									

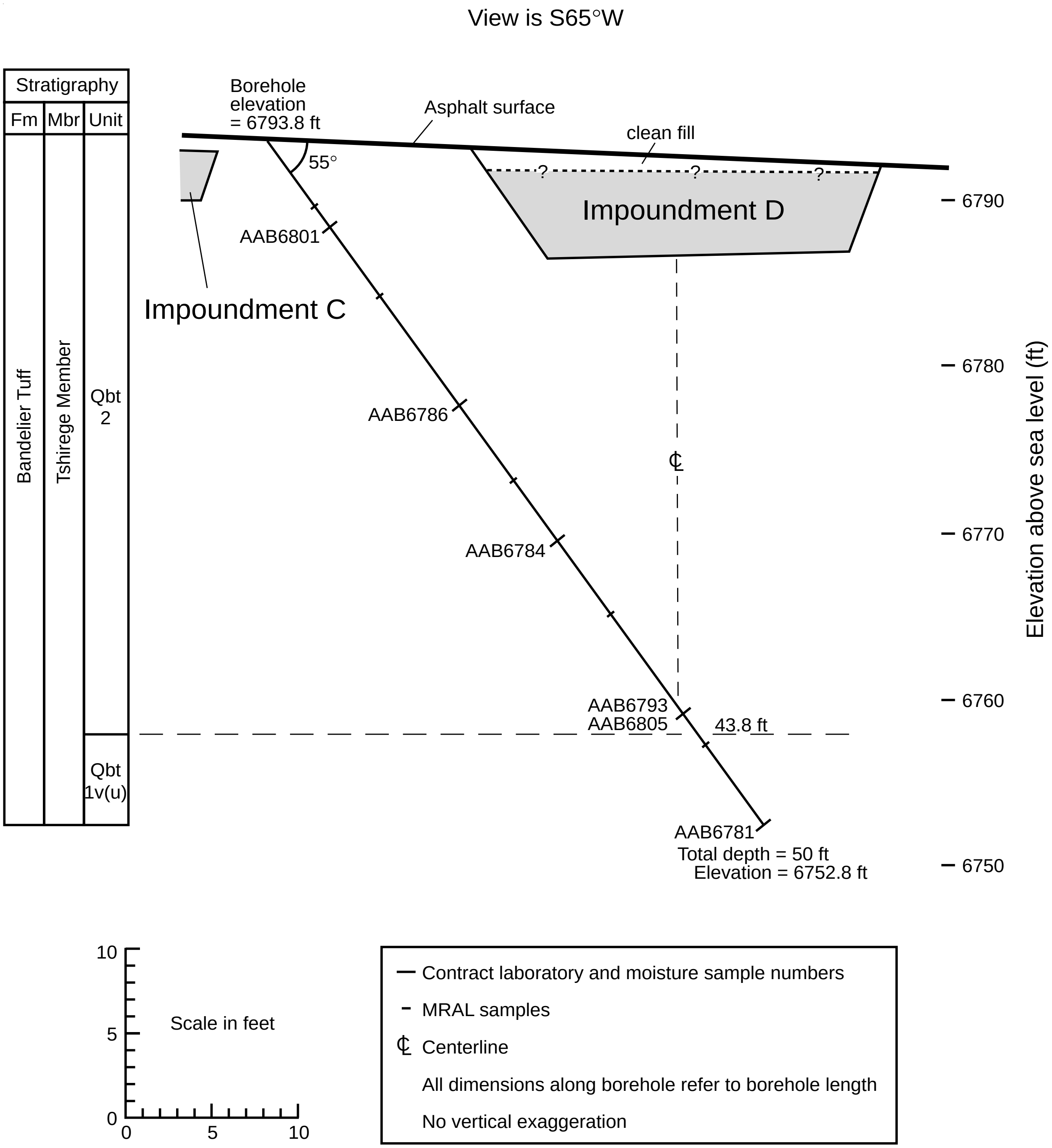


Figure H-14. **Profile of borehole 54-01014 showing subsurface sample locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1014 TA/OU: 54/1148 MDA: L Page: 1 of 1

Drilling Co.: Layne Western Drilling Core Box #(s) 10 Start Date: 7/22/94 Time: 07:45 End Date: 7/22/94 Time: 11:50

Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Split spoon/barrel sampling

Driller: Jim Hayle Geologist: Vince Trujillo LANL Declination: 55.0° Bearing: N 25° W TD: 50.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	1/100%			1/ 0–5.0 ft	0–0.7 ft GRAVEL 0.7–1.3 ft BACKFILL 1.3–43.8 ft TUFF, light to dark gray, nonindurated to slightly indurated, ash flow		Unit 2, Tshirege Member, Bandelier Tuff	NA	Borehole 54-1014 was located adjacent to and angled beneath disposal pit D at MDA L.
	2/0%		0.2						
5	3/100%	AAB6801		2/ 5.0–10.0 ft					
	4/0%								
10	5/100%		0.3	3/ 10.0–15.0 ft					
	6/100%								
15	7/60%		0.3	4/ 15.0–20.0 ft	At 16.5 ft TUFF, same as above (SAA), dark reddish brown with roots				
	8/100%				At 17.5 ft TUFF, SAA, light gray, nonindurated to slightly indurated				
20	9/100%	AAB6786	0.2	5/ 20.0–25.0 ft					
	10/100%		0.1						
25	11/64%			6/ 25.0–30.0 ft					
	12/68%	AAB6784							
30	13/100%		0.2	7/ 30.0–35.0 ft	At 30.0 ft TUFF, SAA, light gray fragments				
	14/100%				At 32.5 ft TUFF, SAA, medium brown, loose, light gray fragments				
35	15/100%		0.3	8/ 35.0–40.0 ft					
	16/60%								
40	17/100%	AAB6793	0.2	9/ 40.0–45.0 ft	At 40.0 ft TUFF, SAA, light gray brown, slightly indurated				
	18/100%	AAB6805			43.8–50.0 ft TUFF, SAA, moderately indurated		43.8 ft Qbt 1v		
45	19/100%		0.1	10/ 45.0–50.0 ft					
	20/100%	AAB6781							
50					TD = 50.0 ft				
55									
60									

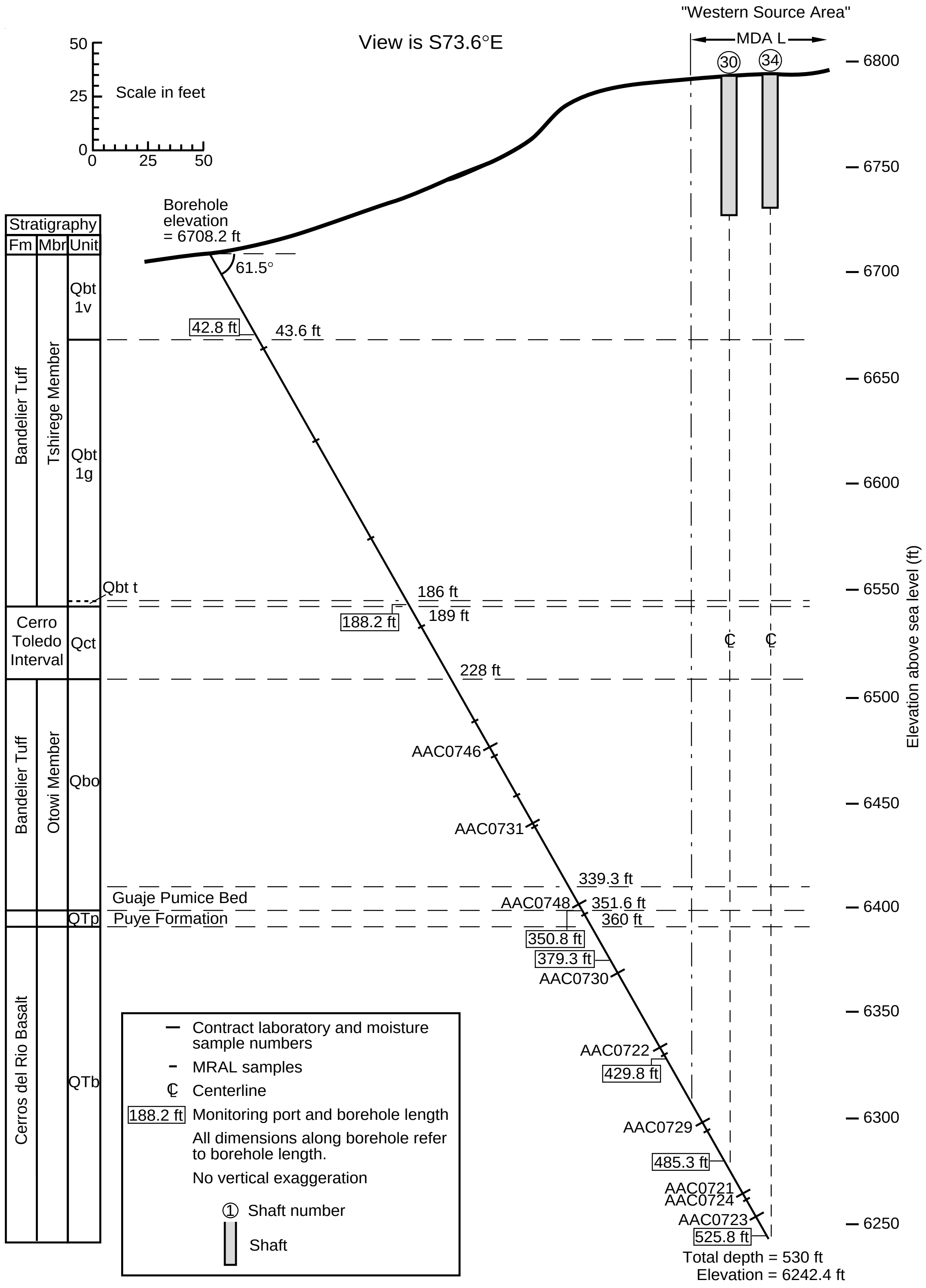


Figure H-15. **Profile of borehole 54-01015 showing subsurface sample and monitoring port locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1015 TA/OU: 54/1148 MDA: L Page: 1 of 5
Drilling Co.: Tonto Environmental Drilling Inc. Core Box #(s) 8 Core 57 Cuttings Start Date: 11/17/94 Time: 10:30 End Date: 1/9/95 Time: 12:00
Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression Sampling Method: Core barrel sampling
Driller: John Eddy, Larry Thoren Geologist: Jon Marin, ERM/Golder Declination: 61.5° Bearing: S 16.4° W TD: 530.0 ft

Depth (ft): 0 – 120

Core Run # / Core Recovery %: Air Rotary Cuttings

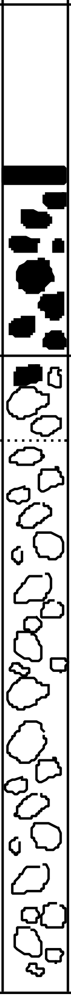
Field Analytical Sample Number:

Field Screening VOCs (ppm) > Background: 0.2, 0.6, 0.3, 0.5, 0.3, 0.3, 1.7, 0.3, 0.6, 0.6, 0.3, 0.3, 2.1, 0.6, 2.0, 1.0, 0.6, 0.9, 5.2, 0.9, 1.5, 0.6, 0.6, 1.2, 0.6, 0.7, 2.0, 1.6

Core Box # From - To (ft): Air Rotary Cuttings in boxes 1 of 57 to 15 of 57

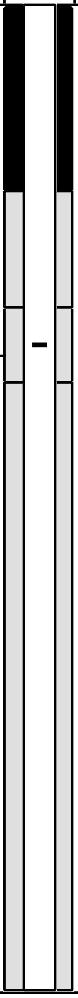
Depth	Lithology
0--23.0 ft	Surface casing set at 23.0 ft, 10-in. diameter
At 20.0 ft	Light brown gray bentonite pebbles
At 22.0 ft	TUFF, light pale yellow brown 10 YR 6/2 ash flow.
At 30.0 ft	TUFF, same as above (SAA), grayish orange pink 5 YR 7/2, quartz and sanidine with Schiller blue iridescence up to 20%, sugary devitrified texture
At 42.5 ft	
43.6--186.0 ft	TUFF, SAA, pale red 5R 6/2. TUFF, vitric, grayish red 10R 4/2, broken glass shards.
At 54.0 ft	TUFF, SAA, pale red 10R 6/2 vitric
At 73.0 ft	TUFF, SAA grayish orange pink 5 YR 7/2 pulverized ash flow tuff, pumice fragments are dark and 15%
At 86.0 ft	TUFF, SAA, pale red 10R 6/2 SAA, pumice fragments 25%
At 92.0 ft	TUFF, grayish orange pink 5 YR 7/2, SAA
At 101.5 ft	TUFF, light brownish gray 5 YR 6/1 SAA, pumice fragments 25%

Graphic Log



Lithologic Unit: Unit 1v, Tshirege Member, Bandelier Tuff; 43.6 ft; Unit 1g, Tshirege Member, Bandelier Tuff

Monitor Well Construction



Notes:

Borehole 54-1015 is located in the tributary to Cañada del Buey north of and angled beneath MDA L.

Solinst vapor port at 42.8 ft

ODEX 8-in.-diameter casing was installed using air rotary drilling from 20.0 ft to 260.0 ft and between air coring for 10.0 ft for every 40.0 ft to the total depth of the borehole.

The volcanic tuff was pulverized by the air hammer drilling. Rotary cuttings were collected in 4-in.-diameter sealed plastic tubes and boxed for curation.

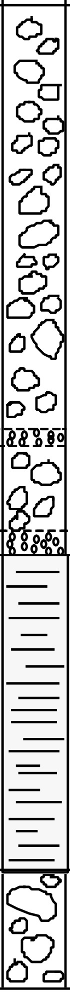
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1015 TA/OU: 54/1148 MDA: L Page: 2 of 5

Drilling Co.: Tonto Environmental Drilling Inc. Core Box #(s) 8 Core 57 Cuttings Start Date: 11/17/94 Time: 10:30 End Date: 1/9/95 Time: 12:00

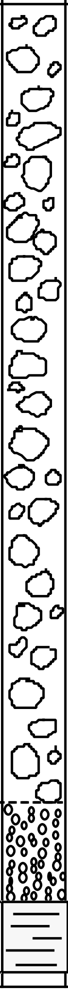
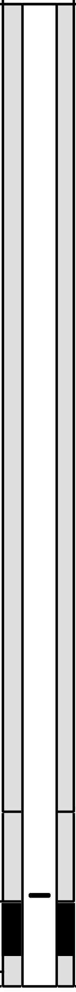
Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression Sampling Method: Core barrel sampling

Driller: John Eddy, Larry Thoren Geologist: Jon Marin, ERM/Golder Declination: 61.5° Bearing: S 16.4° W TD: 530.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
120 130	Air Rotary Cuttings		3.0 3.0 0.2	Air Rotary Cuttings in boxes 15 of 57 to 24 of 57	43.6–186.0 ft (continued)	TUFF, light brown to gray pulverized ash flow		Unit 1g, Tshirege Member, Bandelier Tuff		Air rotary drilling is producing alternating intervals of sorted and poorly sorted pulverized tuff.
140			0.7 0.8 0.7		At 136.0 ft	Pumice fragments decrease to 10%.				
150 160			1.7 1.1 0.7 0.5 0.6		At 146.0 ft	Very fine-grained broken glass shards				Glass shards observed using a binocular microscope cling to the inside of the plastic cuttings tubes.
170			0.6 0.4		At 170.0 ft At 173.0 ft	TUFF, light brownish gray 5 YR 61 pulverized ash flow, vitric pumice fragments 15–25%				Pumice swarm at 173.0 ft
180			0.4 0.2		At 175.0 ft	Pumice SWARM, up to 80% Light brown to gray pulverized ash flow tuff, SAA		186.0 ft		
190			0.9		186.0–189.0 ft	Pumice BED, 50–90%, pulverized vitric pumice		Qbt t 189.0 ft		Solinst vapor port at 188.2 ft, Tsankawi Pumice Bed at 186.0 ft, poor recover due to moisture in cuttings, plugs minicyclone repeatedly
200 210 220			0.2 1.3 0.2 0.4 0.7 0.6 0.4 1.1 0.4		189.0–228.0 ft	SILT, SAND, pale yellowish brown 10 YR 6/2 to brownish gray 5 YR 4/1, poorly to well sorted and layered in 2.0–5.0 ft intervals of silt- and sand-sized, moist, reworked ash, some gravel consisting mostly of subrounded phenocrysts, and broken dacite cobbles.		Cerro Toledo interval 228.0 ft		
230 240			1.1 0.3 0.9 0.4		228.0–339.3 ft	TUFF, pale yellowish brown 10 YR 6/2, much less moist, 10% dacite fragments		Otowi Member		Cuttings recovery doubled at 228.0 ft, rock drills like tuff in Unit 1g

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1015	TA/OU: 54/1148	MDA: L	Page: 3 of 5
Drilling Co.: Tonto Environmental Drilling Inc.	Core Box #(s) 8 Core 57 Cuttings	Start Date: 11/17/94 Time: 10:30	End Date: 1/9/95 Time: 12:00
Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression		Sampling Method: Core barrel sampling	
Driller: John Eddy, Larry Thoren	Geologist: Jon Marin, ERM/Golder	Declination: 61.5°	Bearing: S 16.4° W TD: 530.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
240 250	Air Rotary Cuttings		0.4 0.4 0.6 0.2 0.4	Air Rotary Cuttings boxes 24–26	228.0–339.3 ft (continued)	TUFF, pale yellowish brown 10 YR 6/2 nonindurated, non-welded, pumice-rich vitric ash flow tuff. Pumice lapilli and bombs are 10–20%, obloid, 0.2–5 cm, glassy resinous luster, oxidized, fully inflated tube structures, euhedral quartz and sanidine phenocrysts up to 10%, 0.5–1.5 mm. Lithics are dacite, <5%, 0.1–3 cm.		Otowi Member, Bandelier Tuff		Air rotary ODEXing to 260.0 ft
260	1/100% 2/100%	AAC0746	2.4 0.2 0.5 0.4	1/ 260.0–270.0 ft						Air core 260.0–270.0 ft
270 280 290	Air Rotary Cuttings		0.4 0.2 0.4 0.2 0.3 0.3 0.3 0.3	Air Rotary Cuttings boxes 27–35	At 288.5 ft	TUFF, SAA, oxidized lithics and rounded quartz phenocrysts, <5%, 1.0–3.0 mm, and broken glass shards survive rotary air circulation.				Air rotary ODEXing to 300.0 ft
300	3/100% 4/6%	AAC0731	0.3 1.0 1.0 0.7	2/ 300.0–310.0 ft	At 300.0 ft	TUFF, SAA, pale yellowish brown 10 YR 6/2 massive, very soft and friable, non-indurated, nonwelded vitric ash flow. Pumice lapilli and bombs are equant to obloid, 5–10%, 0.1–12.0 cm, light olive gray 5 Y 3/2 with rare quartz phenos <1%. Lithics are subangular dacite, 5–8%, 1.0–3.0 mm, few oxidized.				Air core 300.0–310.0 ft, light pinkish white vapor-phase alteration clay in pumice lapilli,
310 320 330	Air Rotary Cuttings		0.3 0.7 1.3 2.6 0.3 1.0 1.3 0.6 1.0 0.6	Air Rotary Cuttings boxes 35–42	339.3–351.6 ft	Guaje Pumice BED, 90% 0.5–2.0 mm, light gray to light olive gray 5 Y 5/2 vitric, hard, cemented pumice,10% dark gray, oxidized, dacite lithics.		339.3 ft		air rotary ODEXing to 340.0 ft
340	5/0% 6/33%		0.4	2/ 340.0–348.0 ft				351.6 ft		Air core 340.0–348.0 ft Solinst moisture/vapor port at 350.8 ft,
350 360	Air Rotary	AAC0748	1.0 0.7	Air Rotary 43–45	351.6–360.0 ft	SILT, Puye Formation, brownish gray 5 YR 4/1 to pale orange 10 YR 8/2, moist, some subrounded basalt cobbles		QTp 360.0 ft		brown wet soil 351.6–352.0 ft

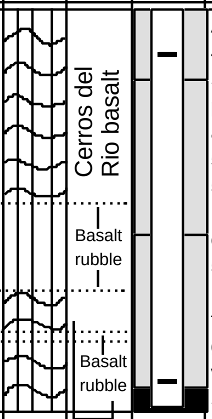
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1015	TA/OU:	54/1148	MDA:	L	Page:	4 of 5
Drilling Co.:	Tonto Environmental Drilling Inc.	Core Box #(s)	8 Core 57 Cuttings	Start Date:	11/17/94	End Date:	1/9/95
				Time:	10:30	Time:	12:00
Drilling Equip./Method:	Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression			Sampling Method:	Core barrel sampling		
Driller:	John Eddy, Larry Thoren	Geologist:	Jon Marin, ERM/Golder	Declination:	61.5°	Bearing:	S 16.4° W
TD:	530.0 ft						

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Lithologic Unit	Notes
360	Air Rotary Cuttings		0.6 0.9 0.7 0.7	Air Rotary Cuttings boxes 45–48	360.0–530.0 ft (continued)	BASALT, medium gray, very dense, aphanitic, local iron oxide on rock chips.	Cerros del Rio basalt	Air rotary ODEXing to 380.0 ft.
380	7/100%		1.1	3/ 380.0–391.0 ft	At 380.0 ft	BASALT, SAA, medium gray, vesicular. Vesicles are 30%, obloid, 1.0 mm to 5.0 cm.		Solinst vapor port at 379.3 ft, air core 380.0–390.0 ft, air rotary ODEXing to 420.0 ft
	8/90%	AAC0730			384.5–391.0 ft	BASALT, dark med. gray, low density, highly vesicular, scoriaceous, frothy, rubble. Vesicles are locally stretched into tubes. Vesicles and fractures are coated with grayish red 5 YR 4/2 fine-grained hematite crystals and local light bluish white stain.	384.5 ft Basalt rubble 391.0 ft	
390	9/100% Air Rotary Cuttings		1.8 0.6 0.9	Air Rotary Cuttings boxes 48–49			Cerros del Rio basalt	
400								
410								
420	10/100%		0.6 0.4	4/ 420.0–430.0 ft	At 420.0 ft	BASALT, medium dk. gray, massive, aphanitic, very hard, very dense. Vesicles are 2–3%, obloid 0.1–1.0 cm. Light brownish green 0.5 mm fayalite crystals in rare clusters are 1–2% of rock. Some fayalite clusters surrounded by prismatic plagioclase laths, coarser than aphanitic groundmass.		Air core 420.0–430.0 ft, Solinst vapor port at 429.8 ft, air rotary ODEXing to 460.0 ft
	11/60%	AAC0722			427.0–428.0 ft		427.0 ft Basalt rubble	
430	Air Rotary Cuttings			Air Rotary Cuttings boxes 50–51			Cerros del Rio basalt	
440								
450			0.4			BASALT, vesicular rubble		
460	12/100%		0.5	5/ 460.0–467.5 ft	At 460.0 ft	BASALT, medium dark gray massive aphanitic, non-vesicular, 65% is light to clear, frosty aphanitic groundmass (plagioclase), 35% is minute equant euhedral pyroxenes with good basal cleavage.		Air core 460.0–465.0–470.0 ft
	13/100%	AAC0729	0.7 0.4	6/467.5–468.8 ft				
470	Air Rotary		0.5	Air Rotary 52–53				Air rotary ODEXing to 500.0 ft
480								

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1015	TA/OU:	54/1148	MDA:	L	Page:	5 of 5
Drilling Co.:	Tonto Environmental Drilling Inc.	Core Box #(s)	8 Core 57 Cuttings	Start Date:	11/17/94	End Date:	1/9/95
				Time:	10:30	Time:	12:00
Drilling Equip./Method:	Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression			Sampling Method:	Core barrel sampling		
Driller:	John Eddy, Larry Thoren	Geologist:	Jon Marin, ERM/Golder	Declination:	61.5°	Bearing:	S 16.4° W
TD:	530.0 ft						



Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Lithologic Unit	Notes
480	Air Rotary Cuttings		0.4 0.3	Air Rotary Cuttings boxes 54–55	360.0–530.0 ft (continued)	BASALT, medium gray, very dense, aphantic to slightly vesicular	Cerros del Rio basalt	Air rotary 460.0–500.0 ft, Solinst vapor port at 485.3 ft, air core 500.0–517.0 ft and 520.0–525.0 ft. Lost all air circulation at 506.0 ft. Light limonite on fractures and goethite in vesicles, Solinst moisture/vapor port at 525.8 ft atop submersible air pump
490			0.9 1.9		At 488.0 ft	BASALT, SAA, highly vesicular, wet		
500	14/100%		3.2	6/400.0–506.0 ft	At 501.0 ft	BASALT, SAA, light gray moderately vesicular, numerous fractures		
510	15/33% 16/100% 17/54%	AAC1721 AAC0724	0.2 0.5 0.7	7/506.0–517.5 ft	506.0–515.0 ft	BASALT, SAA, light gray moderately vesicular rubble	Basalt rubble	
	18, 19, 20 avg. = 60%	AAC0723	0.7		515.0–520.0 ft	BASALT, SAA, light gray		
520			0.7	8/520.0–525.0 ft	520.0–521.0 ft	BASALT, rubble	Basalt rubble	
	21/67% 22/60%		0.6		At 521.0 ft	BASALT, SAA, vesicular core, very wet, water pooled in vesicles		
530	Air Rotary Cuttings			Air Rotary Cuttings box 56–57	TD = 530.0 ft		Cerros del Rio basalt	
540								
550								
560								
570								
580								
590								
600								

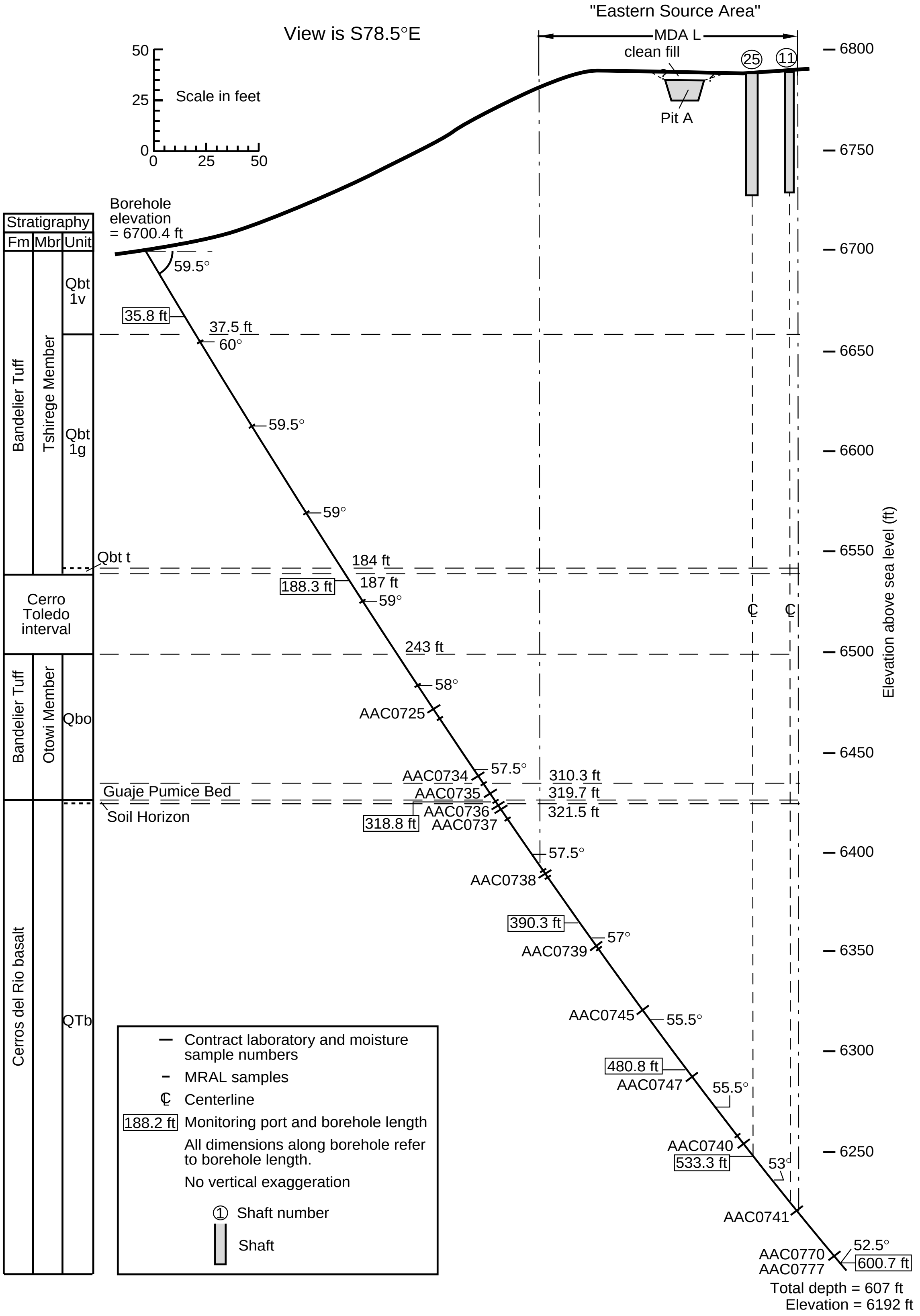


Figure H-16. **Profile of borehole 54-01016 showing subsurface sample and monitoring port locations**

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

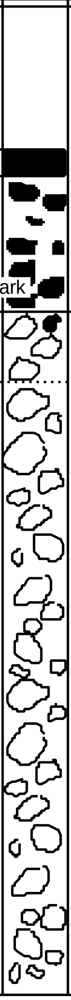
BOREHOLE ID: 54-1016 TA/OU: 54/1148 MDA: L Page: 1 of 6

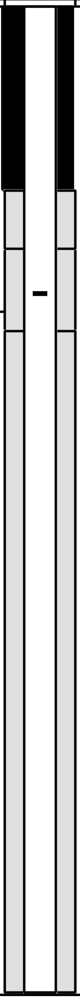
Drilling Co.: Tonto Environmental Drilling Inc. Core Box #(s) 8 Core 59 Cuttings Start Date: 2/1/95 Time: 14:30 End Date: 3/17/95 Time: 10:30

Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression Sampling Method: Core barrel sampling

Driller: Larry Thoren Geologist: Jon Marin, ERM/Golder Declination: Surveyed downhole Bearing: S 11.5° W TD: 607.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
0	Air Rotary Cuttings			Air Rotary Cuttings in boxes 1 of 59 to 17 of 59	0–23.0 ft	Surface casing set at 23.0 ft, 10-in.-diameter, declines 59.5 degrees from horizontal		Unit 1v, Tshirege Member, Bandelier Tuff		Borehole 54-1016 is located in the tributary to Cañada del Buey north of and angled beneath MDA L. Surface declination is 59.5 degrees from horizontal. Solinst vapor port at 35.8 ft
20			0.2 0.2		18.0–21.0 ft	BENTONITE, clay pebbles				
			0.3		21.0–26.3 ft	TUFF, weathered, yellow brown 10 YR 6/2, ash flow.				
30			0.3 0.4 0.3 1.0		26.3–37.5 ft	TUFF, same as above (SAA), grayish orange pink 5 YR 7/2 pulverized ash flow tuff, minute dark brown sugary pumice fragments				
40			1.2 2.1		37.5–184.0 ft	TUFF, pale reddish brown 10 R 5/4, minute glass shards		37.5 ft Unit 1g, Tshirege Member, Bandelier Tuff		
50			1.0 1.8 2.2 1.7 2.9 0.5		At 47.0 ft At 50.0 ft, 60.0 degrees from horizontal	TUFF, SAA, light greenish gray vitric pumice fragments with tube structures inflated, euhedral quartz phenocrysts 2.0 mm, dacite lithics to 0.25 in.				ODEX 8-in.-diameter casing was installed using air rotary drilling from 20.0 to 260.0 ft and between air coring 10.0 ft within every 40.0 ft to the total depth of the borehole.
70			1.2 .02 0.3 1.9 2.3 1.6 2.4 1.6		At 55.0 ft	Decrease in rotary cuttings recovery to 50%				The volcanic tuff was pulverized by the air hammer drilling. Rotary cuttings were collected in 4-in.-diameter sealed plastic tubes and boxed for curation.
100			0.1 1.0 1.4 2.3 3.7 1.6		At 98.3 ft At 100.0 ft, 59.5 degrees from horizontal	TUFF, SAA alternating 2–5 ft intervals of grayish orange pink 5 YR 7/2 to pale red 10 R 6/2 to very pale orange 10 YR 8/2				
120			0.3 1.9		At 199.0 ft	TUFF, SAA, pinkish gray 5 YR 8/1				





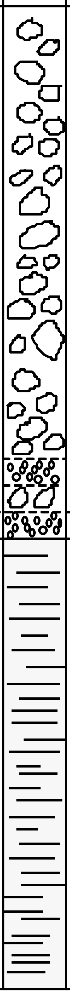
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

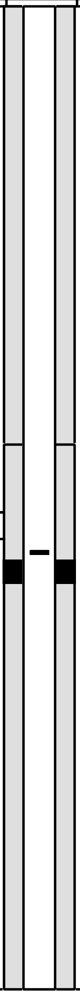
BOREHOLE ID: 54-1016 TA/OU: 54/1148 MDA: L Page: 2 of 6

Drilling Co.: Tonto Environmental Drilling Inc. Core Box #(s) 8 Core 59 Cuttings Start Date: 2/1/95 Time: 14:30 End Date: 3/17/95 Time: 10:30

Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression Sampling Method: Core barrel sampling

Driller: Larry Thoren Geologist: Jon Marin, ERM/Golder Declination: Surveyed downhole Bearing: S 11.5° W TD: 607.0 ft





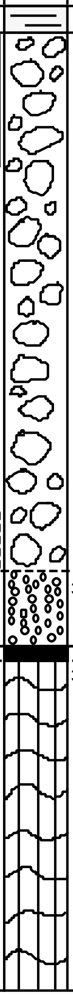
Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Lithologic Unit	Notes
120	Air Rotary Cuttings			Air Rotary Cuttings in boxes 17 of 59 to 30 of 59	37.5–184.0 ft (continued)	TUFF, pinkish gray 5 YR 8/1 pulverized ash flow	Unit 1g, Tshirege Member, Bandelier Tuff	At 109.0 ft air rotary cuttings recovery-100%, at 120.0 ft air rotary cuttings recovery-50%,
			1.6					
			1.5					
130			0.7					
			0.7					
			0.6					
140			0.3					
			0.2		At 150.0 ft, 59.0 degrees from horizontal			at 149.0 ft air rotary recovery-25% Note: air rotary cuttings recovery through the mini-cyclone was decreased by an increased moisture content of the cuttings.
150			0.3					
			1.5					
			1.2		At 158.6 ft	TUFF, very light gray to light brownish gray pulverized ash flow, vitric pumice fragments are 20% and up to 2.0 mm		
160			0.4					
			0.5					
170			0.7					
					At 180.0 ft	TUFF, very light gray to light pinkish gray 5 YR 8/1		
			3.8					
			0.3		At 180.2 ft	Pumice SWARM or BED		
180			1.8		At 180.3 ft	TUFF, SAA	184.0 ft	
			1.6		184.0–187.0 ft	Pumice BED, 50-90% lapilli	Qbt t	Solinst moisture and vapor port at 188.3 ft atop inverted air pump
					187.0–243.0 ft	SILT, SAND, stratified yellowish gray 5 Y 7/2 to pale yellowish brown 10 YR 6/2, 2.0–5.0 ft fine-grained to coarse-grained, massive well sorted to poorly sorted, moist, intervals of silt- and sand-sized reworked ash and subrounded phenocrysts; some gravel consisting mostly of fragments of dark gray brown dacite and up to 60% oxidized vitric pumice fragments	187.0 ft Cerro Toledo Interval	
190								
			3.1					
			2.3		At 200.0 ft, 59.0 degrees from horizontal			
200			0.8					
210			1.3					
220			1.9					
			0.7					
			1.6					
230								
			2.1		At 230.0 ft	SILT, pale yellowish brown 10 YR 6/2, massive, fine-grained, well-sorted		
240			2.0					

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1016 TA/OU: 54/1148 MDA: L Page: 3 of 6
Drilling Co.: Tonto Environmental Drilling Inc. Core Box #(s) 8 Core 59 Cuttings Start Date: 2/1/95 Time: 14:30 End Date: 3/17/95 Time: 10:30
Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression Sampling Method: Core barrel sampling
Driller: Larry Thoren Geologist: Jon Marin, ERM/Golder Declination: Surveyed downhole Bearing: S 11.5° W TD: 607.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology		Lithologic Unit	Notes
240 250	Air Rotary Cuttings		1.4 2.9 0.6 2.3 2.5	Air Rotary Cuttings boxes 30–33	187.0–243.0 ft 243.0–310.3 ft At 250.0 ft, 58.0 degrees from horizontal	SILT, SAA, pale yellowish brown 10 YR 6/2 to very pale orange 10 YR 8/2, 50% reworked ash and 50% sand- and gravel-sized phenocrysts and dacite fragments	Qct 243.0 ft	Air rotary ODEXing to 260.0 ft
260	1/100% 2/100%	AAC0725	0.9 0.9	1/ 260.0–270.0 ft		TUFF, pinkish gray 5 YR 8/1, nonwelded, slightly indurated ash flow. Pumice lapilli are vitric, 5–10%, 0.5–4.0 cm, grayish orange 10 YR 2/4, some oxidized relict pumice lapilli contain local amorphous clay alteration.	Otowi Member, Bandelier Tuff	Air core 260.0–270.0 ft
270 280 290	Air Rotary Cuttings		1.1 1.2 2.6 1.9 2.9 4.2 4.3	Air Rotary Cuttings boxes 33–37	At 288.0 ft At 300.0 ft, 57.5 degrees from horizontal	TUFF, SAA, pumice lapilli are very light gray, phenocrysts are K-spar and quartz, each 2–5% and 0.5–1.5 mm, dacite lithics are dark gray 1–5%, <1 cm.		Air rotary ODEXing to 300.0 ft
300	3/100% 4/6%	AAC0734	0.6 5.0	2/ 300.0–308.4 ft		Guaje Pumice BED, 90% 1.0–4.0 mm, very lt. gray, vitric pumice lapilli, 10% oxidized; 2–3% dark gray dacite lithics		Air core 300.0–330.0 ft Solinst moisture/vapor port at 318.8 ft atop inverted air pump.
310	5/100% 6/100% 7/100%	AAC0735 AAC0736	0.5 1.9 1.4	3/ 308.4–316.3 ft 4/ 316.3–326.4 ft	310.3–319.7 ft	SOIL, moist grayish red 5 Y 4/2 to dark red brown 10 R 3/4, clay and silt with local caliche nodules, 10% angular, vesicular basalt cobbles.	310.3 ft 319.7 ft	
320	8/100% 9/100%	AAC0737	2.5 4.0	5/326.4–364.9 ft	319.7–321.5 ft		321.5 ft	
330 340 350 360	Air Rotary Cuttings no recovery Air Rotary Cuttings		2.0 2.3 5.1 2.2 4.5 4.0	Air Rotary Cuttings boxes 38–45	321.5–607.0 ft At 325.0 ft At 350.0 ft, 57.5 degrees from horizontal At 328.0 ft.	BASALT, weathered, oxidized, fractured, vesicular BASALT, fresh, vesicular, dark blue gray, moist, vesicles are 30%, 0.5 mm to 2.0 cm, lined with minute clear plagioclase laths and hematite iron oxide BASALT, massive, aphanitic, microvesicles are <5%.	Cerros del Rio Basalt	Weathered basalt has multiple oxidized fractures coated with clay and calcite. Fractures in unweathered basalt are fresh. Air rotary ODEXing to 360.0 ft

Graphic Log



Monitor Well Construction

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

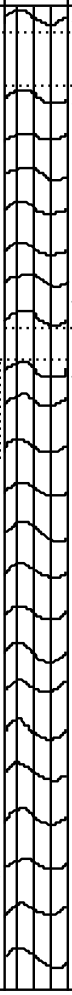
BOREHOLE ID:	54-1016	TA/OU:	54/1148	MDA:	L	Page:	4 of 6
Drilling Co.:	Tonto Environmental Drilling Inc.	Core Box #(s)	8 Core 59 Cuttings	Start Date: Time:	2/1/95 14:30	End Date: Time:	3/17/95 10:30
Drilling Equip./Method:	Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression			Sampling Method:	Core barrel sampling		
Driller:	Larry Thoren	Geologist:	Jon Marin, ERM/Golder	Declination:	Surveyed downhole	Bearing:	S 11.5° W
TD:	607.0 ft						

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
360	10/100%		0.2	5/380.0–364.9 ft
	11/100%	AAC0738	0.3	
			2.2	
370	no recovery	Air Rotary Cuttings		Air Rotary Cuttings boxes 46–47
380			3.3	
390	no recovery		4.2	
			1.0	
400	12/64%		0.4	6/400.0–407.5 ft
	13/67%	AAC0739		
	14/51%		2.8	
410	no recovery	Air Rotary Cuttings		Air Rotary Cuttings boxes 47–47
420				
430			2.4	
	no recovery		1.8	
	15/23%		1.0	
440	16/100%		0.1	6/440.0–443.8 ft
		AAC0745	1.6	
450	no recovery			Air Rotary Cuttings boxes 48–50
460	Air Rotary Cuttings		0.6	
			0.3	
			0.3	
470			0.1	
480				

Lithology

321.5–607.0 ft (continued)	BASALT, fractured, vesicular
At 362.8 ft	BASALT, highly vesicular well oxidized rubble
At 364.0 ft	FRACTURE, open, 2.0–4.0 mm, oxidized, hematite, clay, and goethite in vugs
At 370.0 ft	BASALT, SAA before 362.8 ft, vesicular, clear to white minute plagioclase laths visible in vesicles but lacking the hematite oxidation
At 400.0 ft	BASALT, dark medium gray, highly vesicular rubble, dry
At 400.0 ft, 57.0 degrees from horizontal	
At 402.5 ft	BASALT, SAA, highly vesicular rubble, moist
At 404.0 ft	BASALT, medium light to dark gray moderately to highly vesicular, moist, vesicles are 0.1–2.0 cm, groundmass predominantly aphanitic, minute but visible plagioclase laths up to 0.05 mm are 10%, rare brassy brown micaceous mineral (phlogopite?) is <2%, vesicles and fracture surfaces coated with dull red hematite.
At 450.0 ft, 55.5 degrees from horizontal	
At 430.0 ft	BASALT, SAA, nonvesicular, 20% of rotary cuttings are coated with iron oxide.
At 440.0 ft	BASALT, medium gray, aphanitic groundmass, highly vesicular, moist
At 454.0 ft	BASALT, SAA, massive, non-vesicular

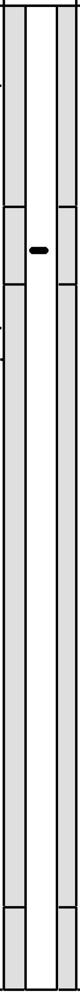
Graphic Log



Lithologic Unit

362.8 ft	Basalt rubble
370.0 ft	Cerros del Rio basalt
400.0 ft	Basalt rubble
404.0 ft	Cerros del Rio basalt

Monitor Well Construction



Notes

Air core 360.0–365.0 ft, air rotary ODEXing to 400.0 ft, void from 372.5–373.0 ft, Solinst vapor port at 390.3 ft, hard drilling at 394.5 ft but no rotary cuttings recovery; 100% air loss, air core 400.0–407.5 ft

Air rotary ODEXing to 440.0 ft

Air core 440.0–443.8 ft, air rotary ODEXing to 480.0 ft

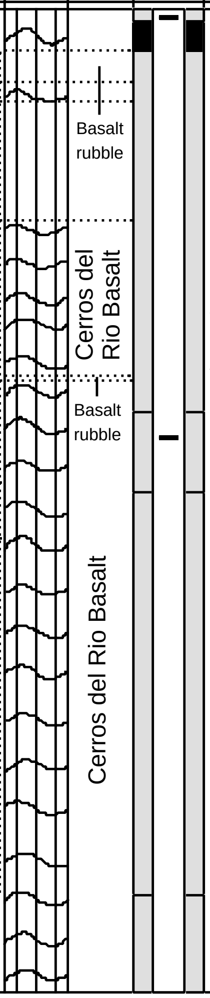
LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID:	54-1016	TA/OU:	54/1148	MDA:	L	Page:	5 of 6
Drilling Co.:	Tonto Environmental Drilling Inc.	Core Box #(s)	8 Core 59 Cuttings	Start Date:	2/1/95	End Date:	3/17/95
				Time:	14:30	Time:	10:30
Drilling Equip./Method:	Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression			Sampling Method:	Core barrel sampling		
Driller:	Larry Thoren	Geologist:	Jon Marin, ERM/Golder	Declination:	Surveyed downhole	Bearing:	S 11.5° W
TD:	607.0 ft						

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)
480	17/70%	AAC0747	0.2	6/480.0–481.0 ft
	18/94%			
			0.9	
490		Air Rotary Cuttings	0.3	7/481.0–486.0 ft
			0.5	Air Rotary Cuttings boxes 51–54
500	no recovery			
			1.3	
510			0.8	
			0.6	
520	19/27%		2.4	7/520.0–526.0 ft
	20/90%			
			2.7	
	Air Rotary Cuttings	AAC0740	0.3	Air Rotary Cuttings box 54–58
530			5.5	
			1.4	
			3.5	
540			0.1	
			1.1	
			0.4	
550			0.9	
			0.1	
560	21/20%			8/560.0–569.5 ft
	22/13%		0.5	
	23/30%		0.2	
570		AAC0741	1.6	Air Rotary Cuttings box 58–59
		Air Rotary Cuttings	2.0	
580	no recovery			
590			0.1	
	24/85%	AAC0770		
			0.1	8/593.5–597.5 ft
	25/71%	AAC0777	5.3	
600				

Lithology

321.5–607.0 ft (continued)	BASALT, SAA, aphanitic non-vesicular to highly vesicular
At 467.0 ft	BASALT, SAA, vesicular
At 478.0 ft	BASALT, SAA, nonvesicular
At 480.0 ft	BASALT, SAA, medium light gray massive, aphanitic groundmass, few vesicles 1.0 mm to 1.0 cm, 2–3%
At 500.0 ft, 55.0 degrees from horizontal	
At 481.0 ft	BASALT, SAA, medium light gray massive, moist, 1.0 cm euhedral calcite crystal in vesicle, dull white to light blue calcite coating on fracture sampled at 483.8 ft and in vesicles
At 485.5 ft	BASALT, rubble, highly vesicular
At 489.0 ft	BASALT, SAA, massive, few microvesicles
At 492.0 ft	BASALT, SAA, rubble, highly vesicular, wet
At 550.0 ft, 53.0 degrees from horizontal	
At 506.0 ft	BASALT, SAA, massive, aphanitic groundmass, 2–5% microvesicles, plagioclase laths 0.5–1.0 mm, <10% of rock
At 511.0 ft	BASALT, SAA, vesicular
At 520.0 ft	BASALT, SAA, highly vesicular, moist
At 525.5 ft	BASALT, highly vesicular to rubble, iron oxide in 4.0 cm open scoriaceous vugs
At 526.0 ft	BASALT, massive, aphanitic, local broken olivine crystals in patches up to 1.0 mm wide



Notes

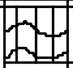
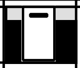
Solinst moisture/vapor port at 480.8 ft atop inverted air pump, air core 500.0–517.0 ft and 520.0–525.0 ft

Void at 521.5–522.25 ft, water in core at 523.5–526.0 ft, solinst vapor port at 533.3 ft

Rotary air circulation blew water through cyclone at 592.0 ft.

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1016	TA/OU: 54/1148	MDA: L	Page: 6 of 6
Drilling Co.: Tonto Environmental Drilling Inc.	Core Box #(s) 8 Core 59 Cuttings	Start Date: 2/1/95 Time: 14:30	End Date: 3/17/95 Time: 10:30
Drilling Equip./Method: Ingersoll-Rand T-4/ODEX casing/air core with total dust suppression		Sampling Method: Core barrel sampling	
Driller: Larry Thoren	Geologist: Jon Marin, ERM/Golder	Declination: Surveyed downhole	Bearing: S 11.5° W TD: 607.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Monitor Well Construction	Notes
600 610 620 630 640 650 660 670 680	Air Rotary Cuttings			Air Rotary Cuttings box 59	321.5–607.0 ft (continued) BASALT, SAA, massive non-vesicular to highly vesicular At 537.0 ft BASALT, light gray, massive, nonvesicular, local 1.0 mm subhedral apple-green olivine crystals <2%, plagioclase laths are microscopic to 0.5 mm, visible laths are 10% At 600.0 ft, 52.5 degrees from horizontal At 560.0 ft BASALT, medium dark gray to brownish gray, highly vesicular At 566.5 ft BASALT, grayish red, highly vesicular to rubble, frothy scoriaceous texture. At 570.0 ft BASALT, dull brownish black massive nonvesicular, 40% of rock chips have bright red hematite coating At 593.5 ft BASALT, SAA. vesicular, vesicles are 20%, up to 3.0 cm and isolated At 596.0 ft BASALT, SAA highly vesicular to scoriaceous, vesicles from 50 to 80%		Cerros del Rio basalt		Solinst moisture/vapor port at 600.7 ft atop submersible air pump
690 700 710 720					TD = 607.0 ft				

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1017 TA/OU: 54/1148 MDA: L Page: 1 of 2

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 0 Start Date: 4/19/95 Time: 10:45 End Date: 4/20/95 Time: 14:30

Drilling Equip./Method: CME/Hollow Stem Auger Sampling Method: Grab samples to MRAL from auger cuttings

Driller: Joel Stewart Geologist: Jon Marin, ERM/Golder Declination: 90.0° Bearing: NA TD: 159.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Extraction Well Construction	Notes
0 10 20 30 40 50 60 70 80 90 100 110 120	Auger Cuttings	NA	NA	NA	Due to the auger drilling with no coring, borehole 54-1017 was not logged as other RFI boreholes at MDA L. No samples were collected for contract laboratory analysis, but grab samples were collected for moisture analysis at the MRAL. Borehole 54-1017 is located 20.0 ft from borehole 54-1018. Refer to the borehole log for 54-1018 for lithology and stratigraphy.	See borehole log for 54-1018.	See borehole log for 54-1018.	Open borehole, cased to 75.0 ft, and capped at surface	Borehole 54-1017 is located in the proposed MDA G development area and is maintained as the extraction well for pilot extraction tests on vapor-phased volatile organic compounds below MDA L. Surface casing set at 75.0 ft.

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1017 TA/OU: 54/1148 MDA: MDA L Page: 2 of 2

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 0 Start Date: 4/19/95 Time: 10:45 End Date: 4/20/95 Time: 14:30

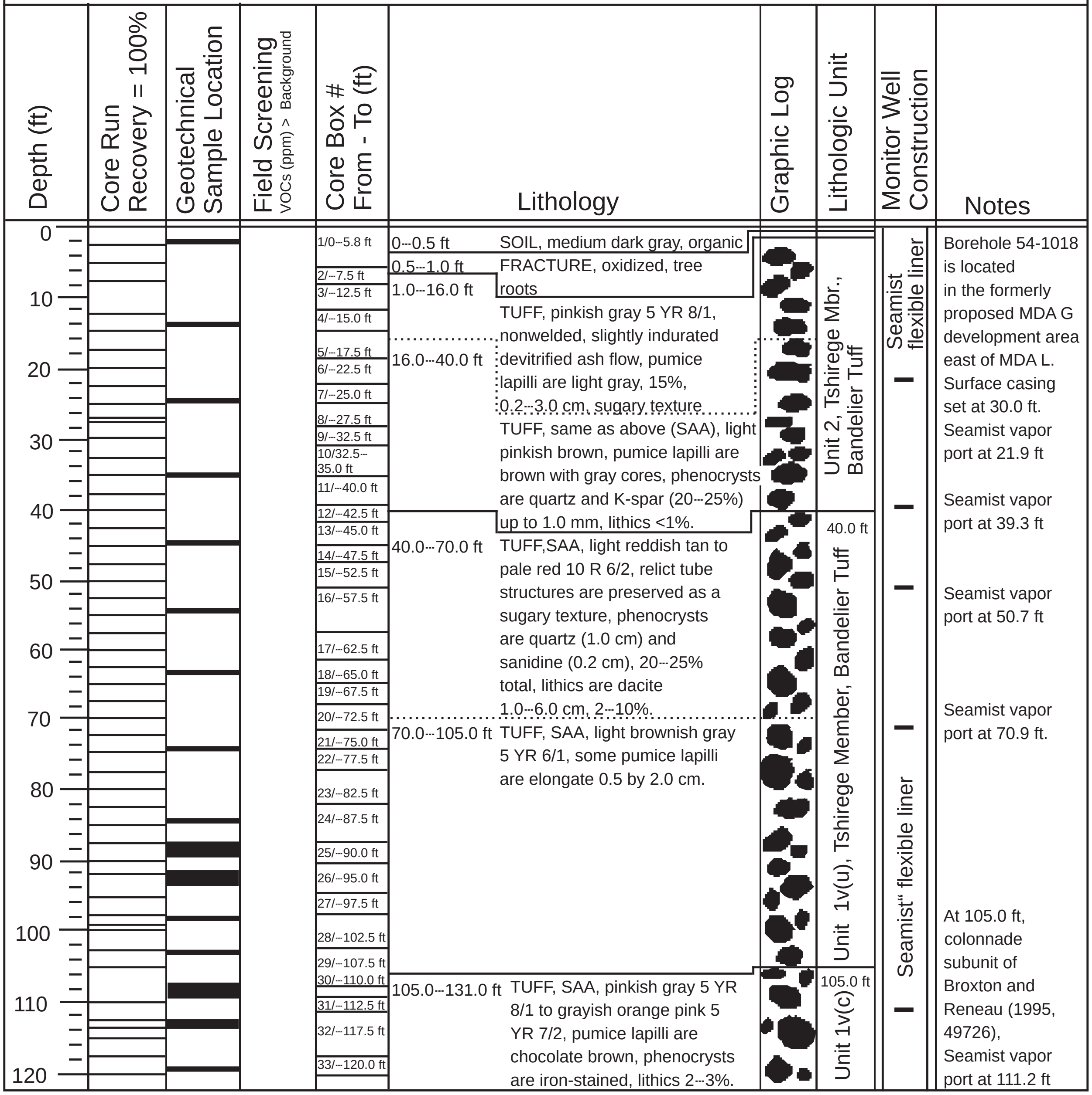
Drilling Equip./Method: CME-750/Hollow Stem Auger Sampling Method: Grab samples to MRAL from auger cuttings

Driller: Joel Stewart Geologist: Jon Marin, ERM/Golder Declination: 90.0° Bearing: NA TD: 159.0 ft

Depth (ft)	Core Run # Core Recovery %	Field Analytical Sample Number	Field Screening VOCs (ppm) > Background	Core Box # From - To (ft)	Lithology	Graphic Log	Lithologic Unit	Extraction Well Construction	Notes
120	Auger Cuttings	NA	NA	NA	Due to the auger drilling with no coring, borehole 54-1017 was not logged as other RFI boreholes at MDA L. Borehole 54-1017 is located 20.0 ft from borehole 54-1018. Refer to the borehole log for 54-1018 for lithology and stratigraphy.	NA	NA	Open borehole, cased at surface	Borehole 54-1017 is an open borehole from 75.0--150.0 ft. Borehole caved from 159.0--150.0 ft
130									
140									
150									
160					TD = 159.0 ft				
170									
180									
190									
200									
210									
220									
230									
240									

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1018	TA/OU: 54/1148	MDA: L	Page: 1 of 3
Drilling Co.: Stewart Bros. Drilling	Core Box #(s) 85	Start Date: 4/21/95 Time: 09:00	End Date: 5/8/95 Time: 16:30
Drilling Equip./Method: CME/Hollow Stem Auger		Sampling Method: Continuous 5.0 ft core barrel	
Driller: Joel Stewart	Geologist: Jon Marin, Rene Evans, ERM/Golder	Declination: 90.0° Bearing: NA	TD: 328.0 ft



Core Box # From - To (ft):
1/0–5.8 ft
2/–7.5 ft
3/–12.5 ft
4/–15.0 ft
5/–17.5 ft
6/–22.5 ft
7/–25.0 ft
8/–27.5 ft
9/–32.5 ft
10/32.5–35.0 ft
11/–40.0 ft
12/–42.5 ft
13/–45.0 ft
14/–47.5 ft
15/–52.5 ft
16/–57.5 ft
17/–62.5 ft
18/–65.0 ft
19/–67.5 ft
20/–72.5 ft
21/–75.0 ft
22/–77.5 ft
23/–82.5 ft
24/–87.5 ft
25/–90.0 ft
26/–95.0 ft
27/–97.5 ft
28/–102.5 ft
29/–107.5 ft
30/–110.0 ft
31/–112.5 ft
32/–117.5 ft
33/–120.0 ft

	Lithology
0–0.5 ft	SOIL, medium dark gray, organic
0.5–1.0 ft	FRACTURE, oxidized, tree roots
1.0–16.0 ft	TUFF, pinkish gray 5 YR 8/1, nonwelded, slightly indurated devitrified ash flow, pumice lapilli are light gray, 15%, 0.2–3.0 cm, sugary texture
16.0–40.0 ft	TUFF, same as above (SAA), light pinkish brown, pumice lapilli are brown with gray cores, phenocrysts are quartz and K-spar (20–25%) up to 1.0 mm, lithics <1%.
40.0–70.0 ft	TUFF,SAA, light reddish tan to pale red 10 R 6/2, relict tube structures are preserved as a sugary texture, phenocrysts are quartz (1.0 cm) and sanidine (0.2 cm), 20–25% total, lithics are dacite 1.0–6.0 cm, 2–10%.
70.0–105.0 ft	TUFF, SAA, light brownish gray 5 YR 6/1, some pumice lapilli are elongate 0.5 by 2.0 cm.
105.0–131.0 ft	TUFF, SAA, pinkish gray 5 YR 8/1 to grayish orange pink 5 YR 7/2, pumice lapilli are chocolate brown, phenocrysts are iron-stained, lithics 2–3%.

Lithologic Unit:
Unit 2, Tshirege Mbr., Bandelier Tuff
40.0 ft
Unit 1v(u), Tshirege Member, Bandelier Tuff
105.0 ft
Unit 1v(c)

Monitor Well Construction:
Seamist flexible liner
Seamist" flexible liner

Notes:

Borehole 54-1018 is located in the formerly proposed MDA G development area east of MDA L. Surface casing set at 30.0 ft. Seamist vapor port at 21.9 ft

Seamist vapor port at 39.3 ft

Seamist vapor port at 50.7 ft

Seamist vapor port at 70.9 ft.

At 105.0 ft, colonnade subunit of Broxton and Reneau (1995, 49726), Seamist vapor port at 111.2 ft

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

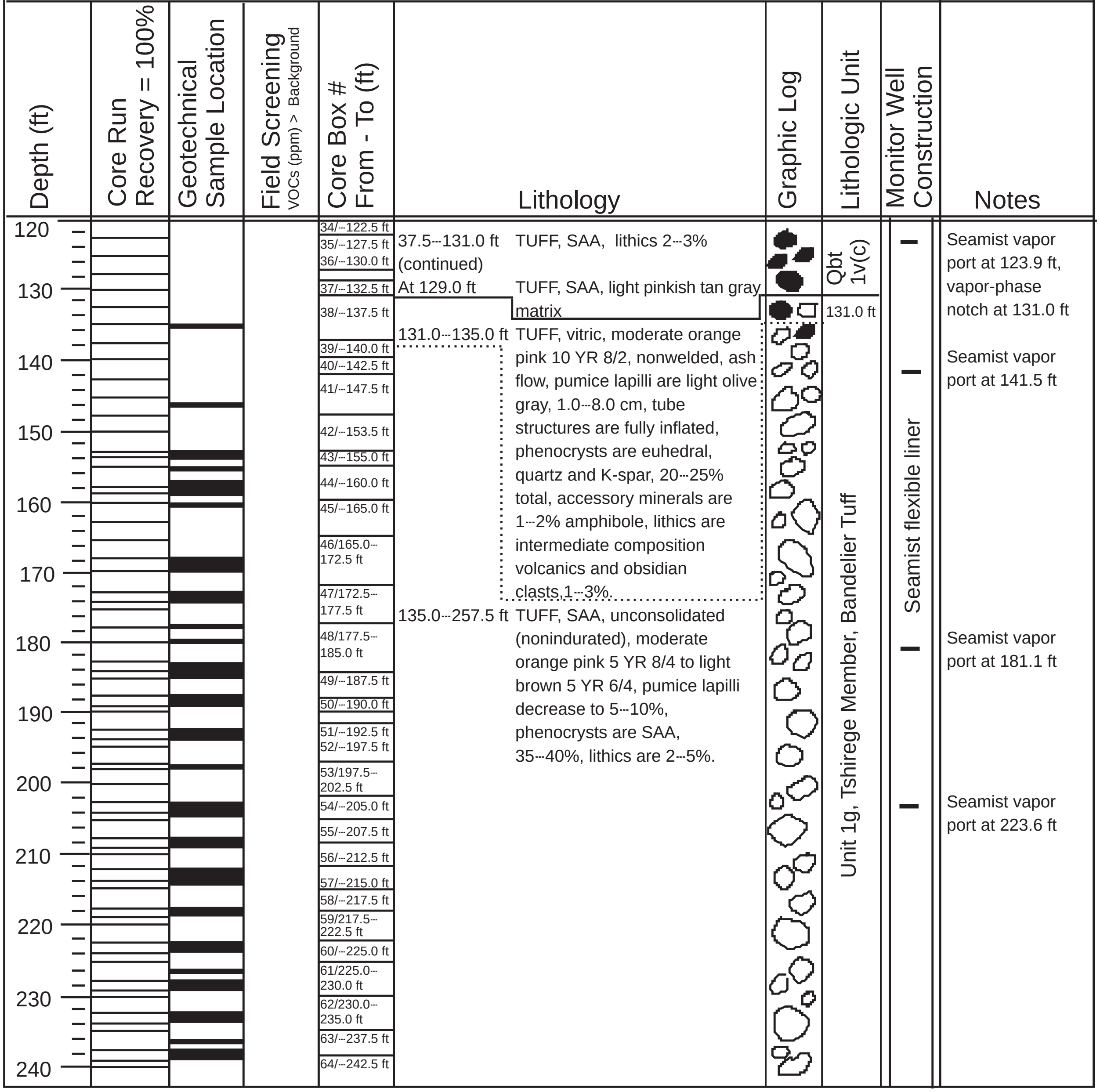
BOREHOLE ID: 54-1018 TA/OU: 54/1148 MDA: L Page: 2 of 3

Drilling Co.: Stewart Bros. Drilling Core Box #(s) 85 Start Date: 4/21/95 End Date: 5/8/95

Time: 09:00 Time: 16:30

Drilling Equip./Method: CME/Hollow Stem Auger Sampling Method: Continuous 5.0 ft core barrel

Driller: Joel Stewart Geologist: Jon Marin, Rene Evans, ERM/Golder Declination: 90.0° Bearing: NA TD: 328.0 ft



Depth (ft)
Core Run Recovery = 100%
Geotechnical Sample Location
Field Screening VOCs (ppm) > Background
Core Box # From - To (ft)
Lithology
Graphic Log
Lithologic Unit
Monitor Well Construction
Notes

Depth (ft)	Core Box # From - To (ft)
120	34/–122.5 ft 35/–127.5 ft 36/–130.0 ft
130	37/–132.5 ft 38/–137.5 ft 39/–140.0 ft
140	40/–142.5 ft 41/–147.5 ft
150	42/–153.5 ft 43/–155.0 ft 44/–160.0 ft
160	45/–165.0 ft 46/165.0–172.5 ft
170	47/172.5–177.5 ft
180	48/177.5–185.0 ft 49/–187.5 ft 50/–190.0 ft
190	51/–192.5 ft 52/–197.5 ft
200	53/197.5–202.5 ft 54/–205.0 ft 55/–207.5 ft
210	56/–212.5 ft 57/–215.0 ft 58/–217.5 ft
220	59/217.5–222.5 ft 60/–225.0 ft 61/225.0–230.0 ft
230	62/230.0–235.0 ft 63/–237.5 ft 64/–242.5 ft
240	

Interval	Lithology
37.5–131.0 ft (continued)	TUFF, SAA, lithics 2–3%
At 129.0 ft	TUFF, SAA, light pinkish tan gray matrix
131.0–135.0 ft	TUFF, vitric, moderate orange pink 10 YR 8/2, nonwelded, ash flow, pumice lapilli are light olive gray, 1.0–8.0 cm, tube structures are fully inflated, phenocrysts are euhedral, quartz and K-spar, 20–25% total, accessory minerals are 1–2% amphibole, lithics are intermediate composition volcanics and obsidian clasts 1–3%.
135.0–257.5 ft	TUFF, SAA, unconsolidated (nonindurated), moderate orange pink 5 YR 8/4 to light brown 5 YR 6/4, pumice lapilli decrease to 5–10%, phenocrysts are SAA, 35–40%, lithics are 2–5%.

Lithologic Unit: Qbt 1v(c); 131.0 ft; Unit 1g, Tshirege Member, Bandelier Tuff

Monitor Well Construction: Seamist flexible liner

Notes:

Seamist vapor port at 123.9 ft, vapor-phase notch at 131.0 ft

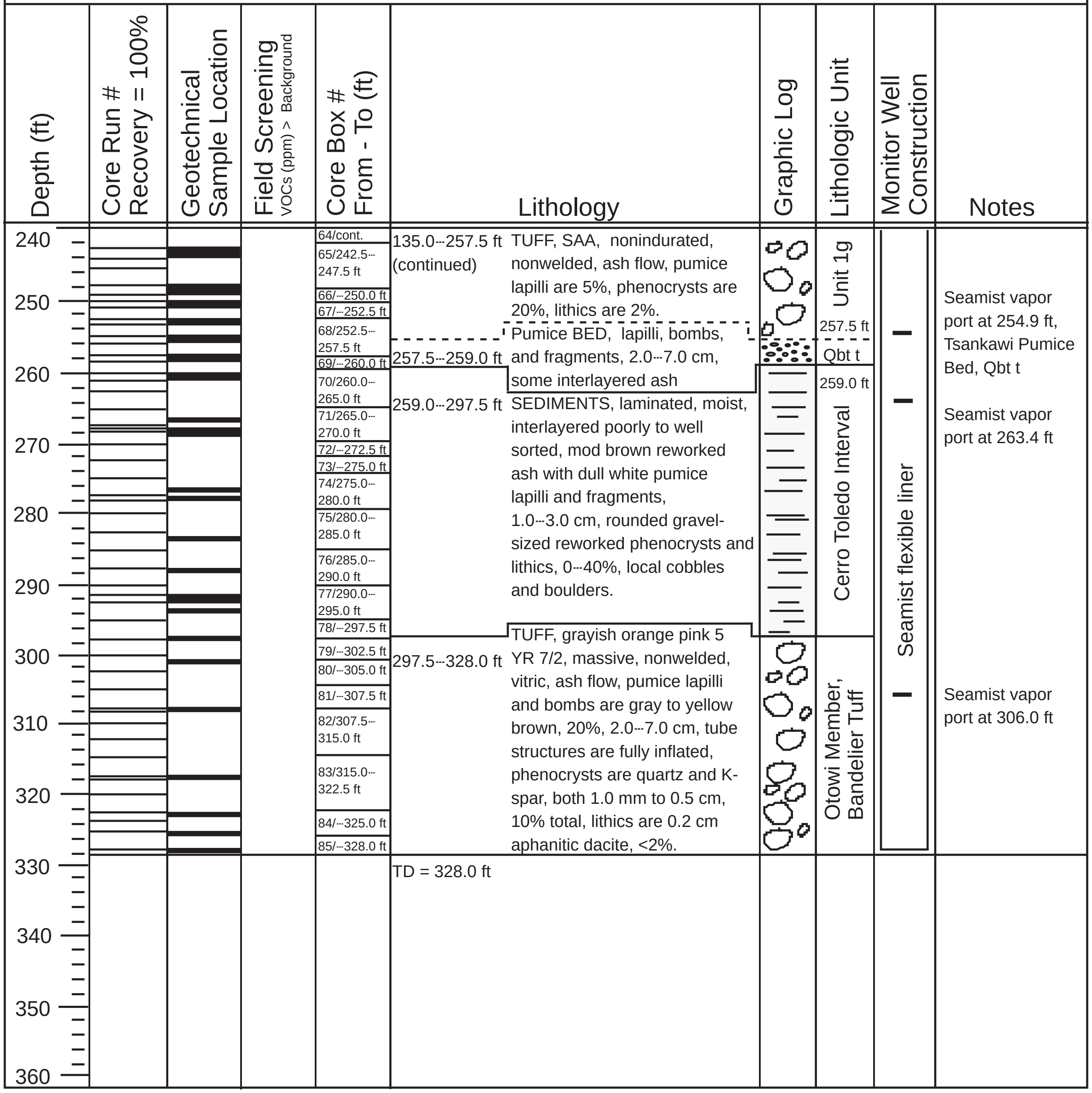
Seamist vapor port at 141.5 ft

Seamist vapor port at 181.1 ft

Seamist vapor port at 223.6 ft

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION PROJECT
FIELD UNIT 5
BOREHOLE LOG

BOREHOLE ID: 54-1018
TA/OU: 54/1148
MDA: L
Page: 3 of 3
Drilling Co.: Stewart Bros. Drilling
Core Box #(s) 85
Start Date: 4/21/95
Time: 09:00
End Date: 5/8/95
Time: 16:30
Drilling Equip./Method: CME/Hollow Stem Auger
Sampling Method: Continuous 5.0 ft core barrel
Driller: Joel Stewart
Geologist: Jon Marin, Rene Evans, ERM/Golder
Declination: 90.0°
Bearing: NA
TD: 328.0 ft



Core Box # From - To (ft)
64/cont.
65/242.5–247.5 ft
66/–250.0 ft
67/–252.5 ft
68/252.5–257.5 ft
69/–260.0 ft
70/260.0–265.0 ft
71/265.0–270.0 ft
72/–272.5 ft
73/–275.0 ft
74/275.0–280.0 ft
75/280.0–285.0 ft
76/285.0–290.0 ft
77/290.0–295.0 ft
78/–297.5 ft
79/–302.5 ft
80/–305.0 ft
81/–307.5 ft
82/307.5–315.0 ft
83/315.0–322.5 ft
84/–325.0 ft
85/–328.0 ft

Lithology		Lithologic Unit
135.0–257.5 ft (continued)	TUFF, SAA, nonindurated, nonwelded, ash flow, pumice lapilli are 5%, phenocrysts are 20%, lithics are 2%.	Unit 1g
257.5–259.0 ft	Pumice BED, lapilli, bombs, and fragments, 2.0–7.0 cm, some interlayered ash	Qbt t
259.0–297.5 ft	SEDIMENTS, laminated, moist, interlayered poorly to well sorted, mod brown reworked ash with dull white pumice lapilli and fragments, 1.0–3.0 cm, rounded gravel-sized reworked phenocrysts and lithics, 0–40%, local cobbles and boulders.	Cerro Toledo Interval
297.5–328.0 ft	TUFF, grayish orange pink 5 YR 7/2, massive, nonwelded, vitric, ash flow, pumice lapilli and bombs are gray to yellow brown, 20%, 2.0–7.0 cm, tube structures are fully inflated, phenocrysts are quartz and K-spar, both 1.0 mm to 0.5 cm, 10% total, lithics are 0.2 cm aphanitic dacite, <2%.	Otowi Member, Bandelier Tuff

TD = 328.0 ft

Notes:

Seamist vapor port at 254.9 ft, Tsankawi Pumice Bed, Qbt t

Seamist vapor port at 263.4 ft

Seamist vapor port at 306.0 ft

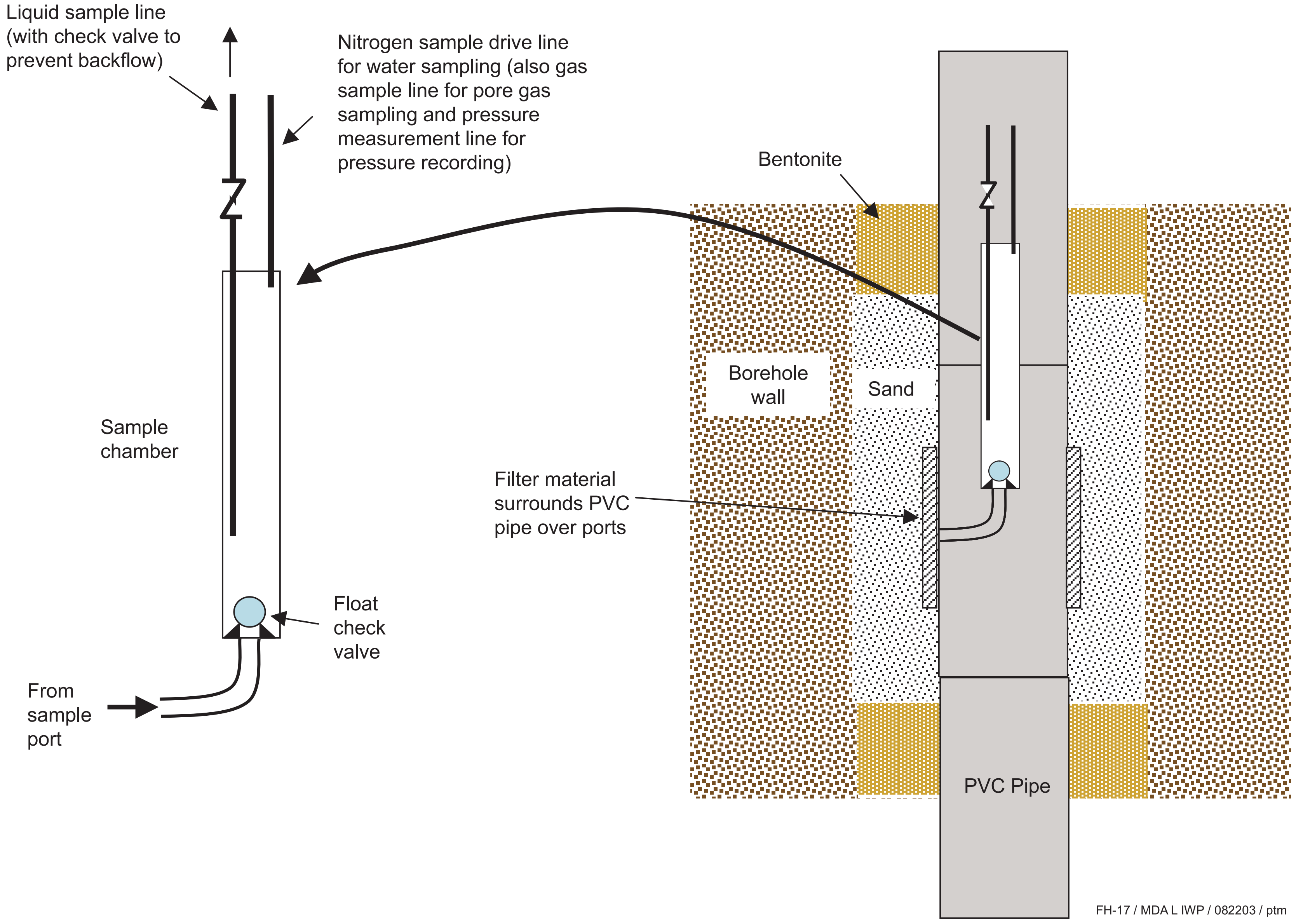


Figure H-17. Diagram showing pore-gas sampling port instrumentation

Appendix I

Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions, Revision 1

Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions

Revision 1 LA-UR-02-2080

Philip Stauffer

Kay Birdsell

Marc Witkowski

Terry Cherry

and

John Hopkins

Earth and Environmental Sciences Division
Los Alamos National Laboratory

May, 2002

Table of Contents

List of Figures and Tables

Figure Number

Table Number

1.0 - INTRODUCTION

TA-54 MDA L is a material disposal area (MDA) that received liquid chemical wastes from the late 1950’s through 1986 [LANL, 2000]. From the late 1950’s through 1975, bulk liquid waste was disposed of in an open pit at MDA L and allowed to evaporate. Due to the high vapor pressure of the organic liquids, most of the VOCs introduced to the open pit should have readily evaporated into the atmosphere. From 1975 through 1985, organic liquids were disposed of in a series of 20-m deep shafts. Some organic liquids were poured directly into the shafts while others were containerized in drums before being disposed of in the shafts. All of these disposal operations occurred beneath the surface of Mesita del Buey in the underlying unsaturated tuff units, some 300 meters above the regional aquifer.

The major chemicals of potential concern (COPC) measured at this site are found in pore-gas sampling and include a host of volatile organic compounds (VOCs) and tritium [LANL, 2000]. Although VOCs may percolate as liquids in the subsurface (especially in saturated systems), the dry subsurface environment at MDA L causes rapid volatilization. The organic vapors emanating from the liquid waste shafts must migrate through the subsurface before reaching the atmosphere. Large amounts of the liquid waste have volatilized to create the current plume of organic vapor in the subsurface. The vapor plume has migrated over 100 meters laterally from the shafts as demonstrated by pore-gas sampling, and it is estimated to contain nearly 1000 kg of vapor-phase VOCs [LANL, 1999]. Pore-gas sampling shows that VOCs disposed of at this site include 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), trichlorotri-flouroethane (FREON), and lesser amounts of chloroform, toluene, benzene, cyclohexane, methyl chloride, and other similar solvents.

The purpose of this work is to develop a calibrated numerical model for the vapor plume beneath MDA L that can be used to analyze the current and future state of the plume. In this report, we initially develop a diffusion model for TCA transport at the site that predicts the migration of the vapor-phase plume from the shafts through the subsurface. This relatively simple model captures the first-order effects that control migration of the vapor-phase plume. For instance, it assumes that the movement of the vapor plume can be described through its most prevalent component, vapor-phase TCA. It also assumes that plume growth is controlled by diffusive processes rather than by air flow within the mesa top. The model is calibrated to pore-gas data collected at the site. Simulations of several different cases that use various diffusion coefficients, source-term concentrations, and boundary conditions are examined. The best-fit simulation is determined with a goodness-of-fit scheme that compares the different model results to the field data. We found that the predicted subsurface concentrations match observed pore-gas concentrations quite well for a few of the better simulations, indicating that this first-order diffusion model adequately describes plume behavior. The model is applied to predict plume growth over the next 50 years, to suggest monitoring frequency, and to estimate the possible system response to the bursting of a buried drum.

The simulations were revised to determine the effects of some second-order processes following an Innovative Treatment and Remediation Demonstration (ITRD) peer review . The reviewers commented on the original April, 2000 version of this report. The current report (Rev. 1) is a modification of the original report and considers the effects of the following processes, as recommended by the peer reviewers:

1) Henry’s Law fractionation of TCA into porewater,

f2) Diffusion coefficient as a function of moisture content,

3) Higher source concentrations during disposal operations (pre-1985) caused by non-containerized releases

4) Surface flux reduction due to boundary layer effects,

5) Fractures,

6) Non-Fickian behavior at low permeabilities, and

7) Sorption of TCA onto the tuff matrix.

To address the reviewers’ concerns, the conceptual model (Section 2.3) was revised to discuss all the items above. Furthermore, new simulations were run that include the processes identified in items 1 through 4, and the results are reported at the end of the paper in Section 4.4 ‘Simulations in Response to the ITRD Peer Review’. The simulated surface flux results have been modified to more accurately calculate the emissions from the surface, and these results are reported in Section 4.1.2. In addition to the major conceptual/modeling concerns of the reviewers, many smaller items have been corrected to make this document more consistent with the TA-54 RFI (LANL 2000) and other supporting documents.

Although the initial goal of the site model was to determine if the first-order processes of pure diffusion of a vapor plume could explain the bulk of the data, the reviewers’ ideas for improving the fit between model and data proved quite useful in showing that the conceptual model for TCA transport is valid, and that the numerical model should perform robustly in exploring the fate of the VOC plume at this site. In a future study, this revised model will be used to explore schemes for site corrective measures, such as passive venting.

2.0 - SITE DESCRIPTION

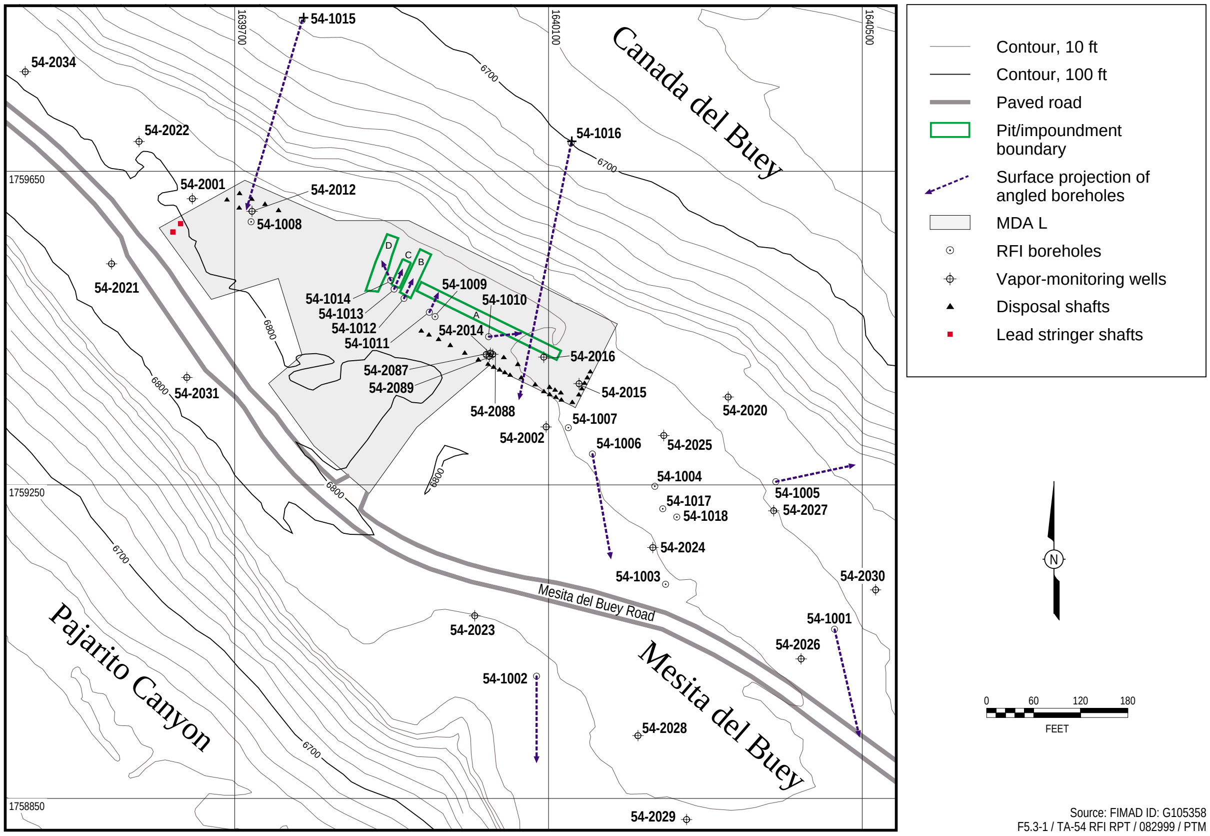
2.1 STRATIGRAPHY AND TOPOGRAPHY

The strata that immediately underlie MDA L are composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs interbedded with thin pumice beds. The rhyolitic units are underlain by a thick basalt unit, and a conglomerate formation [Krier, et al., 1997]. The tuff layers were deposited during violent eruptions of volcanic ash from the Valles Caldera between 1.2 and 1.6 million years ago [Smith and Bailey, 1966; Gardner et al., 1986]. Since then, the tuff has eroded to leave a system of alternating finger-shaped mesas and canyons. MDA L is located atop one such mesa, Mesita del Buey, with the waste disposed in shallow pits (4 m deep) and shafts (approximately 20 meters deep). The surrounding canyons, Canada del Buey and Pajarito Canyon, lie 30 m below the steep-sided mesa, and the regional aquifer is located approximately 300 meters below the disposal pits. There are no known perched aquifers below the mesa. Figure 2.1_1 shows the site topography and the locations of disposal pits, disposal shafts and monitoring wells.

Figure 2.1_2 shows a simplified stratigraphic column of the rocks underlying MDA L. The upper three stratigraphic units make up the Tshirege member of the Bandelier Tuff. Unit 2 and the lower half of the Unit 1v are fractured. The Cerro Toledo interval is comprised of volcanoclastic sediments interbedded with minor pyroclastic flows, and separates the Tshirege and Otowi Members of the Bandelier Tuff. The Otowi Member is nonwelded to poorly welded and is not fractured. The units comprising the Bandelier Tuff dip gently and thin toward the eastern end of the site [Vaniman et al., 1998].

The following subdivisions and thin units are not included in Figure 2.1_2 or in the numerical model domain. The Tshirege Unit 1v is generally subdivided into units 1v-u and 1v-c. Units 1v and 1g are separated by a thin horizon known as the vapor-phase notch, which is easily seen in outcrop, but is not necessarily continuous and additionally is too thin to include in a site-scale model. The Tsankawi Pumice, a thin (20-100cm) bed at the base of Unit 1g, is lumped into Unit 1g in the model. There are surge beds at the bases of both Tshirege Unit 2 and Unit 1 which are not included in Figure 2.1_2 or in the site-wide geologic model [Vaniman et al., 1998]. The Otowi is subdivided into an ash-flow component and a pumice fall that are not separated in Figure 2.1_2 or in the site-wide geologic model. Although these units can be hydrologically significant, their effect on the diffusion equation is minimal, as only the diffusion coefficient and the moisture content of a given unit affect the diffusion solution. As we show later, a uniform diffusion coefficient is chosen for the modeling, and the site moisture content does not vary by more than an order of magnitude. Therefore, excluding these units should not strongly affect the solution.

The Cerros del Rio Basalts, which comprise nearly 50% of the unsaturated zone, display wide variability [Turin, 1995], ranging from extremely dense with no effective porosity, to highly fractured, to so vesicular as to appear foamy. The Puye Formation underlies the Cerros del Rio Basalts and extends from the of base of the unsaturated zone well into the saturated zone. The Puye Formation is an amalgamation of alluvial fan, river, and lake deposits containing cobbles and boulders of both volcanic and plutionic origin in a matrix of silts, clays, and sands. Interbedded basalt flows, dacite flows, and pumice lenses are also common [Purtymun, 1995].



Source: FIMAD ID: G105358
F5.3-1 / TA-54 RFI RPT / 082999 / PTM

Figure 2.1_1 Geographical information for MDA L and the surrounding area.

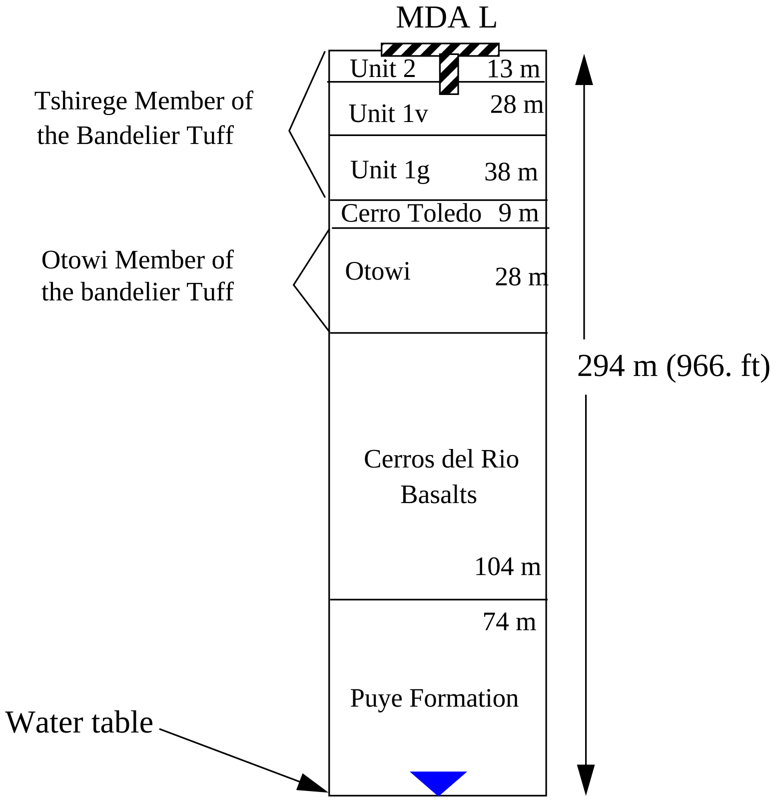


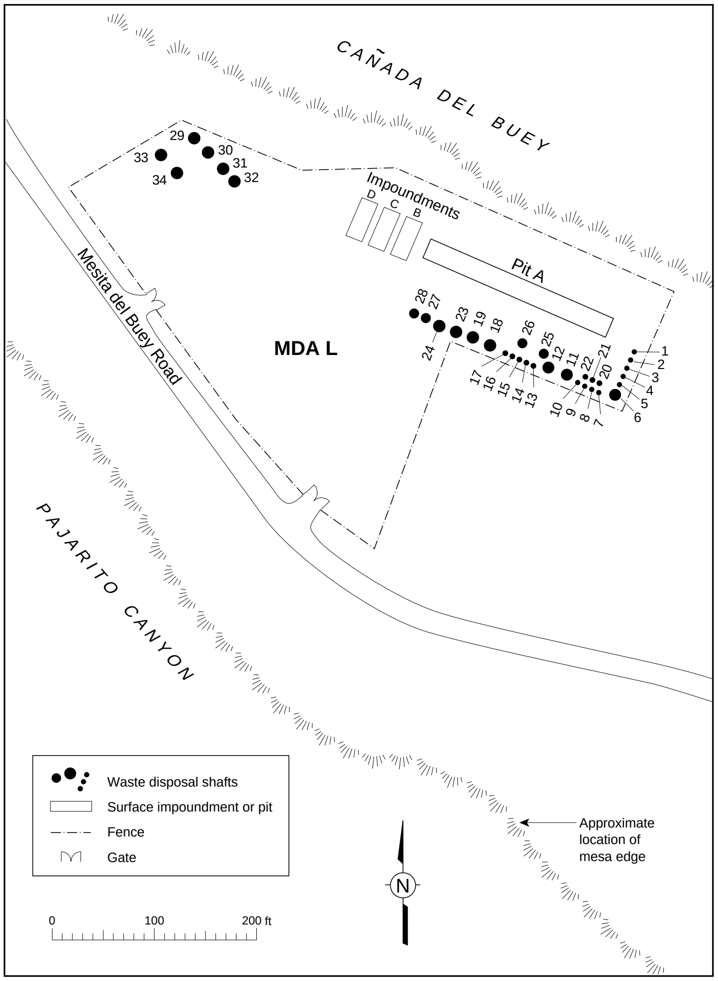
Figure 2.1_2 Simplified site stratigraphy.

2.2 CONTAMINANT SOURCE

MDA L was used as a disposal site for liquid chemical waste from the late 1950's until its closure in 1986 [LANL, 2000]. After passage of the Resource Conservation and Recovery Act (RCRA), regulations concerning the disposal and storage of hazardous waste caused the Laboratory to discontinue subsurface disposal of RCRA regulated chemical wastes. Both solid and liquid chemical wastes are currently stored above ground in facilities at MDA L that allow the waste to be inspected and monitored before removal to permanent disposal/treatment facilities.

2.2.1 Timing of waste disposal at MDA L

One pit, three surface disposal impoundments, and 34 disposal shafts are the Potential Release Sites (PRS) at MDA L (Figure 2_2.1) [LANL, 2000]. These PRSs had varying purposes and were used for different time periods. Disposal Pit A was the only disposal unit in operation before 1975. Dates of operation for Pit A were from 1964 until 1978. Surface impoundment B was established in 1979 and decommissioned in 1985. Impoundments C and D were in use from 1985 to 1986 and 1972 to 1984 respectively.



F5.2-1 / TA-54 RFI RPT / 082899 / PTM

Figure 2.2_1 Location map for waste disposal shafts and pits at MDA L

Operation dates for the 34 disposal shafts ranged from 1975 to 1985. Shaft numbers 1 through 28 operated from 1975 through 1985, while shaft numbers 29 through 34 operated from 1983 through 1985. After decommissioning, most of the 2.5 acres comprising MDA L were covered with asphalt upon which were built temporary storage facilities for chemical waste. The asphalt covering affects the subsurface transport of the VOCs as discussed in Section 2.3.2.

2.2.2 Types of waste found at MDA L

There is little information on specific chemicals, timing, or quantities of waste that were disposed of at MDA L. However, the major COPCs measured at this site are found in pore-gas sampling and include a host of volatile organic compounds (VOCs) and tritium [LANL, 2000]. Pit A received non-containerized bulk quantities of treated aqueous waste that was left to pool and evaporate without added absorbent material. This waste is not reported to contain VOCs. However, if some VOCs were disposed of in Pit A, their high vapor pressures would have led to quick evaporation into the atmosphere. Therefore our conceptual model of MDA L does not include Pit A as a source of VOC vapor in the subsurface.

Surface Impoundments B, C, and D were exclusively used as evaporative lagoons for treated salt solutions. Salt solutions such as ammonium biflouride and electroplating wastes were a source of copper, barium, chromium, and zinc contamination in the impoundments [LANL, 2000]. Records indicate that the majority of waste disposed of in the surface impoundments was inorganic, therefore these disposal units are not included as a source term in the simulations of the VOC vapor plume.

The 34 shafts received metal drums (55 gallon) containing chemical liquid waste. The waste drums were packed in lifts with one to six barrels per layer. In the shafts, layered waste was covered with crushed tuff to provide absorbent material as well as structural support for the drums. Additionally, unknown quantities of small containers and free product were dropped directly into the shafts. The locations of the pits and shafts can be seen on Figure 2.2_1. Shaft numbers 1 through 28 are located near Pit A, while shaft numbers 29 through 34 are located 60 m northwest of Pit A. The spatial distribution of the waste led to two main source regions for organic vapors, causing the development of the double-lobed plume seen in the site data (Figure 2.2_2). Records indicate that the majority of material placed in the shafts was organic waste. The records do not differentiate between pure liquid and organic contaminated solids (rags, paper, etc.). However, because MDA L is a designated liquid waste disposal area, contaminated solids were most likely disposed of at MDAs C and G. For these reasons, a source term for the organic liquids can only be roughly defined. The major long-term source for organic contamination in the disposal shafts is expected to be from potential future releases as a result of drum deterioration.

Sampling conducted to determine the existing VOC plume in rock core and pore gas from various boreholes on or near the site found a vapor-phase plume that consists primarily of TCA, TCE, carbon tetrachloride, and chloroform [LANL, 2000]. Although we cannot rule out the possibility that free product existed at some point in time, current vapor phase concentrations are well below the vapor pressure of TCA which implies that free product is not present near the sampling points. Peak concentrations of TCA vapor found below the bottom of the shafts suggests that some limited liquid transport of VOC may have occurred prior to the core studies [LANL, 2000].

The major vapor-phase contaminant measured in the second quarter of FY99 was TCA, which composed approximately 75% by volume of the spatially averaged plume. The second most prevalent contaminant found was TCE, comprising 12.5% by volume of the plume, while

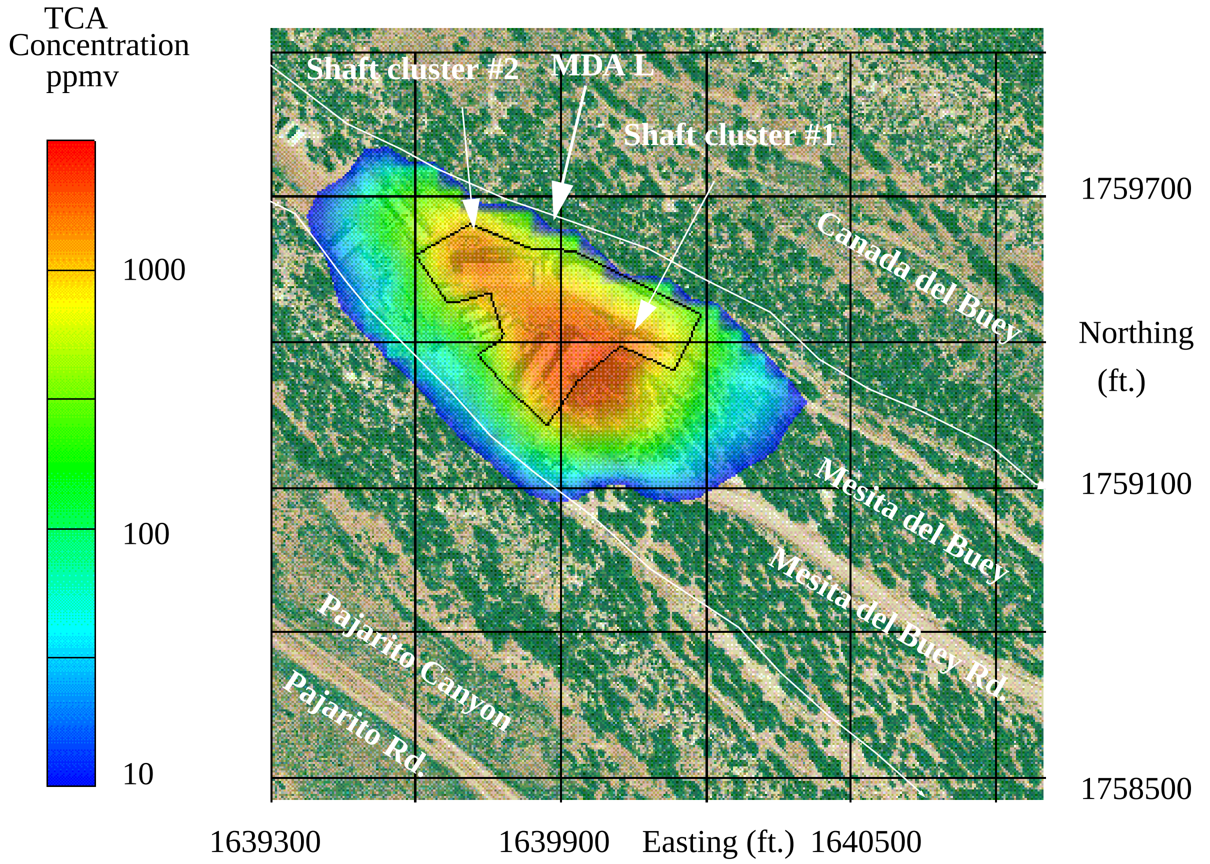


Figure 2.2_2 Second Quarter FY99, MDA L, TCA concentration data (log-scale) contoured on a plane 18 m (60 feet) below the mesa top.

Freon 113 composed 11.2% by volume of the averaged plume. These values are averaged over 140 sampling locations measured using the B and K field-screening method, which detects only TCA, TCE, and Freon. Although these numbers are spatial averages, individual sampling ports show wide variation in the ratios of the most prevalent VOCs, and the more complete analytic laboratory analyses show some ports (for example, well 54-2032 at 47.5 m (156 ft) below the collar) have significant percentages of compounds such as napthalene (12%) and dichloroethene 1,1 (14%) [Smith et al., 1999b].

2.2.3 Pore-gas monitoring data

Quarterly pore-gas monitoring has been conducted at the site since 1985 in accordance with a compliance ordered issued by the state of New Mexico [LANL, 2000]. Continued monitoring of soil gas has shown that the organic vapor-plume source region is coincident with the disposal shafts, and that the plume does not appear to have grown at a detectable rate over the past three years [Smith et al., 1998, 1999a, 1999b]. In fact, the current maximum TCA pore-gas concentration is similar to the value of 3400 ppmv reported by Trent [1992] in data from June, 1988.

The individual shafts that have contributed the largest portion of the plume are not well defined, and the simulations we present are designed to capture the general behavior of the main source regions. Figure 2.2_2 shows the second quarter FY99 monitoring data of measured TCA concentration at a depth of 18.3 m (60 ft.) below the mesa top contoured in map view. The data have been clipped at 10 ppmv to represent the lower limit of data reliability, which is 5 to 10 ppmv.

2.3 CONCEPTUAL MODEL and MODEL ASSUMPTIONS

The conceptual model on which the numerical simulations are based contains several key features [Rogers, 2000]. During the initial version of this document, we assumed that VOC migration at the site can be described by the diffusive transport of TCA vapors. Although some advective processes, such as barometric pumping, may enhance plume migration, Auer et al. [1996] showed that this can be modeled as enhanced diffusion. The plumes, however, do not grow as ideal spherical plumes because several external factors influence their shape. These factors include nonideal boundary conditions such as the topography of the site, the asphalt cover, and the venting of the plume through the deep basalt unit. Disposal history and source location also contribute to nonspherical plumes.

As a result of the ITRD peer review and questions from the NMED, this document (Revision #1) has been updated to explore several other processes that are known to be important in subsurface transport of VOCs. In Section 4.4, we present results from modeling that includes Henry’s Law fractionation of VOC between porewater and the vapor phase, reduction in the TCA diffusion coefficient as a function of moisture content, and reduction in diffusion across the land/air interface due to boundary layer processes which may impede mass transfer.

2.3.1 Unsaturated-Zone Transport Processes

As suggested by the preliminary conceptual model [Rogers, 2000], the original version of this document assumes that diffusion is the fundamental process controlling migration rates of TCA vapors in this unsaturated environment. Diffusion moves chemicals from areas of high concentration to areas of low concentration [Fetter, 1999]. Diffusion is caused by random motion of molecules and is a function of both temperature and the chemical’s molecular weight. Thus, chemicals with a low molecular weight diffuse more rapidly at a given temperature. The effect of diffusion is to homogenize an initially heterogeneous distribution of chemical concentrations. The speed at which a chemical diffuses is described by the diffusion coefficient, D. D is much larger in air than in water, thus a drop of dye in water spreads more slowly than, for example, perfume spreads in air. Also, diffusion is slower in a porous medium than in free space because of the tortuous nature of small pores. Typically, a porous medium diffusion coefficient D* is 1/2 to 1/100 the value in free space [Freeze and Cherry, 1979].

Several secondary processes may play a role in affecting the size and growth rate of the plume. Henry's Law fractionation would tend to buffer the vapor plume's growth relative to the pure diffusion case [Fetter, 1999], by storing some of the TCA mass in the porewater of the Bandelier tuff. This effect increases with increasing water content and may help to explain why transport is less pronounced in the vertical direction within the Cerro Toledo interval and the Otowi Member, which both have higher background saturations than the Tshirege Units (Figure 2.1_2). Section 4.4 examines this process.

The vapor-phase diffusion coefficient for TCE in the Bandelier Tuff was measured at two saturation intervals (1-3% and 13-15%,). As expected from the literature (Millington, 1959), the measured diffusion coefficient was about an order of magnitude lower in the higher saturation experiments (Fuentes et al., 1991). Lower diffusion at higher moisture content will also help to bring the base model into agreement with the measured data within the Otowi Member and the Cerro Toledo interval. Diffusion coefficients for TCA have not been measured in Bandelier Tuff, but because TCA and TCE have similar molecular weights, we assume their diffusion coefficients are in the same range. Section 4.4 examines the effect of saturation on the diffusion coefficient.

Observations of alluvium on the mesa top at MDA L and examples from the literature citing lowered surface flux due to boundary-layer effects (Jury, 1990) have prompted us to determine the sensitivity of the model to a decrease in the diffusion coefficient across the land/air interface. The need for this modification was also suggested by a large difference in the original predicted versus measured surface flux at the site. The estimated surface flux from the base model was much higher than that measured at and around MDA L. Section 4.4 examines this process as well.

Fractures can affect the mobility of vapor-phase contaminants. At this site, however, fractures are found predominantly in Unit 2 and the very top of Unit 1v with fracture spacing on the order of one meter (Reneau et al., 1998). Additionally, fractures on the Pajarito Plateau are often filled with clay/calcite mixtures in the near surface that would effectively limit thier ability to act as high flux pathways for organic vapors (Broxton and Reneau, 1995). Although fractures may play a secondary role in gross plume behavior, we do not explicitly address this issue numerically.

At low permeabilities (<1e-14 m2) vapor-phase diffusion in porous media may be better modeled by equations such as the Dusty Gas Model. However, because permeabilities at this site are greater than $1x10^{-13}$, we do not invoke this theory.

Sorption of TCE onto unsaturated Bandelier tuff has been measured by Ong and Lions (1991). Results from their study show that at high vapor-phase concentrations (20,000 ppmv) and low moisture contents (<0.3%), some amount of TCE partitions onto the solid mineral surfaces. However, at moisture contents found in the mesa, their data shows a low Kd of < 0.5 mL/g. Thus, for Revision 1, we do not numerically address this issue.

2.3.2 The effect of system geometry on plume growth

Because MDA L is located on the edge of a narrow finger mesa, the interaction of the subsurface vapor-phase contamination with atmospheric air must be considered [Rogers, 2000]. The topographic relief of the mesa provides an atmospheric boundary condition of near zero concentration [Mishier and Anderson, 1994] where the plume intersects the mesa top and sides. Because diffusion occurs from areas of high concentration to low concentration, the atmospheric boundary provides a huge sink, or low concentration volume, that can accept the VOCs that diffuse from the subsurface. This boundary maintains a steep concentration gradient between the subsurface plume and the mesa sides, which limits plume growth along the axis of the mesa.

Additionally, Neeper [1997] reports that the air in the basalt appears to be much more connected to the atmosphere than the air in the Bandelier tuff. We hypothesize that a low concentration boundary, similar to the atmospheric boundary, exists in the basalt unit. We test the hypothesis by fixing the concentration in the basalt at an atmospheric (zero) concentration of TCA in some simulations during model calibration.

The presence of the asphalt at MDA L potentially affects the ability of TCA vapor to migrate upward into the atmosphere. For this reason we test the sensitivity of the system with sealed asphalt (choosing $D^* = 1x10^{-14}\ m^2/s$ to effectively stop diffusion through the asphalt), leaky asphalt (choosing $D^* = 4x10^{-7}\ m^2/s$ to allow limited communication of the source with the atmosphere above the asphalt), and no asphalt.

2.3.3 Release and mobility of TCA vapor

The migration of TCA vapor from the shafts is conceptualized as a time-release phenomenon. This is based on the idea that liquid will leak slowly from the buried drums and quickly volatilize in the subsurface. Once released from the shafts, we assume the mobility of TCA through the unsaturated zone is controlled by diffusion along concentration gradients. The steepest concentration gradients will form along pathways to the atmosphere [Fetter, 1999].

Migration of TCA in the liquid phase is not included in the model, because there are no observations at the site of saturated conditions in the subsurface. In fact, moisture monitoring shows that the current subsurface moisture profiles are near background conditions, despite the previous disposal of liquid waste at the site [LANL, 2000]. The pore-gas concentrations also clearly indicate that no migration of free product (pure TCA) occurs. If pure-phase TCA were in the pores, its vapor pressure would yield pore-gas concentrations from one to two orders of magnitude larger than the highest concentrations observed in the monitoring data.

2.4 HYDROGEOLOGIC DATA

This study deals strictly with vapor-phase diffusion in the subsurface of MDA L. Therefore, the subsurface flow of water and air is decoupled from the diffusive transport. The major parameters affecting diffusive vapor transport are porosity, saturation, and the porous medium diffusion coefficient (D*). The porosities and saturations are fairly well characterized for the six Bandelier Tuff units. Saturated permeabilities, porosities, and saturations for the tuff units [Rogers and Gallaher, 1995] and the Guaje Pumice were measured on core samples. Estimated values for the porosity and saturation of the Puye Formation are used. No hydrologic property data were available for the basalts at the time this study was performed. Therefore, the porosity of a vesicular basalt located beneath Idaho National Engineering Laboratory is used as an analog [Bishop, 1991]. The saturation of the basalt is based on previous modeling results [Birdsell et al., 1997]. Fortunately, the model of the contaminant plume is relatively insensitive to the properties of the Puye Formation and Cerros del Rio Basalts. Table 1 summarizes the hydrologic parameters used for all of the units in the unsaturated-zone flow and transport model.

Table 1: Physical Parameters used in the numeric model, bold indicates the base simulation

Unit	Effective porosity	Saturated permeability m^2	In-situ saturation	Effective diffusion coefficient (10^6xD* in m^2/s)
Tsh 2	0.48	7.48e-13	0.05	1, 2, **4**, 8, 20
Tsh 1 v	0.51	1.96e-13	0.04	1, 2, **4**, 8
Tsh 1 g	0.48	3.68e-13	0.2	1, 2, 3, **4**, 8

Table 1: Physical Parameters used in the numeric model, bold indicates the base simulation

Unit	Effective porosity	Saturated permeability m^2	In-situ saturation	Effective diffusion coefficient (10^6xD* in m^2/s)
Cerro Toledo	0.473	8.82e-13	0.3	1, 2, **4**, 8
Otowi Member	0.435	7.25e-13	0.25	1, 2, **4**, 8
Cerros del Rio basalt (matrix)	0.23	2.96e-13	0.25	1, 2, **4**, 8, 20
Puye Formation	0.25	4.73e-12	0.25	1, 2, **4**, 8
Shafts	0.5	7.48e-13	0.05	1, 2, **4**, 8
Asphalt	0.5	1e-21	0.05	**$1x10^{-8}$**, 0.4, 4
Surface (not including asphalt)	0.48		0.05	1, 2, **4**, 8, 20

2.5 TRANSPORT PROPERTIES

The modeling uses an estimate for the subsurface, vapor diffusion coefficient (D*) of the predominant vapor-phase contaminant, TCA. The initial estimate of the diffusion coefficient for TCA vapor (D*= $4x10^{-6}$ m^2/s) is based on core-scale measurements of TCA diffusion in Bandelier Tuff from TA-54 [Fuentes et al., 1991]. The model is run with a range of diffusion coefficients centered on the core-scale results to determine which diffusion coefficient best fits the site data. Because the diffusion coefficient of TCA in asphalt is unknown, we examine the sensitivity of the system to two values of the diffusion coefficient through the asphalt. In the first case, we assume a diffusion coefficient of $1x10^{-14}$ m^2/s in the asphalt, which essentially stops the contaminant from mixing with the atmosphere in asphalt-covered regions. In the second case, we assume the asphalt is leaky, with D* = $4x10^{-7}$ m^2/s, allowing some mixing of the source with the atmosphere above the asphalt.

3.0 - NUMERICAL MODEL OF TCA TRANSPORT AT MDA L

The MDA L site model is a three-dimensional representation of the hydrogeologic system, including the surface topography. The numeric modeling is limited to diffusive transport in the subsurface and reduces the complexity of the problem by neglecting water flow (infiltration), air flow (barometric pumping and wind effects), Henry’s law phenomenon (solubility of the vapor contamination in the aqueous phase), and dispersivity (increased mixing due to airflow). These simplifications are suggested by the preliminary conceptual model [Rogers, 2000].

The simulations are run with FEHM, a three-dimensional finite-volume heat and mass transfer code suitable for simulating systems with complex geometries [Zyvoloski et al., 1997]. The governing equations in FEHM arise from the principles of conservation of water mass, air mass, contaminant mass, and energy. Darcy's law is assumed to be valid for the momentum of the air and water phases. The advection-dispersion equation, which governs solute transport in FEHM [Fetter, 1999; Zyvoloski et al., 1997], becomes the diffusion equation under no-flow conditions. Water flow is restricted by using van Genuchten [1980] parameters that result in no appreciable water flux. Air convection is damped by fixing a horizontally stratified temperature gradient in the model domain. This results in air velocities that are negligible relative to the diffusivity of the contaminant and allows us to better understand the process of diffusion within the mesa.

3.1 MODEL DOMAIN AND COMPUTATIONAL GRID

The model domain covers a rectangular map area with the southwest corner at State Plane (SP) coordinate (1639275,1758825) and the northeast corner at SP coordinate (1640625,1759775). The model uses SI units, and the SP data (feet) were converted to meters for the simulation. The grid is 411 m (1350 ft.) wide in the x direction (east-west) and 290 m (950 ft.) in the y direction (north-south), as shown in Figure 3.1_1. The land surface in the model domain is based on Digital Elevation Model (DEM) data, which allow accurate representation of the major features of the mesa/canyon system. The grid uses a subset from the DEM data to approximate the surface with 15-m spacing. The model surface shown in Figure 3.1_1 compares favorably to the site topography seen in Figure 2.1_1. Node spacing is 15.24 m (50 ft.) in both the x and y directions, and is variable in the z direction from a minimum spacing of 1 m (3.3 ft.) to a maximum of 15.24 m (50 ft.). The node spacing was chosen to assure a final grid that will compute in a reasonable time frame (on the order of 1 hour for a 10 year simulation) while maintaining the basic site topography. Model geometries of the subsurface hydrogeologic units are based on interpolated data from existing boreholes and outcrop, and are of a lower resolution than surface geometry.

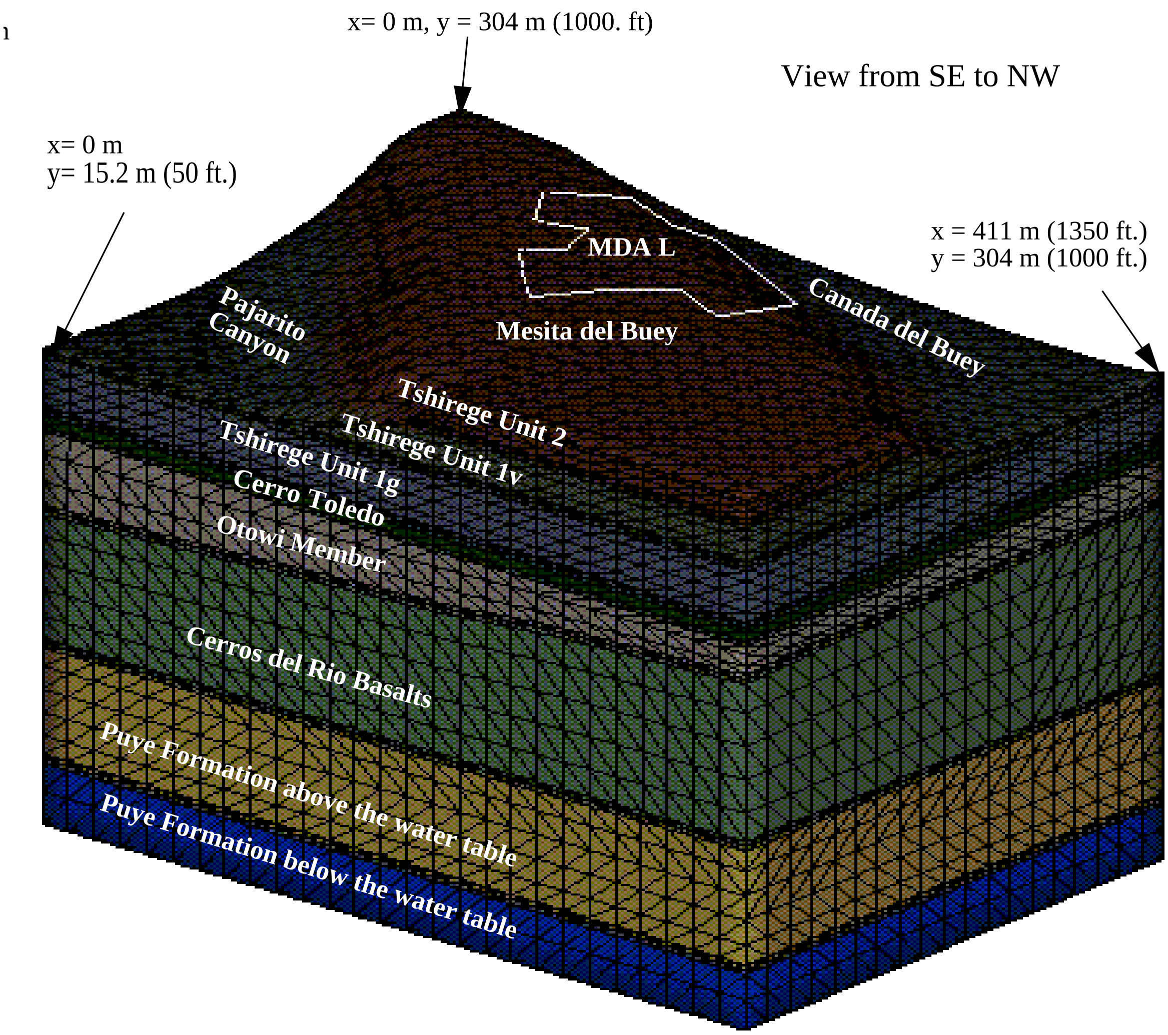


Figure 3.1_1 Model topography and computational grid

The model domain extends vertically from the land surface to below the water table and delineates a rectangular volume of over 43 million cubic meters. The stratigraphic configuration used for the model (Figure 3.1_2) is derived from the LANL site-wide geologic model [Vaniman et al., 1998]. Surfaces and interfaces are loaded into the LaGrit grid generation software [Trease et al., 1996; George, 1997], and a computational grid is formulated that maintains positive definite coupling coefficients at all volume interfaces. Furthermore, the stratigraphic interfaces are given higher-resolution node spacing to allow for sharp gradients in material properties. The final grid contains 25,456 nodes and 147,438 tetrahedral volume elements.

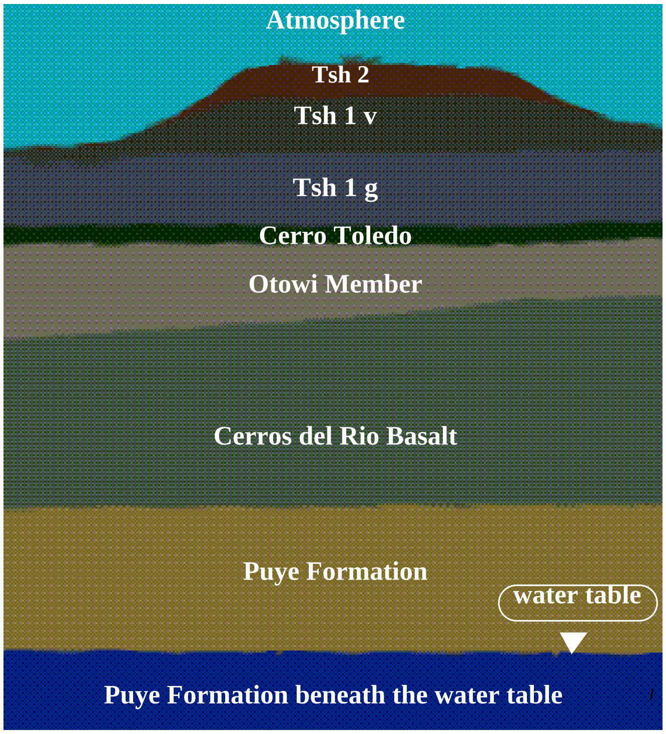


Figure 3.1_2 Model stratigraphy for cross-section B-B' (see Figure 4.3.1_2).

3.2 BOUNDARY AND INITIAL CONDITIONS

The bottom boundary of the domain is flat and lies below the water table. The presence of the water table within the model domain allows us to estimate travel times to this important horizon. No flow of water or vapor is permitted across the bottom boundary, and its temperature is held constant at 25°C, based on well bore measurements [Griggs, 1955]. The atmosphere at the top of the model is held at a pressure of 0.078 MPa, and the temperature is fixed to the yearly average of 10°C [LANL weather website]. The atmosphere is represented by fixing the concentration at zero in the nodes above the land surface. The vertical side boundaries of the domain are no flow with respect to both mass and heat.

Before running the contaminant transport simulations, a static air pressure field is established by running the model until pressures and temperatures reach equilibrium. This ensures that the transport simulations are not affected by transient behavior associated with establishing a static air pressure field. The steady-state initial condition has no TCA present and is meant to represent the mesa before release of contaminants.

3.3 SHAFTS AND ASPHALT

The model node spacing is too coarse to explicitly include each shaft found at MDA L. Therefore, we group the shafts into two clusters, with cluster #1 containing shafts 1 through 28 and cluster #2 containing shafts 29 through 34. Each cluster is specified using three nodes which include a volume of the model domain (3520 m^3) extending from two meters below the surface to a depth of approximately 20 meters (60 ft.). The model shafts coincide spatially with the two actual shaft clusters shown in Figure 2.2_1. TCA is introduced to the model shafts based on a simplification of the available data. The shaft nodes are assigned fixed concentrations of TCA based on the highest measured concentrations from vapor ports near the shafts. Because maximum measured concentrations vary through time, we simulate both high (11,000 ppmv) and low (3000 ppmv) fixed concentration sources in the shafts.

The asphalt cover is modeled as having been laid down as one layer at the beginning of 1985. The timing of the asphalt cover is not well documented, and our approach is meant to capture the gross system behavior. The spatial location of the asphalt is based on the site map and personal communication from Dennis Newell that 98% of MDA L is paved. In addition to the extensive asphalt covering within the boundaries of the site, substantial portions of the mesa around MDA L have been paved for parking lots, trailer foundations, and roads [Site visit, Jan. 2000]. The modeling presented below includes only the asphalt within the boundaries of MDA L. The aerial extent of the asphalt covering is identical to the site boundaries and can be seen in Figure 4.1.2_1. The asphalt restricts surface flux to the atmosphere. Future modeling may include more detailed representation of the surrounding asphalt and structures as data become available.

The time-varying site model is run in three stages to capture the main events that occurred during the emplacement of waste at MDA L. We begin all the contaminant transport simulations in 1975 by fixing TCA concentrations in shaft cluster #1. The simulation is halted at 1983 to add shaft cluster #2, then restarted and run until 1985, at which time the asphalt is added to the mesa top. The simulations is again restarted and run to 2000 and beyond. The above simplification of the sequence of events at MDA L is justified based on the limited site data and the need to minimize the complexity of the simulations.

3.4 SUMMARY OF LOGIC FLOW FOR THE BASE SIMULATION

The first simulation we present uses our initial best estimate for the in-situ effective diffusion coefficient and other important hydrogeologic parameters. We refer to this initial model as the base simulation (Table 1). We create a set of results for the base simulation to which we compare results for simulations with variations in boundary conditions (asphalt vs. no asphalt), variations in the TCA effective diffusion coefficient (D*), and variations in source concentration.

The base simulation is initiated in 1975 when shaft cluster #1 (representing shafts 1-28) is fixed to a concentration of 3000 ppmv and held at this concentration throughout the simulation. This source is allowed to diffuse until 1983 when the model is halted to add shaft cluster #2 (representing shafts 29-34). The second shaft cluster is then also fixed at 3000 ppmv for the duration of the simulation. The model is restarted and run until 1985. Finally, the asphalt cover is added, and the model is run until the year 2000. The base simulation results in approximately 865 kg of TCA in the modeled plume at the year 2000. The method for modeling the TCA source is reasonable given the sparse data on disposal operations at the site. The TCA mass generated with this method also compares favorably to the integrated mass of the measured TCA vapor plume, which yields a value in the range of 1000 kg based on data from 1999 [LANL, 1999].

4.0 - RESULTS

4.1 BASE SIMULATION RESULTS

4.1.1 TCA concentrations through the model domain

Figure 4.1.1_1 shows the predicted TCA concentration in the year 2000 for the base simulation with a TCA diffusion coefficient of 4 x 10^{-6} m^2/s. The figure is a two-dimensional horizontal slice of the model domain at a depth of approximately 18 m (60 ft.) below the top of the mesa. The concentrations are shown in powers of ten (log scale) to allow regions of both high and low concentrations to be visualized. The maximum concentration (red) of 3000 ppmv TCA shows the locations of the shaft clusters. The edges of the mesa are clearly visible as areas where concentrations drop quickly to near zero (darkest blue). The plume at this depth is spreading along the axis of the mesa, while TCA is being removed from the system along the mesa edges. As discussed in the conceptual model, the atmospheric boundary at the mesa edge is expected to give

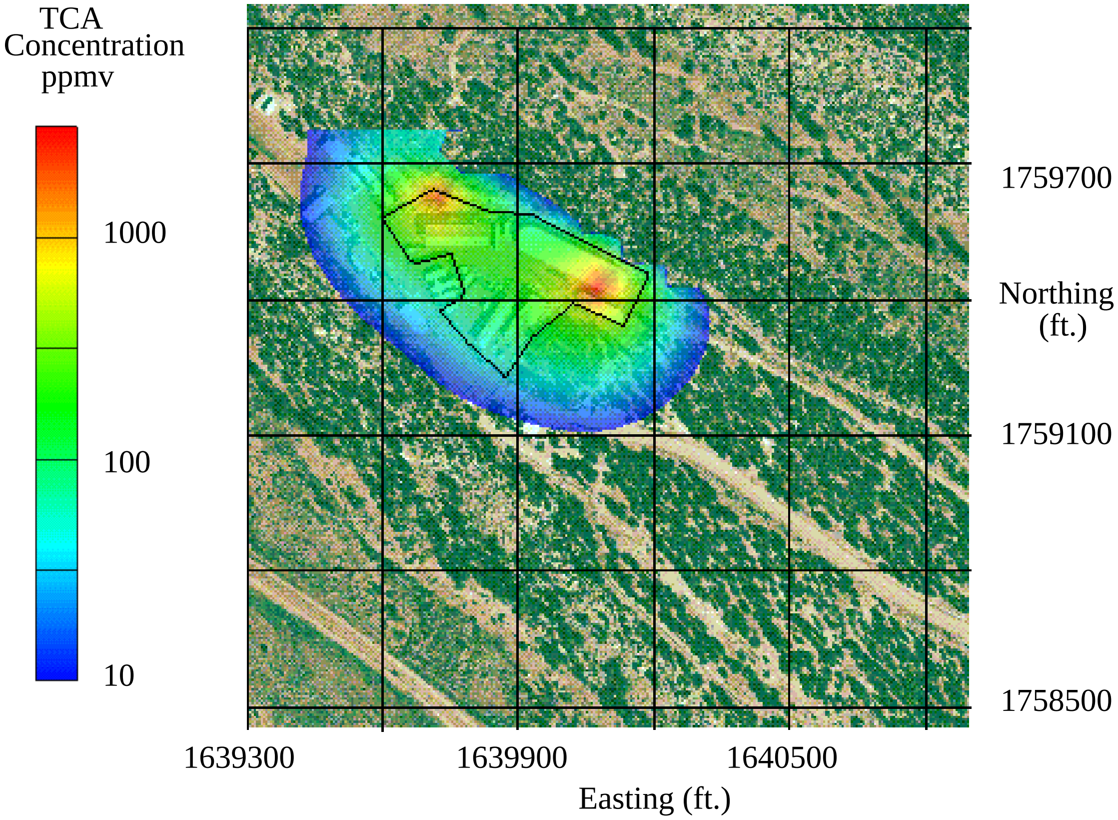


Figure 4.1.1_1 TCA concentration (log scale) for the base simulation contoured on a plane 18 m (60 ft.) below the mesa top.

rise to the high concentration gradient along Canada del Buey that is evident in the figure. This figure can be compared directly with the monitoring data shown in Figure 2.2_2. The most obvious similarities are the shape of the plume and the location of the highest concentrations near the two shaft clusters. The 10 ppmv contour outline in both figures covers approximately the same areal extent.

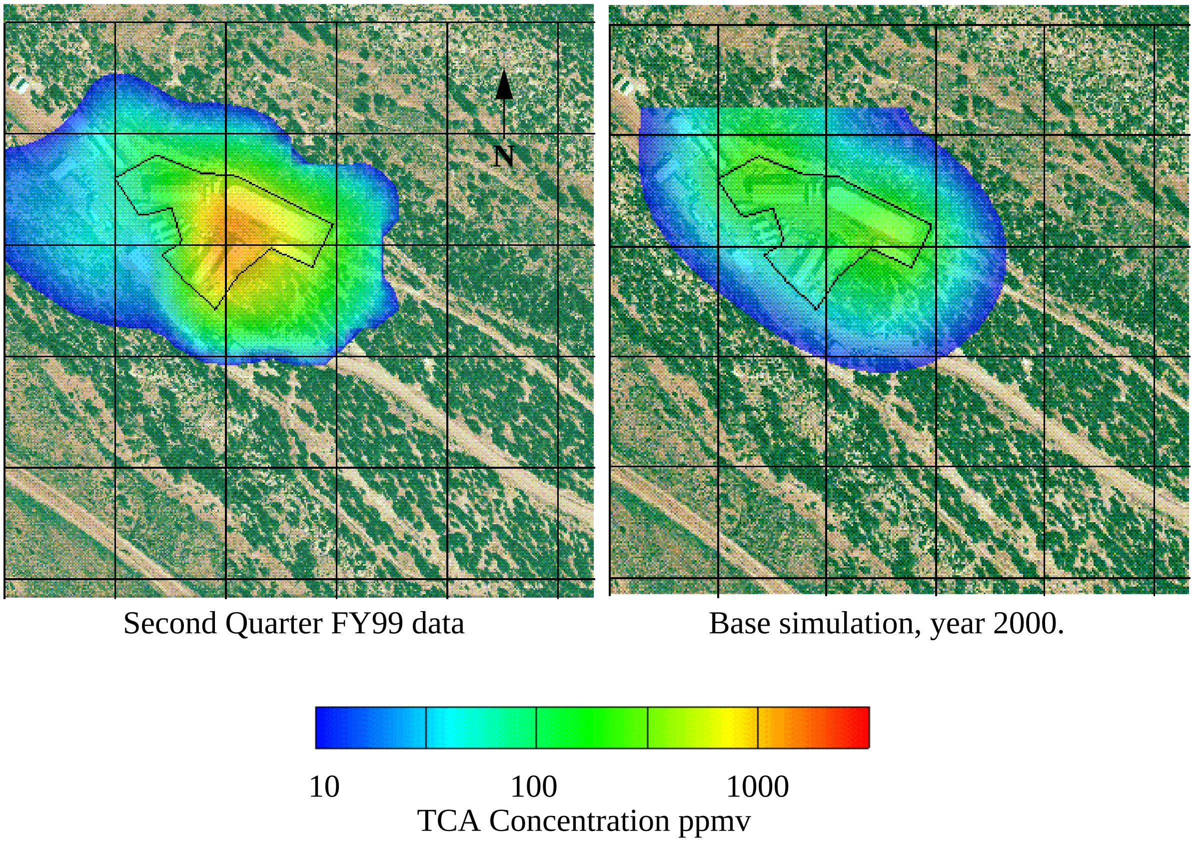
Several differences are evident as well between the data and the simulation. The first is that the two source areas are not as pronounced in the data as in the model results. The data are not gathered at regularly spaced intervals and therefore require interpolation for the visualization. The data presented here are interpolated with a nearest neighbor scheme. Monitoring data are gathered near the two shaft clusters but not near the center of MDA L (Figure 2.1_1). Because of this, the nearest neighbor interpolation scheme yields higher concentrations between the two concentrated source regions than calculated by the diffusion model. For this reason, visual interpretation in itself cannot be used to assess the quality of the calibration. In a later section, we present a goodness-of-fit analysis that is used to determine the best-fit simulation.

Another difference between the data and the simulation is seen on the north boundary of the model domain where the model's no-flow boundary becomes apparent. At this boundary, TCA is unable to leave the system, leading to higher concentrations than seen in the data. The effect of the no-flow boundary is explored later in simulations by fixing this boundary at zero concentration rather than as no flow.

Figure 4.1.1_2 is a comparison of TCA concentration for the data and the base simulation contoured on a horizontal plane at a depth of 49 m (160 ft.) below the mesa top. The extent of the 10 ppmv contour of the simulation matches the data very well over most of the domain. Again the source regions differ and the effect of the no-flow northern boundary is evident in the simulation results.

4.1.2 Surface flux

Figure 4.1.2_1 shows the predicted surface flux of TCA at the interface between the ground surface and the atmosphere. We present the surface flux from the best fit calculation of Revision #1, which is explained in more detail in section 4.4. The surface flux is calculated simply from Ficks Law using the modeled concentration at the surface, the distance from the surface node to the first air node (zero concentration), and the land surface diffusion coefficient (1.e-6 m2/s). The location of the simulated asphalt is seen as the dark blue patch overlying the outline of MDA L. Flux through the asphalt is very low because the asphalt is modeled with a very low diffusion



Second Quarter FY99 data

Base simulation, year 2000.

Figure 4.1.1_2 TCA Concentration for the data versus the base simulation on a plane 49 m (160 ft.) below the mesa top.

coefficient that forces the TCA to diffuse by an alternate path to the surface. The effects of the asphalt on surface flux are clearly seen by the high fluxes around the edge of the site. Because TCA flux is controlled by concentration gradients, the model predicts that the highest loss of TCA to the atmosphere occurs along the edges of the asphalt, the shortest path from the high concentration source to the atmosphere. The wall of Canada del Buey, immediately to the north of the site, also has high concentration gradients and is important in removing TCA from the subsurface. The high surface fluxes seen along the northern boundary of the model domain are artifacts of the no-flow boundary condition and should not be interpreted as physically significant.

In the base model, 1780 kg of TCA are lost to the atmosphere during the simulation. This loss represents nearly 70% of the 2645 kg of TCA mass input during the simulation. Our surface flux results compared qualitatively to surface flux chamber measurements performed in 1993 that show high fluxes around the edge of the site boundary and on the slopes of Canada del Buey to the north [Trujillo, 1998]. Quantitatively, however, the maximum computed surface flux from the model ($4.7\text{x}10^{-2}$ kg/(m^2 yr)) is more than 100 times higher than the maximum values reported for

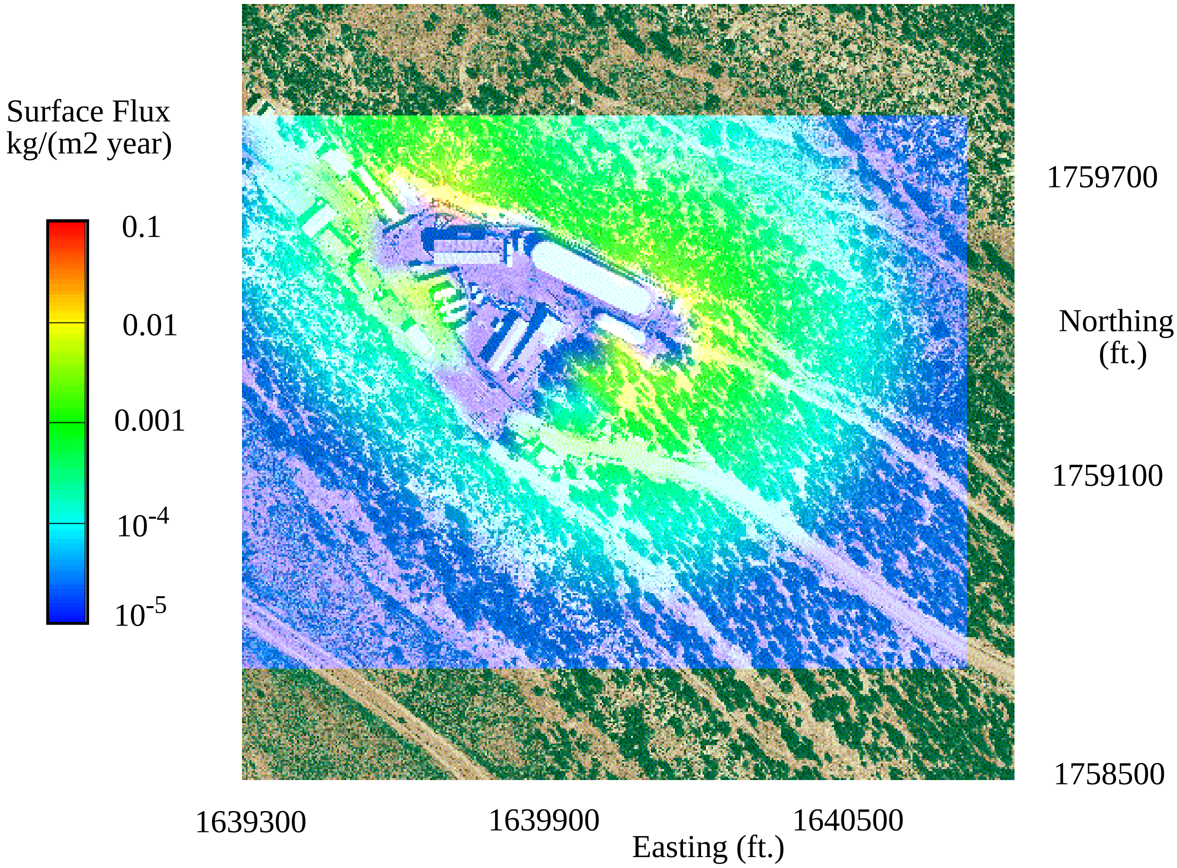


Figure 4.1.2_1 Flux of TCA to the atmosphere for the base simulation.

the sampling (668 ng/(m^2 min) = 3.5x10^{-4} kg/(m^2 year)). Simulations in support of Revision #1, discussed further in section 4.4, show conclusively that reductions in surface flux of 10x or more cause the modeled plume geometry to diverge considerably from the observed plume. The best-fit simulation in Revision #1 was found to have a land-surface diffusion coefficient of 1.e-6 m2/s.

We also present a back-of-the-envelope calculation based on the observed near-surface concentrations of TCA (approx. 1000 ppmv) in well 54-2089 at a depth of 4 meters and assumed land-surface D* = 1x10^{-6} m^2/s from Revision #1. One thousand ppmv is equivalent to 0.001 (moles TCA)/(mole air). One m^3 of air is about 34.5 moles. Thus there are 0.034 moles TCA/(m^3 air). TCA contains 133 g/mole yielding 4.6 grams of TCA per cubic meter of air. Calculating the flux to the surface using these numbers gives: Surface flux = D* x (dC/dz) = 1x10^{-6} m^2/s x (4.6 g/m^3)/(4 m) = 1.15 x 10-6 g/(m^{2}s) = 0.036 kg/(m^2 yr), which agrees well with the maximum model surface flux of 0.047 kg/(m^2 yr). We believe that this discrepancy between the simulated and the measured surface flux may be affected by systematic measurement error. One source of possible error in the measurements is that 5.4 centimeters of rain fell during the sampling period, which could decrease the ability of organic vapor to diffuse to the surface. Furthermore, nearly half of the 15 samples sent out for EPA review showed TCA concentrations in excess of the linear response range of the calibration [Trujillo, 1998]. These problems were noted in the TA-54 RFI report, and for this reason the surface flux data are used only qualitatively to describe the extent of the plumes at MDA L [LANL, 2000].

4.1.3 Goodness of fit of the base simulation

To analyze the goodness of fit between the model results and the monitoring data (Second quarter, FY99), we calculate the mean (μ) and standard deviation (R) of the relative error of the model as a percentage of the data (PE = model/data) [Boas, 1983]. Percent error is used instead of the more traditional absolute residual (model - data) to capture the three order of magnitude variation in the data. Using this scheme, values for PE are greater than 1 when the model is higher than the data, and less than 1 when to the model is less than the data. To generate meaningful statistics, the values less than 1 are renormalized as the negative of the inverse of the value which can be expressed as a logical statement: If PE < 1. then PE = -1*(1/PE). Thus, when the model is higher than the data, PE ranges from 1 upward, and when the model is lower than the data, PE ranges from -1 downward. The values are then shifted to PE = PE - abs(PE)/PE. This results in an ideal mean that lies at zero and allows a standard deviation about the mean to be calculated consistently for the various simulations. To avoid infinite percentages when the data are very close or equal to zero, we choose a lower cut-off of 10 ppmv and consider the model to be in agreement with the data when both values are below the lower cut-off. The reliability of the data falls as values approach 5 to 10 ppmv and this fact provides further justification for the chosen cut-off.

We also employ a conditional statement that is designed to flag potentially spurious data points or sections of the model domain that are extremely different than the data. This condition states that if the ratio, model/data, is greater than 3 or lower than 0.33, the model/data pair is flagged and removed from the calculation of the mean and standard deviation. The number of points removed is counted and reported along with the statistical properties to determine goodness of fit for the base simulation as well as other simulations presented later. This gives us a consistent approach to differentiate simulations and find the model parameters that yield the best overall fit to the greatest number of monitoring points. Future fitting should include all relevant data sets, perhaps with quality control at the level of the data collectors to remove questionable data based on intimate knowledge of the sampling apparatus and site-specific problems. Such quality control would help tremendously in yielding meaningful results.

Using the logic outlined above, the base simulation gives a mean of -0.068 and a standard deviation of 0.72, with 29 of the 142 data points removed from the calculation [Table 2]. The mean model result is therefore only 6.4% below the data, with one standard deviation including values from (1.72 x data) on the high side to (0.58 x data) on the low side. This is a good fit considering the simple nature of the parameters used in the simulation.

4.2 MODEL BEHAVIOR WITH VARIATION FROM THE BASE SIMULATION

We next present a series of simulations that explore variations in the base model. Results are shown in Table 2 for several scenarios.

Table 2: Goodness of Fit for various simulations

Changes from the Base simulation	mean	Standard Deviation	Points removed
None (Base simulation)	-0.068	0.72	29
no asphalt	-0.24	0.69	31
leaky asphalt	-0.13	0.69	28
D*=1x10^{-6} m^2/s	-0.23	0.52	44
D*=8x10^{-6} m^2/s	0.0015	0.69	44
Basalt C = 0.	-0.072%	0.71	24
N. and W. C = 0.	0.089	0.68	18
N., W., and B.; C = 0.	-0.093%	0.67	15

B. = basalt; N. = North boundary; W. = West boundary; CT = Cerro Toledo, S. = surface

First, we simulated the site with no asphalt. The number of points lying outside the cut-off for this case is slightly larger than the base case (N = 31 vs. 29), however the mean of -0.24 is much lower and implies that the simulated concentrations are lower than the measured concentrations at more points. The standard deviation is nearly the same implying that both simulations spread equally about their respective means. The results for the leaky asphalt (D*=4x10^{-7} m^2/s) are shifted similarly toward the model underestimating the data. Thus, the asphalt at MDA L appears to be best fit as a non-diffusive barrier forcing VOC's to migrate downward and laterally to reach pathways that lead to the atmosphere.

We next explore the effect of varying the porous-medium, vapor diffusion coefficient. When D* is doubled from the base case to $8x10^{-6}$ m^2/s, 44 points fall outside the cut-off, and the mean is positive showing that the simulated concentrations overestimate the data. When D* is quartered from the base case to $1x10^{-6}$ m^2/s, 44 points again fall outside the cut-off, and the mean lies well below zero, showing that the simulated concentrations are lower than measured concentrations. Because both of these simulations have more points lying outside of the cut-off, the base simulation is seen to be a better fit to the data.

We explore the effects of the no-flow boundary and of the potential of the basalt to rapidly exchange pore gas with the atmosphere by fixing these sections of the model domain to zero concentration. When the basalt is fixed to zero concentration, there are 24 points lying outside of the cut-off, whereas when the north and west boundaries are fixed to zero, there are only 18 points removed. Combining these two simulations results in only 15 points removed and a slightly improved standard deviation.

Figure 4.2_1 shows the data versus model regressions for all simulations except the 'no asphalt' and 'leaky asphalt'. This series of plots helps to show differences between the individual simulations in a graphical manner. In an ideal model, the regression would plot exactly on the 1:1 line, which is shown in red on Figure 4.2_1.

Figure 4.2_2 shows another way of representing the data versus model regression. The regression is now in the form log10(model) versus log10(data). Log(10) is used to reduce the dominance of high values that occurs when a simple model versus data regression is performed. Most importantly, there have been 10 points deemed to be spurious data removed from each of the simulations and the data. These 10 points were found to lie outside the statistical cut-off used for most of the simulations, and the individual points removed were checked by hand to ensure that they meet criterion for being spurious data (i.e. values that change radically from one quarter to the next, or values that are unrealistically low or high for their position in the plume). This figure shows the same trend as seen in Figures 4.2_1 as well as in Table 2. The different simulations are clearly separated graphically and show that the best-fit simulation has the north and west boundaries and the basalt fixed to zero concentration (NWB; standard deviation (R) = 0.94, intercept (I) = 0.095; slope (S) = 0.88), in complete agreement with Table 2. The base simulation yields R = 0.844, I = 0.44, and S = 0.72 showing that the base simulation is overestimating

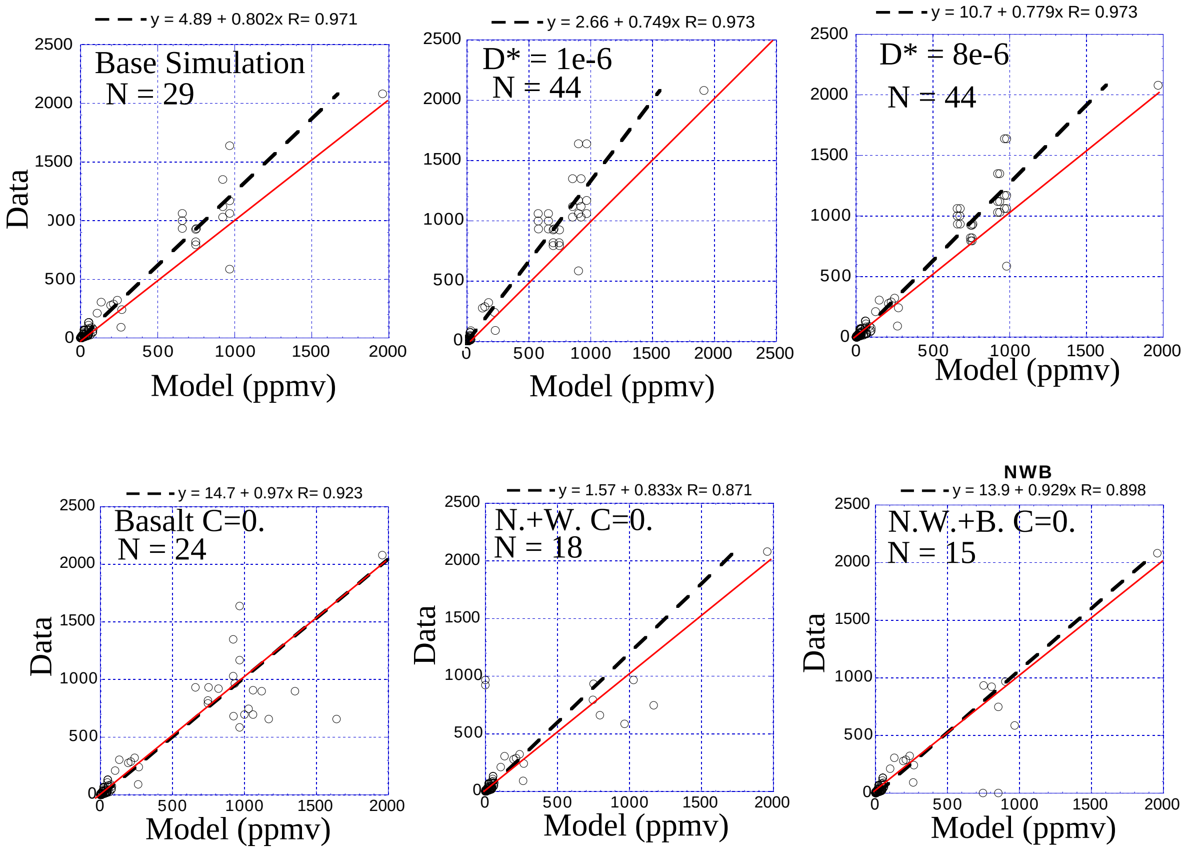


Figure 4.2_1 Regression plot of simulations presented, based on GOF statistics. Points flagged by the upper and lower cut-off in the statistical logic (N) have been removed from these plots.

concentration data at the low end while underestimating data at the high end. The D* = 1e-6 simulation (labeled as 1D) intercept (I = -0.19) lies well to the left of the 1:1 line and has R = 0.88 and S = 0.82, while the D* = 8e-6 simulation yields I = 0.79, R = 0.80, and S = 0.59.

Not shown on Figure 4.2_2 are the no-asphalt, leaky asphalt, fixed basalt, and fixed north and west boundary examples. The leaky and no asphalt cases have intercepts which plot well to the right of the 1:1 line and both have R = 0.84. The fixed basalt example has R = 0.88 and an intercept of 0.3. The fixed north and west boundary case (NW) has R = 0.84.

4.3 RESULTS FROM THE BEST-FIT SIMULATION

4.3.1 Basic results

The best-fit simulation maintains the north and west boundaries and the basalt at a concentration of zero for all times. The justification for fixing the basalt to zero comes from observations that the air pressure in the basalt is in phase with and of the same magnitude as the

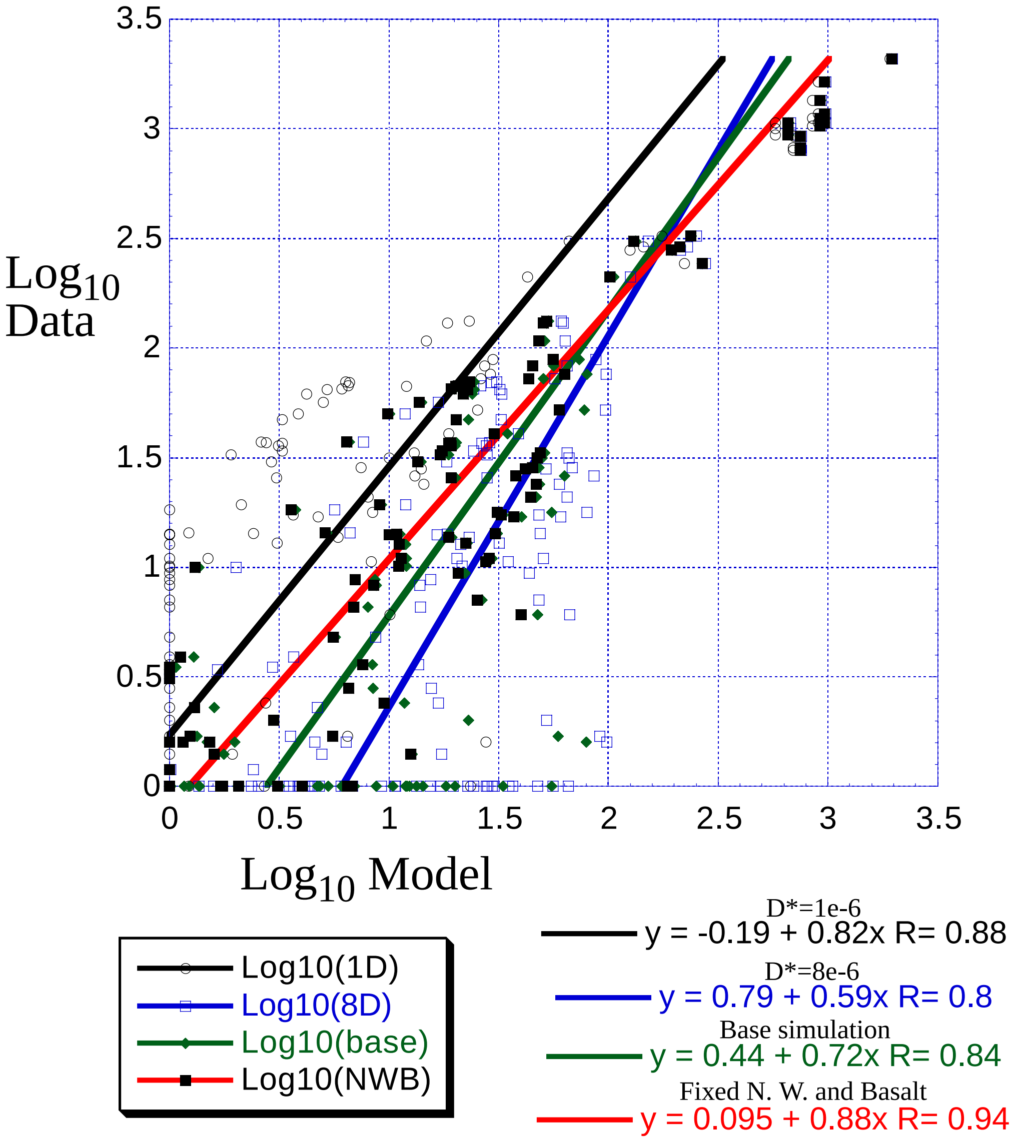


Figure 4.2_2 Regression plot of simulations presented, based on removing potentially spurious data.

atmospheric pressure. The north and west boundaries are set to zero concentration to minimize boundary effects caused by the size of the model domain. Figure 4.3.1_1 shows the effect of fixing the boundaries and basalt to C=0. on concentrations in the deep domain. The base simulation results in a plume that reaches much further into the basalts. The concentrations seen in the best-fit scenario are much closer to the data and support the idea that the basalt is readily exchanging air with the atmosphere.

For the best-fit simulation, we next show a more detailed look at the distribution of the plume, both along the axis of the mesa and perpendicular to the axis of the mesa. Figure 4.3.1_2 shows the relationship of the plume to the geologic units on a cross-section B-B' running through

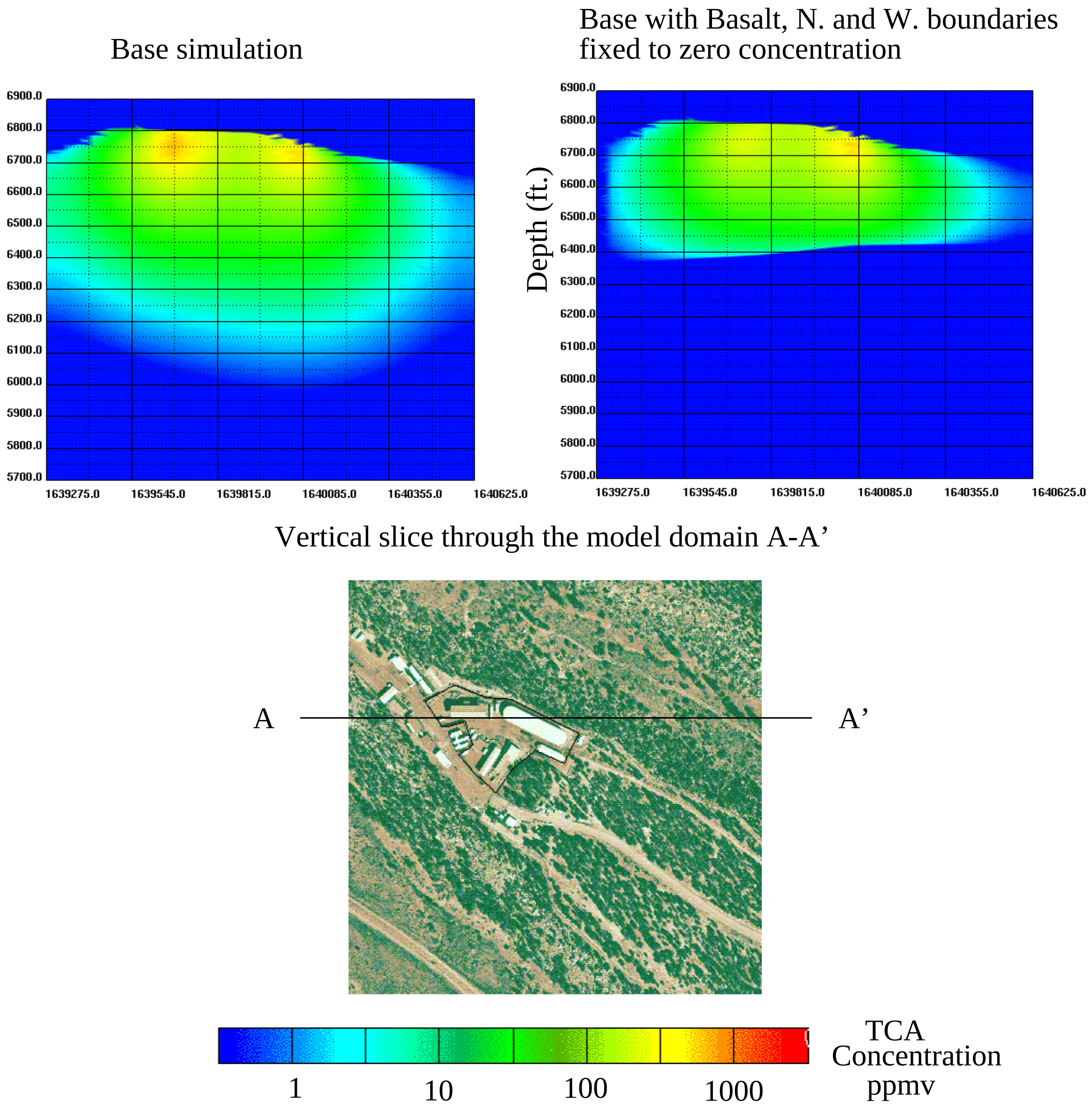


Figure 4.3.1_1 The effect of fixing the basalt, and the north and west boundaries to zero concentration on the concentrations deep in the model domain.

MDA L perpendicular to the mesa top. Figure 4.3.1_3 shows the relationship of the plume to the geologic units on a cross-section C-C' running through MDA L along the axis of the mesa top. Boundary effects are seen in both cross-sections, at B' and at C. Boundary effects do not appear to be effecting the plume to the southeast, as shown by the smoothly varying plume in the directions of B and C'.

Another useful way to compare the base simulation with the best-fit simulation is to examine the amount of TCA in the system, the amount of TCA removed from the system, and the total amount of TCA added to the system as functions of time. This will provide quantitative

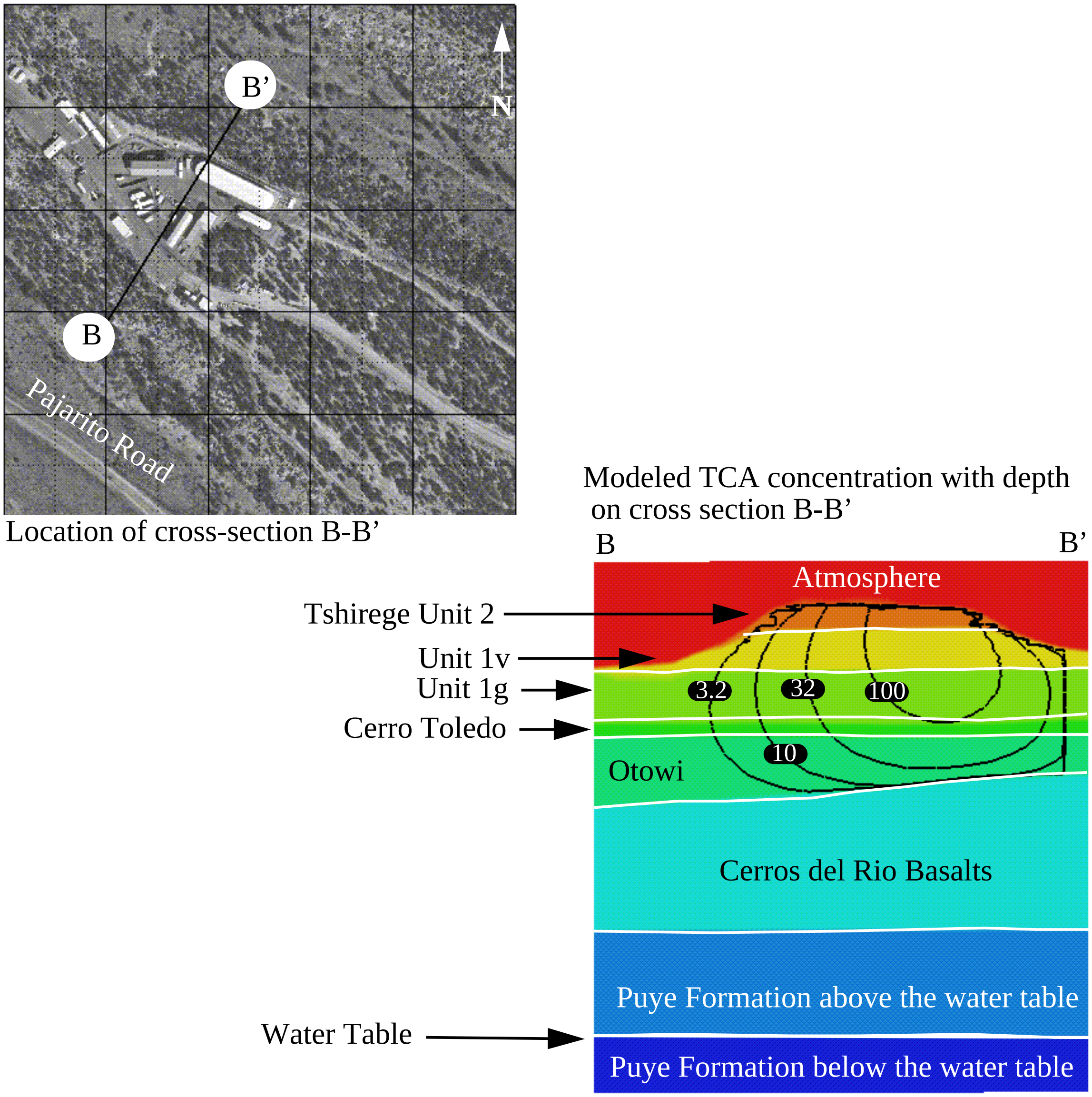
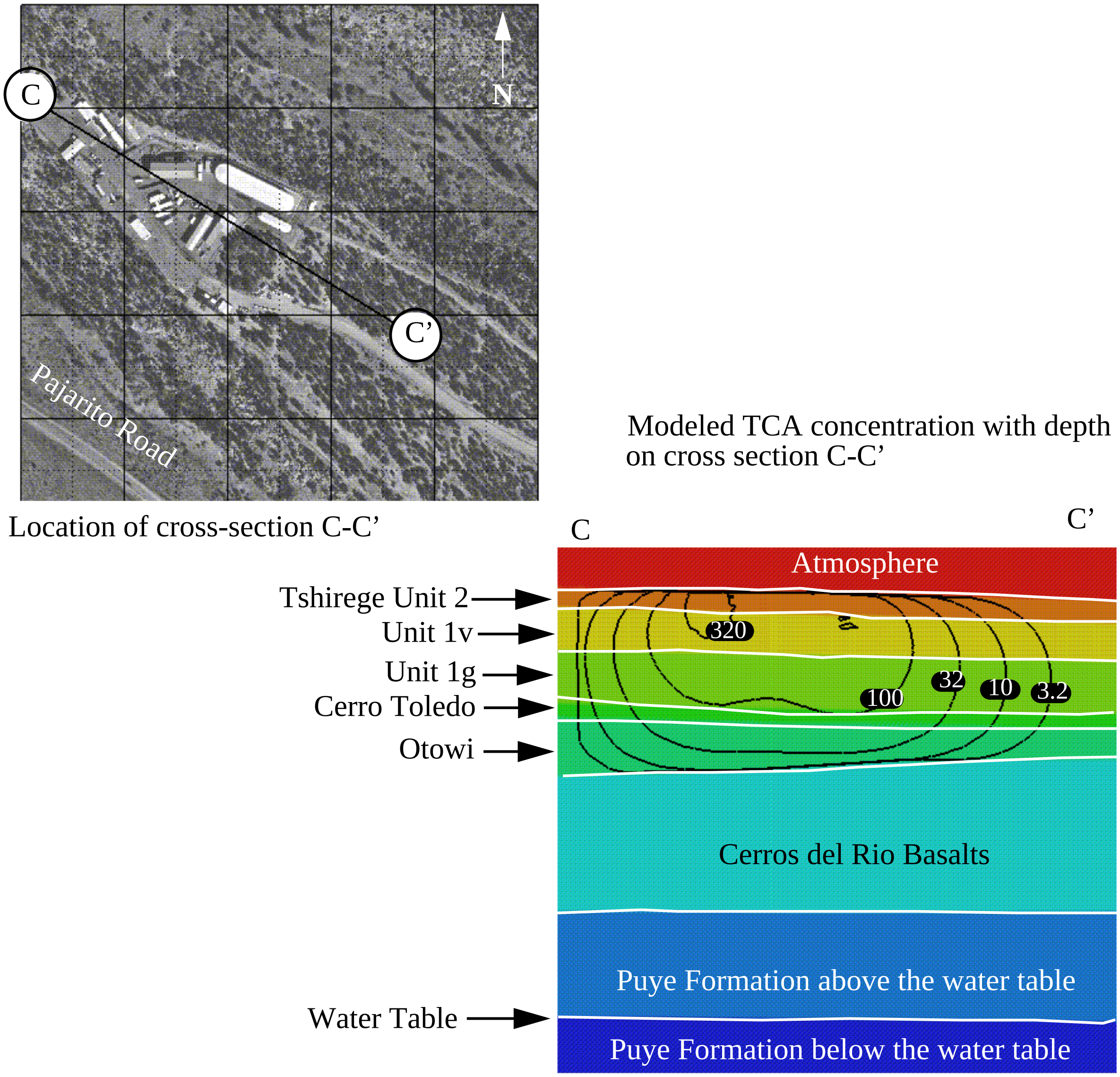


Figure 4.3.1_2 Vertical slice through the best-fit simulation (fixed N. and W. boundaries, and basalt C=0.) at cross-section B-B'. Contours are marked as TCA concentration in ppmv.

estimates of absolute plume growth that are difficult to see in cross-section or horizontal slices. Figure 4.3.1_4 shows the total number of gallons of TCA that are in the subsurface of the model as a function of time for the base simulation and the best-fit simulation. Clearly, the best-fit simulation reaches a steady-state plume mass equal to about three 55 gallon drums full of liquid TCA. The base simulation continues to add mass to the subsurface beyond the year 2050 and leads to a plume mass equal to about five 55 gallon drums of liquid TCA. The differences in the two simulations are due to the zero concentration north and west boundary conditions, and especially the fixed zero concentration in the basalts. These two cases represent end-members, with the best-fit simulation probably underestimating the true growth of the plume, while the base simulation



Location of cross-section C-C'

Modeled TCA concentration with depth on cross section C-C'

Figure 4.3.1_3 Vertical slice through the best-fit simulation (fixed N. and W. boundaries, and basalt C=0.) at cross-section C-C'. Contours are marked in TCA concentration in ppmv.

definitely overestimates plume growth because of the no-flow boundary effects. We next compare the total amount of TCA introduced from the source to the subsurface, as well as the amount of TCA that has escaped the system. Figure 4.3.1_5 shows that the amount of TCA added to the base simulation is nearly the same amount added to the best-fit simulation. The best-fit simulation, however, loses more TCA to the atmosphere (and the zero concentration basalts) and thus is able to reach a steady-state plume, as shown in Figure 4.3.1_4.

A conservative estimate for the total available source can be calculated by assuming that the shafts were filled with drums containing pure liquid TCA. There are 23 shafts having diameters

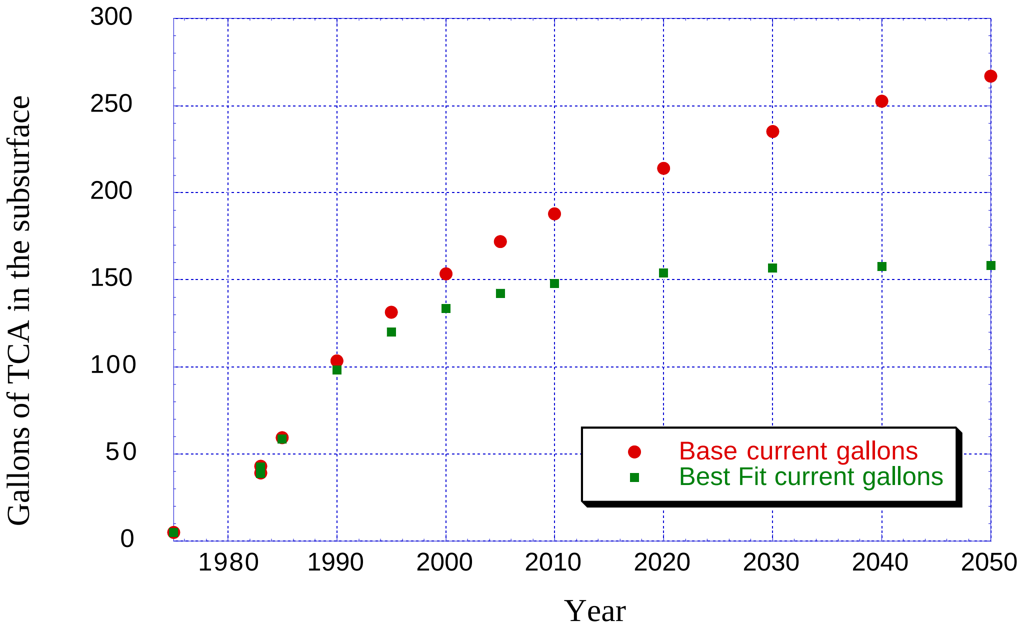


Figure 4.3.1_4 Amount of TCA in the subsurface as a function of time. Vapor-phase mass has been converted to equivalent mass in liquid gallons for comparison to waste emplacement.

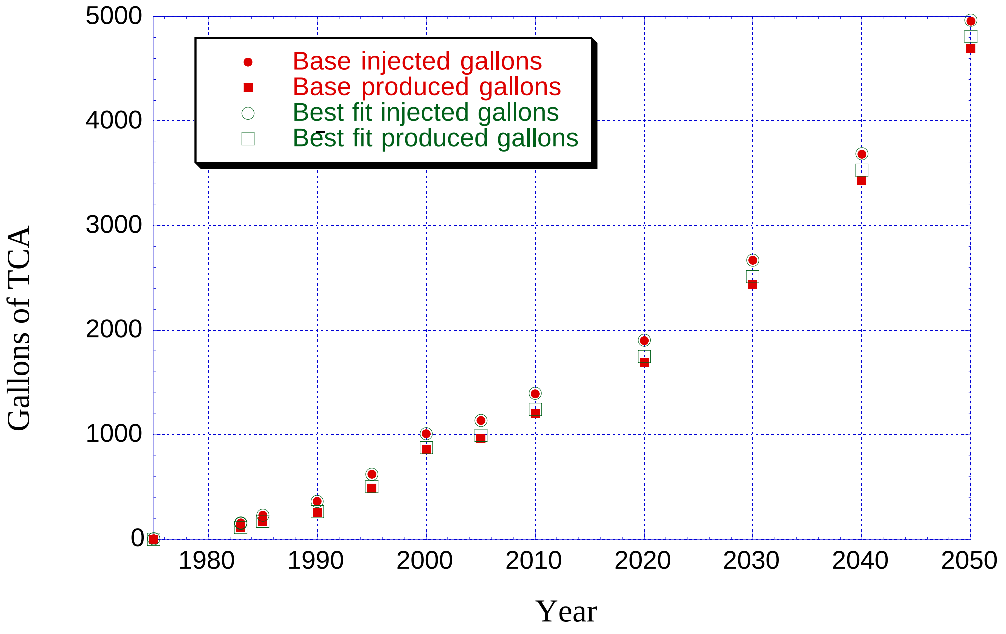


Figure 4.3.1_5 Amount of TCA injected and produced as a function of time. Vapor-phase mass has been converted to equivalent mass in liquid gallons for comparison to waste emplacement.

of 3 and 4 feet, in which one barrel per layer was emplaced, seven shafts having diameters of 6 feet in which a maximum of five barrels per layer were emplaced, and four shafts having diameters of 8 feet in which six barrels per layer were emplaced. Assuming that each layer takes 4 feet and that there are 3 feet at the top used for capping the waste suggests a maximum of 14 layers of barrels per shaft. The maximum TCA source is then found by summing the total number of barrels as: 14x(7x5 + 23x1 + 4x6) = 1148 barrels (63,140 gallons) of TCA. As shown in Figure 4.3.1_5, the total amount injected into the subsurface during the simulations is less than 1/10 of the maximum possible source. A more realistic estimate of the available TCA source is probably on the order of 1/10 or less of the maximum computed value, suggesting that the contaminant source may only last until the year 2060 (or less). Once the contaminant source is completely volatilized, the plume will begin to dissipate significantly on a time scale of decades, as suggested by the relaxation time of catastrophic drum failure presented in a later section.

4.3.2 Current plume growth

Predicted pore-gas concentrations as a function of time are examined at several locations to determine the current rate of plume growth for the best-fit simulation. Figure 4.3.2_1 shows simulated concentration values at a depth of 49 m (160 ft.) for five locations to the southeast of shaft cluster #1. These locations are chosen to show the variation in concentration for regions with high, medium and low values. The figure shows that the simulated concentrations change quite slowly in the year 2000. In fact, the plume is at near steady conditions, in agreement with Figure 4.3.1_4. Yearly monitoring would adequately capture the current plume growth.

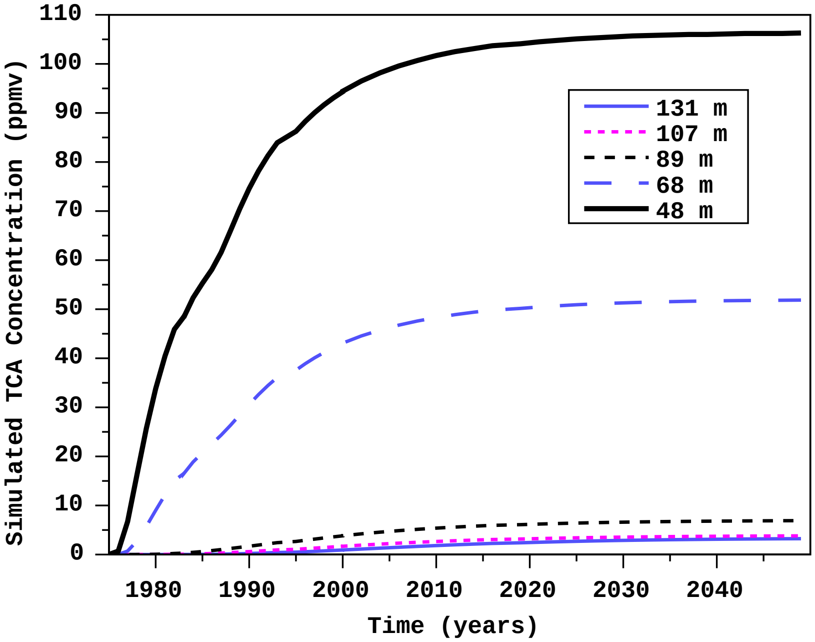


Figure 4.3.2_1 Best-fit simulation, change in concentration with time at five locations. Distance in legend shows distance to the southeast of shaft cluster #1, depth is 49 m (160 ft.) bgs.

4.3.3 Future plume growth: Year 2000 to 2050

The best-fit simulation was next run from the present (year 2000) to the year 2050 to demonstrate expected plume growth during the next 50 years. Figure 4.3.3_1 shows the simulation results at year 2000 (black line), year 2020 (red line), and 2050 (white line), sliced on a horizontal plane 48.8 m (160 ft.) below the mesa top. Of particular significance is the fact that the 50 ppmv contour does not move outward from the source at an appreciable rate. This is because the plume is reaching a steady-state equilibrium with the atmospheric boundary condition, where the amount of TCA released from the source over a given time is equal to the amount lost to the atmosphere. Our estimate of plume growth is conservative with respect to the size of the future plume, because the source is maintained at current levels. A less conservative estimate might include a source that decreases in strength with time. Increases in source strength are possible if individual drums of

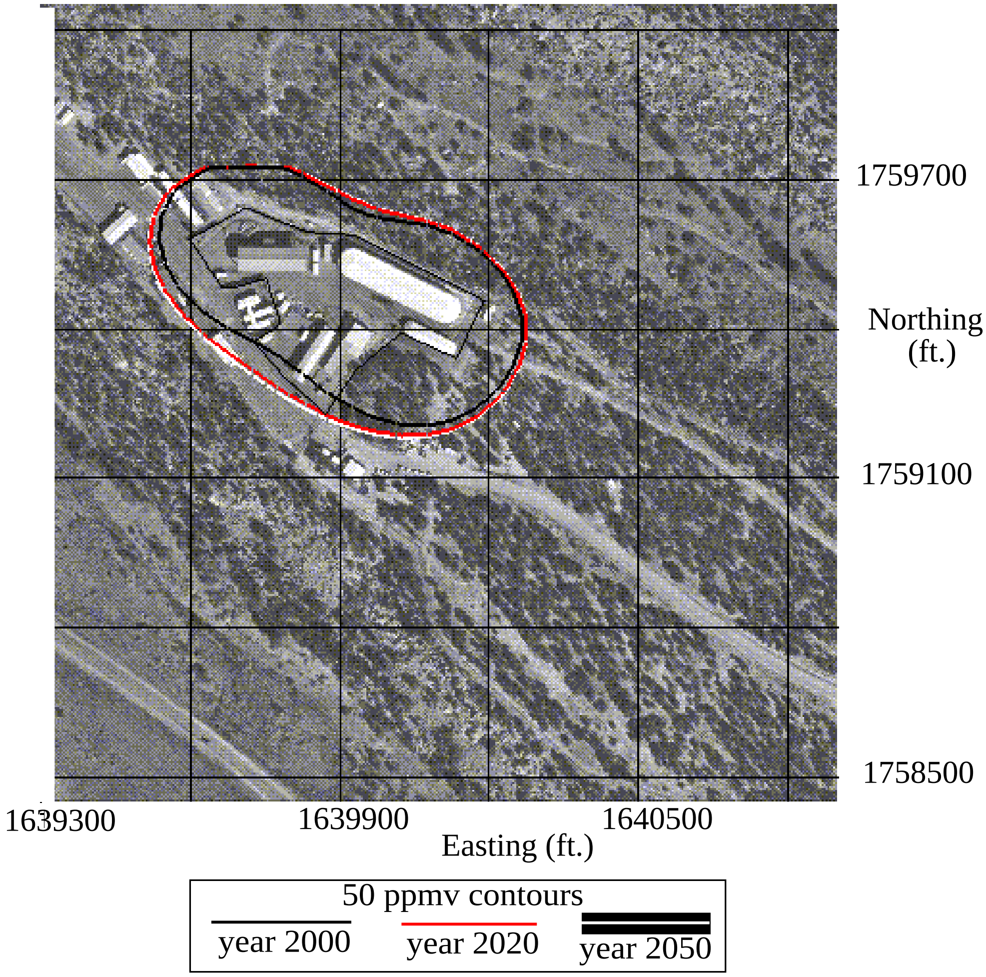


Figure 4.3.3_1 Best-fit simulation, future plume growth. 50 ppmv contours shown for the years 2000, 2020, and 2050.

concentrated solvent burst suddenly (Section 4.3.4), however drum corrosion data suggest slow leaking to be a more plausible scenario [Lyon et al., 1996].

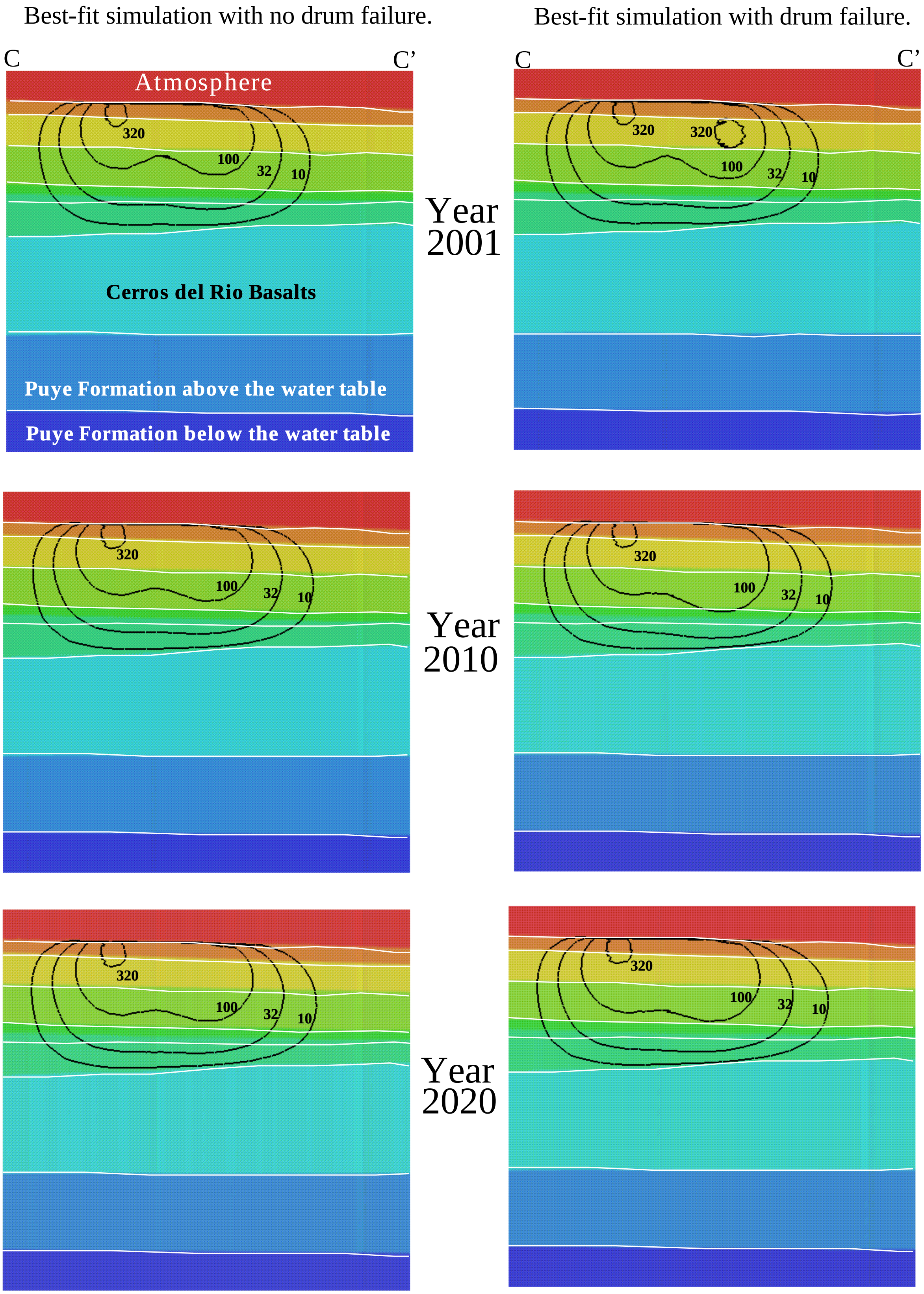
4.3.4 Simulating catastrophic drum failure with the best-fit simulation

We next present the results of a simulation designed to explore catastrophic drum failure. We assume, for a worst case scenario, that approximately 55 gallons of pure TCA liquid are introduced to the system suddenly by the failure of a drum at the bottom of a shaft. The liquid flows downward, smearing homogeneously to a depth of 30 m below the shaft bottom, or 50 m below the top of the mesa. We next assume that the TCA volatilizes rapidly to create a subsurface cloud having a concentration of 20,000 ppmv. This drum failure simulation begins in the year 2000, and uses the best-fit scenario at the year 2000 as the initial condition. Figure 4.3.4_1 shows side-by-side comparisons of the best-fit simulation and the drum failure simulation in the years 2001, 2010, and 2020.

Initially, the size of the plume increases under shaft cluster #1 for the drum failure case. The 302 kg of TCA (60 gallons) that were added to the system lead to a locally elevated region of TCA concentration that extents for tens of meters laterally from the location of the failure. The extra 60 gallons injected in this simulation increases the mass of TCA in the simulation by approximately 40%, as seen in Figure 4.3.1_4. Therefore, the simulation truly represents a catastrophic event. The rate of removal of the spill from the subsurface is shown in Figure 4.3.4_2. After one year, 22% of the initial pulse from the drum failure has been vented to the atmosphere. After two years, 31% has been removed, and after five years 50% has been removed. During this time period, monitoring should be able to detect such a catastrophic occurrence, especially during the first two years following drum failure.

By the year 2010 however, monitoring will probably not be able to detect the effect from the drum failure because 70% of the original catastrophic spill is gone from the system, and the remaining 30% is beginning to spread from the source region. As seen in Figure 4.3.4_1, the plume is slightly larger directly below the source region, where the 100 ppmv contour is pulled into the Cerro Toledo. By 2020, 88% of the spill has left the system, and the plume is nearly identical to the scenario with no drum failure (Figure 4.3.4_1).

As shown in Figure 4.3.4_2, the time rate of removal of TCA from the system can be fit nicely with an exponential curve. This final result is particularly satisfying because analytical solutions to the diffusive transport equations generally follow solutions of an exponential form.


Best-fit simulation with no drum failure.

Best-fit simulation with drum failure.

Contours lines are TCA concentration labeled in ppmv.

Figure 4.3.4_1 Comparison of no drum failure simulation with drum failure simulation. 302 kg of TCA are added as a pulse in the year 2000. Cross-section C-C' is shown in Figure 4.3.1_3.

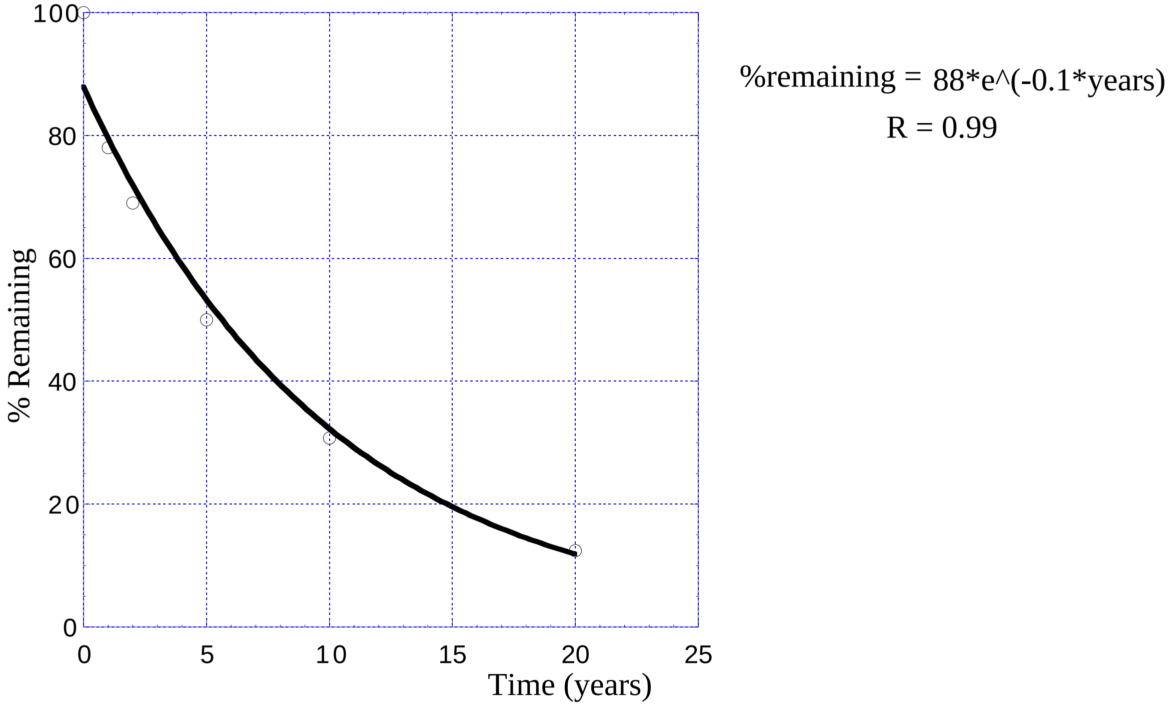


Figure 4.3.4_2 Time dependence of TCA removal from the mesa after catastrophic drum failure.

4.4 Simulations in support of Revision #1

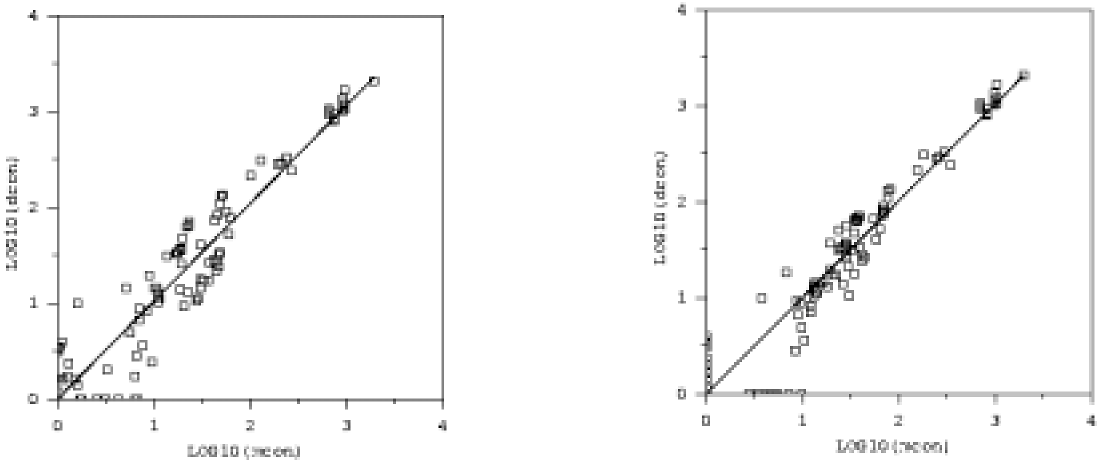
We now present results from new simulations performed to address the concerns of a group of independent reviewers, organized through the ITRD Program. Although the initial goal of the site model was to determine if the first-order process of pure vapor-phase diffusion could explain the bulk of the data, the reviewers ideas for improving the fit between model and data are quite useful in showing that the conceptual model for TCA transport is valid, and that the numerical model should prove quite robust in exploring the fate of the VOC plume for various remediation options at this site.

Our ability to do extensive sensitivity analyses was limited by time/funding allotted for this revision, therefore we present only a select set of simulations that demonstrate improved model/ data correlation. The most important assumption inherent in the limited sensitivities performed for this section is that we fix the saturations in the subsurface to values within the measured range that would tend to accentuate the effects of Henry’s Law and vapor-phase diffusion as a function of saturation. For example, measured saturations in Unit 2 range from 2% to 10%, however for this study we chose to use the lowest value of 2%. Unit 1v was set to 5% saturation and Unit 1g was fixed at 10%. The Cerro Toledo and Otowi units were both fixed at the high end of measured values (40% and 35%) based on the observed data. Deeper units play little role in transport at this site and units below the Otowi were set to 2% saturation. Four additional processes were incorporated into the numerical model that considerably improved the correlation between the observed data and the model output.

The first modification to the base simulation described in section 4.1 was to add Henry's Law fractionation between TCA in the vapor phase and TCA in the porewater within the mesa. The dimensionless Henry's coefficient for 1,1,1-TCA at standard pressure and temperature is 1.46 [Jury et al., 1990], defined as the concentration in the vapor phase divided by the concentration in the liquid phase, both expressed in moles of TCA per liter of fluid. The second modification was to reduce the effective diffusion coefficient in the more saturated Otowi and Cerro Toledo units from 4.e-6 m^2/s to 4.e-7 m^2/s based on the work of Fuentes et al. (1991). Next, we explored the possibility that the source at shaft cluster #1 was higher in the past. A limited sensitivity to source strength in shaft cluster #1 found that by fixing concentration in this region to 11,000 ppmv for the first 8 years (1975-1983), we are able to more accurately capture the magnitude of the plume seen in the boreholes to the east of the site. Justification for higher source concentration during this time frame comes from site records that indicate waste was better packed after the early 1980's due to guidance from regulatory agencies [LANL, 2000]. The final adaptation was to examine the model sensitivity to reduction in the flux across the land/air interface. Justification for reducing the diffusion coefficient in the very near surface comes from boundary layer arguments found in Jury et al. (1990). Furthermore, measured surface flux is well below that predicted by the modeling. Sensitivity to this parameter showed that a reduction from 4e-6 m^2/s to 1e-6 m^2/s in the near surface gave the best fit to the data with only 8 points failing the cut-off, however a value of 2e-7 m^2/s yielded a very good fit with 14. points failing the cut-off. The highest modeled surface flux using 1e-6 m^2/s on the surface predicted in revision #1 is still more than one hundered times greater than the values reported in Trujillo et al. (1998). As the land-surface diffusion coefficient is decreased below 2e-7 m^2/s, the model begins to diverge considerably from the data.

These modifications improved the overall model/data correlation without the need to fix zero concentration on the north or west boundaries nor in the basalt. The total number of points failing the 3x cut-off was reduced to 8, of which six are located beneath the canyon hinge in the angled boreholes (1015 and 1016) above the Otowi and Cerro Toledo units. This implies that we are still missing a second-order effect that tends to reduce concentrations in the area beneath the canyon bottom. These same six points fail the cut-off criterion for all simulations that have reasonable overall fits.

To compare the previous ‘best fit’ result from Section 4.3.1 to the current results from revision #1, we employ a least squares regression in $\log_{10}$ space (Figure 4.4_1). The only points not included in the calculation of the correlation coefficient (r^2) are those having both model and data values below 10 ppmv, however all data points passing the cut-off are included in Figure 4.4_1, so that there are 124 points plotted for the revised simulations and 121 points plotted for the original ‘best fit’ simulation. The old ‘best-fit’ simulation yields an r^2 of 0.926, while the revision #1 best-fit simulation yields an r^2 of 0.973. Figure 4.4_1 shows that the revision #1 best fit is more clustered around the data=model line. Finally, the results of the second order analyses are



Old ‘Best fit’ simulation

Revision #1 best fit simulation
with Henrys Law, diffusion as
a function of water content, higher
source in cluster #1 until 1983, and
surface diffusion of 1e-6 m2/s.

Figure 4.4_1 Comparison of Revision #1 best fit to the best fit of Section 4.3

presented below in Table 3. The last four rows in this table give results that are quite similar, leading us to conclude that the most important second order effects are diffusion as a function of saturation (D*(sat) , Henrys Law partitioning between soil moisture and pore-gas, and increased historical source strength. D*(sat) appears to have a more positive effect on the Base Case, however all of the best fit cases from Revision #1 include Henrys partitioning. The final case in the table is the best fit from Revision #1 and is shown in Figure 4.4_1.

Table 3: Goodness of fit statistics: Examining second order effects

Simulation	points failing the cut-off	r^2 (log) %
Base Case (BC)	25	91.3
BC with fixed zero concentration boundaries (Best Fit of the initial simulations)	11	92.6
Simulations in support of Revision #1	-----------	--------------
BC + Henrys	31	93.0
BC + higher early source	29	93.0
BC + D*(sat)	20	91.6
BC + D*(sat) + higher early source	29	91.8
BC + Henrys + surface flux reduction	21	92.4
BC + Henrys + higher early source	11	96.6
BC + Henrys + D*(sat)	9	97.0
BC + Henrys + higher early sources + D*(sat)	11	97.0
BC + Henrys + higher early sources + D*(sat) + surface flux reduction	8	97.3

4.5 Future work

As LANL acquires increased understanding of the subsurface, we will continue to update the conceptual and numerical models of VOC transport at MDA L. One major task waiting to be accomplished is the creation of an average data set for use in comparison with model results. Currently we are comparing to only one quarter of data and have not had funding to incorporate all relevant quarters of data. Additionally, the model currently does not explain low measured concentrations in the upper ports of wells 1015 and 1016. Fitting this data will require a more sophisticated conceptual model that may include higher local infiltration based on topographic gradients [Stauffer et al., 2000]. We have also created a high resolution grid of the site with six embedded well bores. We plan to use the high resolution grid to explore remediation and closure options once the Technical Advisory Group has recommended an appropriate technology.

Modeling of potential remediation will require examination of the effects of fractures on local flow paths and thier potential to short circut a passive venting system.

5.0 - CONCLUSIONS

The site numerical model is calibrated using the pore-gas data gathered at MDA L. The model demonstrates that diffusive behavior captures the general characteristics of the vapor plume. The base-case diffusion coefficient of $4x10^{-6}$ m^2/s fits the data better than either $1x10^{-6}$ or $8x10^{-6}$ m^2/s. A goodness-of-fit analysis is used to determine the model that best fits the data. The best-fit simulation maintains a zero concentration boundary in the subsurface basalt unit and along the northern and western boundary of the model. Also, no liquid source is used, in agreement with field observations.

The observed site data and simulated results indicate that the vapor plume is currently at a near steady condition, both in size and in concentration. The constant flushing of the plume at the mesa sides and in the deep basalt should maintain the plume at its current size until the liquid source, which remains in buried drums, has been exhausted. Therefore, we do not expect that the vapor plume will spread any closer to White Rock or to the deep aquifer than its current location. Also, because no migration of liquid is thought to occur, we do not expect that VOCs can travel as liquids to the deep aquifer either. Estimates based on a conservative TCA source predict that the plume will start to shrink when the source is depleted, before the year 2060.

The site numerical model also shows that the asphalt cover at MDA L acts as a non-diffusive barrier that forces VOCs to migrate downward and laterally to reach pathways to the atmosphere. Little or no flux emanates from the asphalt itself, but enhanced flux from the mesa top to the atmosphere occurs around the edges of the asphalt. This predicted behavior agrees qualitatively with the surface flux measurements also gathered at the site. In the future, the site model will provide a useful tool for exploring the effects of potential corrective measures, such as venting and/or removing the asphalt cover at MDA L.

The agreement of the numerical model with the pore-gas and surface flux data indicates that the monitoring program has successfully defined both the nature and extent of the vapor plume at MDA L. The simulations show that both current and future plume growth (over the next 50 years) are quite small. These results, combined with the recent observations of slowly changing pore-gas concentrations, indicate that pore-gas monitoring could be performed less frequently than the current three-month interval. Yearly monitoring should be sufficient to capture any changes in the plume. In fact, the simulation of catastrophic drum failure predicts that the results of such an event would be apparent in the monitoring data for several years. Therefore, yearly monitoring is not only capable of capturing the current rate of plume growth, it should also be capable of detecting a large perturbation, such as a drum burst.

Revision #1 shows that second order effects can help to improve the match between the data and the model. Furthermore, the second order processes remove the need to fix zero concentration boundaries to achieve data/model correlation. The r^2 correlation coefficient (in log space) was improved from a value of 0.926 to 0.973 by including second order processes. The most important second order processes were diffusion as a function of saturation, inclusion of Henrys Law, and changes in source strength through time. These three processes interact in a complex manner making it difficult to determine which is the dominant driver. Surface flux reduction due to boundary layer effects had less of an impact on the data/model correlation. This revision helps to show that our conceptual model is appropriate for this site, and also suggests that the conclusions drawn from the initial report are still valid.

6.0 - ACKNOWLEDGEMENTS

This work was supported by the LANL Environmental Restoration Project for the U.S. Department of Energy. The authors would like to thank Veraun Chipman for his help with data visualization. We would also like to thank David Rogers, Bryan Travis, Diana Hollis, and Dennis Newell for their reviews of this manuscript.

Revision #1 was helped greatly by the input of an external review committee including Steve Webb, Joe Rossabi, Bruce Thomson, Marilyn Gruebel, John Kupar, Malcom Siegel, Mike Smith, and Eliza Frank.

7.0 - REFERENCES

Birdsell, K.H., W.E. Soll, K.M. Bower, A.V. Wolfsberg, T. Orr, T.A. Cherry, (1997). “Simulations of Groundwater Flow and Radionuclide Transport in the Vadose and Saturated Zones Beneath Area G, Los Alamos National Laboratory,” Los Alamos National Laboratory manuscript LA-13299-MS.

Bishop, C.W., (1991). “Hydrologic Properties of Vesicular Basalt,” Masters thesis, University of Arizona.

Boas, M.L. (1983), Mathematical Methods in the Physical Sciences, Wiley, New York.

Broxton D.E., and Reneau, S.L., (1995) Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory, Los Alamos National Laboratory manuscript LA-13010-MS.

Freeze, R.A., Cherry, J.A. (1979), Groundwater, Prentice-Hall, NJ, USA.

Fetter, C.W. (1999), “Contaminant Hydrogeology”, Prentice-Hall, NJ, USA.

Fuentes, H.R., W.L. Polzer, and J. L. Smith, (1991). “Laboratory Measurements of Diffusion Coefficients for Trichloroethylene and Orthoxylene in Undisturbed Tuff”, J. Environ. Quality, 20, p. 215-221.

Gardner, J.N., F. Goff, S. Garcia and R.C. Hagan (1986). “Stratigraphic Relations and Lithologic Variations in the Jemez Volcanic Field, New Mexico,” J. of Geophysical Research 91, 1763-1778.

George, D. (1997). Unstructured Toolbox for Modeling and Simulation, LA-UR-97-3052, presented at the 1997 Workshop on Computational Electronics and Nanoelectronics, Urbana, Illinois, October 20-22, 1997.

Griggs, R.L. (1955). Geology and Groundwater Resources of the Los Alamos Area, New Mexico, U.S. Geologic Survey Report to the U.S. Atomic Energy Commission.

Jury, W.A., D. Russo, G. Streile, and H. Abd, (1990). “Evaluation of Volatilization by Organic Chemicals Residing Below the Soil Surface”, Water Resources Research, 26(1) p. 13-20.

Krier, D., P. Longmire, R. Gilkeson and H.J. Turin, (1997). “Geologic, Geohydrologic, and Geochemical Data Summary of MDA G, Technical Area 54, Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-95-2696.

LANL (1999). “Material Disposal Areas Core Document,” Los Alamos National Laboratory draft report LA-UR-99-4423.

LANL (2000). “RFI Report for Material Disposal Areas G, H, and L at Technical Area 54,” Los Alamos National Laboratory report LA-UR-00-1140.

Lyon, B.F., Holmes, J.A., Kosiewicz, S.T., Wilbert, K.A., Travis, C.C. (1996). Estimation of corrosion on carbon steel TRU waste drums using Poisson distribution, J. Hazardous Materials, 51, p. 165-179.

Meisher and Anderson (1994)., Ambient monitoring of Volatile Organic Compounds at Los Alamos National Laboratory in TA54, Areas G and L, LANL doc. 63525.

Millington, R.J., (1959), Gas diffuision in porous media. Science, 130:100-102.

Neeper, D.A. (1997). "Monitoring Pore Gas Pressure and Chemical Constituents at Wells 54-1015 and 54-1016 during 1995 and 1996," SEA-SF-TR-97-170.

Purtymun, W.D., (1995). "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory manuscript LA-12883-MS.Rogers, D.B., (2000). "Conceptual Model for Vapor Movement at MDAs," Los Alamos National Laboratory document LA-UR-00-950.

Reneau, S.L., D.E. Broxton, J.S. Carney, and C. LaDelfe (1998), Structure of the Tshirege Member of the Bandelier Tuff at Mesita del Buey, Technical Area 54, Los Alamos National Laboratory, Los Alamos National Laboratory manuscript LA-13538-MS

Rogers, D.B., and B.M. Gallaher, (1995). "The Unsaturated Hydraulic Characteristics of the Bandelier Tuff," Los Alamos National Laboratory manuscript LA-12968-MS.

Smith, R.L. and Bailey, R.A. (1966). "The Bandelier Tuff: A Study of Ash-Flow Eruption Cycles and Zoned Magma Chambers," Bulletin of Volcanology 29, 83-104.

Smith, J., Hardesty, B., McCranie, N. (1999a), Quarterly Pore Gas Sampling at TA-54 MDA L and MDA G First Quarter FY1999, PMC-LA-99-002.

Smith, J., Hardesty, B., McCranie, N. (1999b), Quarterly Pore Gas Sampling at TA-54 MDA L and MDA G Second Quarter FY1999, PMC-LA-99-003.

Smith, J., Crocker, J., McCranie, N. (1998), Quarterly Pore Gas Sampling at TA-54 MDA L and MDA G Second Quarter FY1998, PMC-LA-98-009.

Stauffer, P. H., B.A. Robinson, and K.H. Birdsell (2000), Modeling transport in Los Alamos Canyon : effects of hypothetical increased infiltration after the Cerro Grande Fire, Los Alamos National Laboratory document, LA-UR-00-5923

Turin, H.J., (1995). "Subsurface Transport Beneath MDA G: A Conceptual Model," Los Alamos National Laboratory document LA-UR-95-1663.

Trease, H., George D., Gable C. W., J. Fowler, A. Kuprat, A. Khamyaseh (1996), The X3D Grid Generation System Numerical Grid Generation in Computational Fluid Dynamics and Related Fields, B. K. Soni, J. F. Thompson, H. Hausser and P. R. Eiseman, Engineering Research Center, Mississippi State Univ. Press.

Trent, B., (1992), "Analysis of the Pore Gas Monitoring at Area L, TA-54 Los Alamos National Laboratory," Los Alamos National Laboratory document.

Trujillo, V., Gilkeson, R., Morgenstern, M., Kreir, D. (1998), Measurements of Surface Emission Flux Rates for Volatile Organic Compounds at TA-54, LA-13329-MS.

van Genuchten, M.T., (1980). "A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," Soil Science Society of America Journal 44, 892-898

Vaniman, D., G. Cole, J. Gardner, J. Conaway, D. Broxton, S. Reneau, M. Rice, G. WoldeGabriel, J. Blossom, and F. Goff, (1998). "Development of a Site-Wide Geologic Model for Los Alamos National Laboratory," Los Alamos National Laboratory unpublished document.

Zyvoloski, G.A., B.A. Robinson, Z.V. Dash, and L.L. Trease, (1997). "Summary of the Models and Methods for the FEHM Application - A Finite Element Heat- and Mass-Transfer Code," Los Alamos National Laboratory manuscript LA-13307-MS.

Appendix J

Summary Report: Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L

EM U.S. Department of Energy
Office Of Environmental Management

SUBSURFACE CONTAMINANTS FOCUS AREA

ITRD

Innovative Treatment & Remediation Demonstration Program

Summary Report:
Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L

October 2002

Editors:
Marilyn Gruebel
Nirmala Khandan
Bruce Thomson

This report was produced for the U.S. Department of Energy with funding from the Office of Environmental Management's Subsurface Contaminants Focus Area Technical Assistance Program by:

Sandia National Laboratories, Albuquerque, New Mexico

For more information on this project, please contact:

Malcolm Siegel, Sandia National Laboratories, 505-844-5426

SAND2002-
Unlimited Release
Printed October 2002

Distribution
Category UC-

Innovative Treatment & Remediation Demonstration Program Summary Report:

Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L

Editors:
Marilyn Gruebel, Sandia National Laboratories
Nirmala Khandan, New Mexico State University
Bruce Thomson, University of New Mexico

Abstract

From June 2001 through September 2002, the Innovative Technology and Remediation Demonstration (ITRD) Program conducted an evaluation of possible remediation technologies at the DOE Los Alamos National Laboratory (LANL) in New Mexico. For ten years (1975 to 1985), LANL disposed of liquid chemical wastes at Material Disposal Area L. Large amounts of the liquid waste have volatilized to create a plume of organic vapor in the subsurface. A Technical Advisory Group (TAG) was formed from the ITRD Program to assess two issues—the conceptual modeling previously performed by LANL Environmental Restoration (ER) and remediation options for the site. The goal of the project was to evaluate a corrective measure strategy proposed by LANL ER, passive venting, with respect to other corrective measures. Although the TAG did not recommend a particular technology, it concluded that, based on LANL's vapor transport modeling, soil vapor extraction is a reasonable remediation method that is likely to be successful. The TAG also provided a more general recommendation: LANL ER and the New Mexico Environment Department should continue to work together to identify the regulatory requirements that will affect the design and implementation of the soil vapor remediation process at MDA L.

Acknowledgments

The ITRD Summary Report on Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L was funded by the United States Department of Energy, Office of Environmental Management (EM). Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

The ITRD Technical Advisory Group for this project acknowledges the contributions made by the following individuals in support of this effort:

John Hopkins, Los Alamos National Laboratory

Kay Birdsell, Los Alamos National Laboratory

David Cobrain, Hazardous Waste Bureau, New Mexico Environment Department

Neelam Dhawan, Hazardous Waste Bureau, New Mexico Environment Department

Eliza Frank, Hazardous Waste Bureau, New Mexico Environment Department

Marilyn Gruebel, Sandia National Laboratories

Ken Kisiel, SEA/Los Alamos National Laboratory

Dan Levitt, SEA/Los Alamos National Laboratory

Bill Lowry, SEA/Los Alamos National Laboratory

Don Neeper, SEA/Los Alamos National Laboratory

Dennis Newell, SEA/Los Alamos National Laboratory

Phil Stauffer, Los Alamos National Laboratory

Woody Woodworth, Los Alamos Area Office, U.S. Department of Energy

Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185-0720

October 2002

ITRD
LANL TA54 MDA L Technical Advisory Group

One of the purposes of the ITRD program is to provide an independent evaluation of remediation approaches and applicable technologies on a site-specific basis. The “target audience” for ITRD reports includes both the specific site’s Technical Advisory Group, which includes DOE site project managers, M&I/O scientists and engineers, regulators, public stakeholders, and technology experts, and also interested parties with similar challenges at other sites throughout the DOE complex. The intent of the program is to provide technical assistance by developing treatment and deployment information on potentially useful innovative technologies, and to make recommendations in conjunction with all of the parties to a remedial action decision. It has been demonstrated that this inclusive process can help build consensus on a site’s eventual technology selection and treatment approach.

Because the ITRD process is inclusive and seeks to present information to all interested parties in a fair manner, the *Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L* Summary Report includes a series of comments and responses in Appendix C between members of the Technical Advisory Group and LANL Environmental Restoration personnel involved with the project.

Several exchanges of comments and responses resulted in no substantial changes to the original Technical Advisory Group findings and recommendations from the draft May 2002 reports, but some text was modified to provide clarification in the context of continued discussion and more recent work. Inclusion of the comments and responses in Appendix C seeks to indicate that there was a diversity of opinion over some issues that was not resolved within the Technical Advisory Group report.

Marilyn Gruebel
ITRD LANL Projects Technical Lead

Innovative Treatment and Remediation Demonstration (ITRD) Summary Report: Conceptual Model Review and Remediation Options for Los Alamos National Laboratory Technical Area 54, Material Disposal Area L

CONCEPTUAL MODELING SUBTEAM

Nirmala Khandan (Subteam Chair)
New Mexico State University
Las Cruces, New Mexico

Joe Rossabi
Savannah River Technology Center
Aiken, Georgia

Mike Smith
TechLaw, Inc.
Atlanta, Georgia

Steve Webb
Sandia National Laboratories
Albuquerque, New Mexico

REMEDIATION OPTIONS SUBTEAM

Bruce Thomson (Subteam Chair)
University of New Mexico
Albuquerque, New Mexico

John Kupar
TechCon Program, Argonne National Laboratory
Argonne, Illinois

Joe Rossabi
Savannah River Technology Center
Aiken, Georgia

Malcolm Siegel
Sandia National Laboratories
Albuquerque, New Mexico

CONTENTS

FIGURES

[This page intentionally left blank]

EXECUTIVE SUMMARY

From June 2001 through September 2002, the Innovative Technology and Remediation Demonstration (ITRD) Program conducted an evaluation of possible remediation technologies at the DOE Los Alamos National Laboratory (LANL) in New Mexico. For ten years (1975 to 1985), LANL disposed of liquid chemical wastes, including uncontained liquid waste and liquid waste contained in drums at Material Disposal Area L (MDA L). Large amounts of the liquid waste, which were disposed of in pits, impoundments, and shafts, have volatilized to create a plume of organic vapor in the subsurface. Testing indicates volatile organic compounds (VOCs) disposed of at this site include 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), trichlorotriflouroethane (FREON), and lesser amounts of chloroform, toluene, benzene, cyclohexane, methyl chloride, and other similar solvents.

A Technical Advisory Group (TAG) was formed from the ITRD Program to assess two issues—the conceptual modeling previously performed by LANL Environmental Restoration (ER) and remediation options for the site. The goal of the project was to evaluate a corrective measure strategy proposed by LANL ER, passive venting, with respect to other corrective measures. The specific objectives of the TAG were: (1) review the site characterization data and conceptual modeling for the contaminant plume at MDA L, (2) screen remediation technologies to determine those with direct applicability, and (3) identify the most appropriate technology or technologies for remediation of the contaminant plume at MDA L. The criteria used in this evaluation included technical, regulatory, and public acceptability.

Although the TAG did not recommend a particular technology, it concluded that, based on LANL's vapor transport modeling, the proposed soil vapor extraction strategy is a reasonable remediation method that is likely to be successful. However, additional data would significantly improve the understanding of the extent and movement of the subsurface vapor plume. The TAG recommended collection of additional information on vapor flux to the water table and on surface vapor flux. Because a site-specific design has not yet been selected for MDA L, the TAG was unable to evaluate cost-effectiveness, environmental safety and health risk reduction for workers, and safety and risk reduction for the public and the environment.

The TAG also provided a more general recommendation: LANL ER and the New Mexico Environment Department should continue to work together to identify the regulatory requirements that will affect the design and implementation of the soil vapor remediation process at MDA L. In particular, the following regulatory requirements need to be identified to allow comparison of specific vapor extraction technologies: off-gas emission requirements, process monitoring requirements for soil vapor extraction, contaminant plume monitoring requirements, required soil vapor cleanup levels, final monitoring requirements, acceptable public and worker risk levels, and public participation requirements.

ACRONYMS

DNAPL	dense non-aqueous-phase liquid
DOE	Department of Energy
EPA	Environmental Protection Agency
ER	Environmental Restoration
FREON	trichlorotriflouroethane
GC	gas chromatography
IR	infrared
ITRD	Innovative Technology and Remediation Demonstration
LANL	Los Alamos National Laboratory
LNAPL	light non-aqueous-phase liquid
LUST	leaking underground storage tank
MDA L	Material Disposal Area L
NMED	New Mexico Environment Department
PESP	Pilot Extraction Study Project
RBCA	risk-based corrective action
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SVE	soil vapor extraction
TA	Technical Area
TAG	Technical Advisory Group
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
VOC	volatile organic compound

1. INTRODUCTION

Based on a request from Los Alamos National Laboratory (LANL), the Innovative Technology and Remediation Demonstration (ITRD) program established a Technical Advisory Group (TAG) to conduct a peer review for a project dealing with remediation options for Material Disposal Area L (MDA L) in Tech Area 54 at LANL. During the second half of 2001, the TAG received background materials provided by the Site Project Manager and briefings from LANL Environmental Restoration (ER) project members. The TAG held its meeting on December 12, 2001, in Pojoaque, New Mexico. At the beginning of the meeting, the TAG was introduced to the ITRD process and the desires of LANL ER and the U.S. Department of Energy (DOE) for an independent peer review. Two subteams of experts were formed to review specific issues: one to review the conceptual modeling previously performed by LANL ER and another to evaluate remediation options for the site. Based on subsequent conference calls and analysis, the TAG prepared this report.

The goal of this project is to assess a corrective measure proposed by LANL ER, passive venting, with respect to other possible corrective measures. The specific objectives are as follows:

1. Review the site characterization data and conceptual modeling for the contaminant plume at MDA L.
2. Screen remediation technologies to determine those with direct applicability to MDA L.
3. Recommend the most viable technology or technologies for remediation of the contaminant plume at MDA L.

The Conceptual Modeling subteam addressed Objective 1. The Remediation Options subteam addressed Objectives 2 and 3. This report combines the work of the two subteams.

Section 2 of this report provides background information on MDA L. Section 3 identifies the criteria that were used to review the conceptual modeling and the remediation options. Sections 4 and 5 summarize the findings and recommendations of the two subteams. Section 6 provides biographical information about the subteam members.

Appendices A and B contain the analyses conducted by the Conceptual Modeling and Remediation Options subteams, respectively, and the results of their evaluations. Appendix C contains comments and responses about issues that were not fully resolved in the TAG report.

2. BACKGROUND INFORMATION ON MDA L

Los Alamos National Laboratory is located in Los Alamos County in north-central New Mexico, approximately 97 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Figure 1). LANL occupies an area of about 112 km^2 (43 mi^2) located directly south of the town of Los Alamos. LANL is situated on the Pajarito Plateau, which lies between the Jemez Mountains and White Rock Canyon of the Rio Grande River. The Bandelier Tuff, a thick sequence of ash-flow and air-fall pyroclastics, caps the Pajarito Plateau. Erosion of the relatively soft tuff created numerous deep canyons that separate narrow, finger-like mesas. MDA L is a 2.58-acre site on top of Mesita del Buey, within TA-54, that was historically used as a disposal site for laboratory-generated hazardous (non-radioactive) wastes. Land disposal stopped in 1985. It is presently used for RCRA-permitted hazardous waste storage and treatment and for mixed waste storage under interim status authority.

Figure 1. Location of Los Alamos National Laboratory

2.1 LANL MDA L PLUME

From 1975 to 1985, LANL disposed of liquid chemical wastes, including uncontained liquid waste and liquid waste contained in drums, in pits, impoundments, and shafts at MDA L. Large amounts of the liquid waste have volatilized to create a plume of organic vapor in the subsurface. Testing indicates volatile organic compounds (VOCs) disposed of at this site include 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), trichlorotriflouroethane

(FREON), and lesser amounts of chloroform, toluene, benzene, cyclohexane, methyl chloride, and other similar solvents.

2.2 MDA L SITE BACKGROUND

Violent eruptions of volcanic ash from the Valles Caldera between 1.2 and 1.6 million years ago deposited tuff layers in the LANL area. Since then, the tuff has eroded to leave a system of alternating finger-shaped mesas and canyons. MDA L is located atop one such mesa, Mesita del Buey, with the waste disposed in shallow pits (4 m or 13 ft deep) and shafts (approximately 20 m or 66 ft deep). The surrounding canyons, Canada del Buey and Pajarito Canyon, lie 30 m (98 ft) below the steep-sided mesa, and the regional aquifer is located approximately 300 m (984 ft) below the disposal pits. The strata immediately below MDA L are composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs interbedded with thin pumice beds. The rhyolitic units overlie a thick basalt unit, which in turn overlies a conglomerate formation (Figure 2).

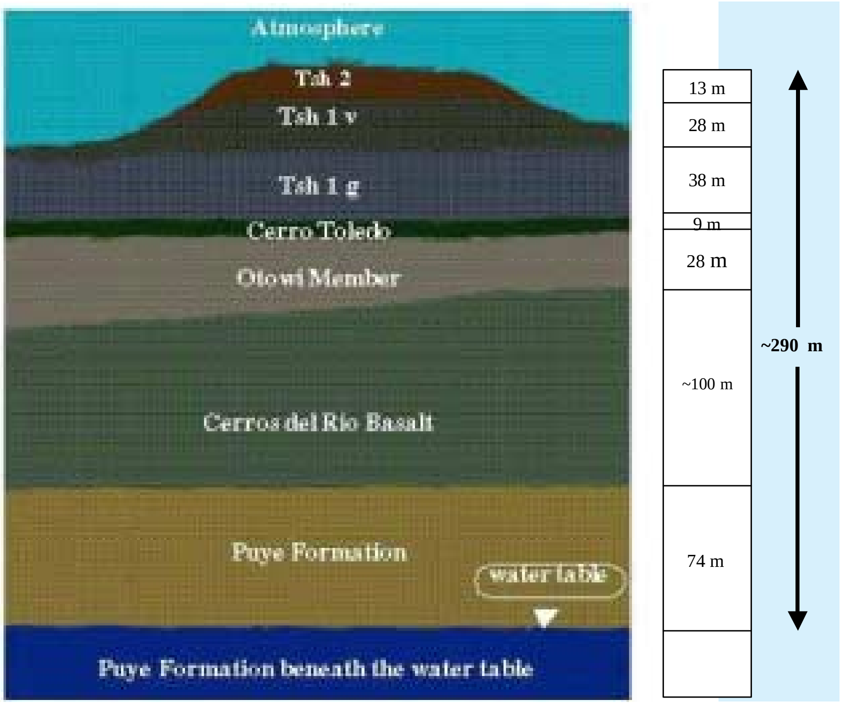


Figure 2. Generalized Cross-Section at Los Alamos National Laboratory

LANL has conducted quarterly sampling at MDA L since 1990, monitoring the pore gas in the VOC plume resulting from the disposal of liquid waste. The pore gas monitoring provided sufficient data for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to estimate the nature and extent of the VOC vapor plume at MDA L. Rock samples from boreholes as deep as 92 m (300 feet) indicated no condensed liquid VOC or sorption of organic compounds on the matrix. This observation was consistent with expectations based on the absence of organic carbon, low moisture content, and low specific surface area of the matrix.

As part of the RFI, LANL ER conducted a Pilot Extraction Study Project (PESP) to examine both active and passive vapor extraction with the goal of reducing the size of the VOC vapor plume. LANL gained extensive experience with vapor venting in Bandelier Tuff during the PESP and the RFI investigation at MDA L. During active vapor extraction, the vapor moved at the same velocity as the pore gas, showing no retardation. The absence of retardation was expected due to the absence of condensed liquid VOC. In the PESP, LANL measured both the *in situ* horizontal permeability as a function of depth at several boreholes and the penetration of barometric pressure variations within the Bandelier tuff and the underlying Cerros del Rio basalt. Data analysis shows that, in one stratigraphic unit, vertical gas motion is dominated by fracture flow. LANL also measured the flow in open boreholes that is induced by barometric pressure variations. Close agreement of the data with theory indicates that the flow into and out of a borehole is governed by the horizontal permeability as measured *in situ*, and is reduced by the vertical penetration of barometric pressure variations into the earth from ground surface. Sites with extensive pavement (such as in MDA L) may be slower to respond to atmospheric pressure variations, thereby enhancing the vapor flow in a borehole that is open to the atmosphere.

3. PEER REVIEW CRITERIA

The two subteams developed criteria for reviewing the LANL MDA L conceptual model and the remediation options. Section 3.1 lists the criteria for the conceptual model review; Section 3.2 provides the criteria for the remediation options evaluation.

3.1 CRITERIA FOR CONCEPTUAL MODELING REVIEW

The TAG assessed LANL ER's conceptual modeling based on the following review criteria:

1. Has the Site Project Team adequately reviewed the pertinent, current technical literature in this area?
2. Are the conclusions cited in their reports supported by the work performed?
3. Have the practical limits of detection been determined in terms of minimum and maximum depth, plume size, and type of contaminant being detected?
4. Do site conditions offer any unique opportunities or constraints in terms of characterization or modeling?
5. Has the Site Project Team collected sufficient data to respond to regulatory, stakeholder, and risk evaluations?
6. Have the technical uncertainties associated with the model been adequately identified and addressed?
7. Does the model adequately represent the field data?

3.2 CRITERIA FOR REMEDIATION OPTIONS ANALYSIS

The TAG assessed the options for remediation at the site based on the following review criteria:

1. Has the Site Project Team adequately reviewed the pertinent, current technical literature in this area?
2. Is the Site Project Team's proposal for remediation a logical extension of existing technology?
3. Do site conditions offer any unique opportunities or constraints in terms of characterization or remediation?
4. Have the technical uncertainties associated with the application of this technology been adequately identified and addressed?
5. Is there a clear path shown towards measuring the success of the technology?
6. Does this technology show a clear benefit in terms of (a) cost effectiveness, (b) environmental safety and health risk reduction for workers, and (c) safety and risk reduction for the public and the environment?
7. Has the Site Project Team collected sufficient data to respond to regulatory, stakeholder, and risk evaluations?

8. Based on the overall assessment of the site proposal, should it be initiated? If not, what remediation technology should be used and why?

4. FINDINGS OF THE PEER REVIEW SUBTEAMS

Sections 4.1 (Conceptual Modeling) and 4.2 (Remediation Options) contain findings of the Peer Review Subteams. Background information for the findings is described in more detail in Appendix A (Overview of the Conceptual Model) and Appendix B (Summary of Remediation Technologies). Some of the findings in Section 4.1 generated considerable discussion between LANL ER and the Conceptual Modeling Subteam. Several exchanges of comments and responses have resulted in no substantial changes to the original TAG findings from the draft May 2002 reports, but some text has been modified to provide clarification of the findings in the context of the continued discussion and more recent work. The comments and responses are included in this report as Appendix C to indicate that there was a diversity of opinion that was not resolved within the TAG report.

4.1 CONCEPTUAL MODELING

The conceptual model of the site is by nature a historically inclusive snapshot in time that must evolve as additional accurate information is added to the current site data set. The information that improves the conceptual model is often additional measurements but can also include application of more accurate theoretical behavior of the modeled system or inclusion of results from numerical simulations using the mathematical description of the system dynamics in the numerical model. The conceptual model is the most important construct for characterizing and remediating a contaminated waste site and should be as accurate as possible; however, the development of the conceptual model cannot supercede the primary goal of remediating of the site.

The TAG recognizes that, ultimately, the conceptual model must provide the framework for making correct decisions for the next step on the path to site remediation. If the correct decisions can be made from a scientific basis at a particular time, the conceptual model has served its purpose even though the model may include elements that are not precisely descriptive of the physical behavior of the system. It is important to maintain the perspective of improving the accuracy of the model in the context of cleaning up the site.

The TAG has reviewed the work of the LANL ER project team and agreed with their general conclusions on choices for site remediation and the general conceptual model used to select those choices. The TAG has also identified some areas and made some recommendations for potentially improving the conceptual model of the site.

1. In most areas, the Site Project Team has adequately reviewed the pertinent, current technical literature. The areas lacking are:
    a. Surface flux including modeling of the boundary layer. The model for the boundary layer is very simplistic and will influence the surface flux of TCA and the plume size. This topic is discussed in more detail as Recommendation 2 in Section 5.1.
    b. Vapor-solid sorption. Vapor-solid sorption can be important for TCE as experimentally investigated by Ong and Lion (1991) for Bandelier tuff. However, their data indicate that it will only be significant when the moisture content is less than about 1-2%. The minimum *in situ* moisture content is about 2%, with the majority of the units having moisture contents of 10% or greater (Stauffer et al,

2000). Therefore, the TAG does not believe it will play a significant role in this case. However, we recommend that the phenomenon at least be acknowledged and discussed rather than ignored.

   c. *In situ* degradation. The TAG does not recall any discussion of *in situ* degradation of the plume. Of course, neglecting degradation would be conservative.

   d. Gas diffusion model. The gas diffusion model is based on Fick's law. For low permeability media, it is well known that Fick's law is inadequate due to the influence of gas-solid interactions and coupling between diffusive and advective effects (Webb, 1998). It is recommended that the permeability of the various units be listed. If the values are greater than 10^{-13} m^2 (1.1×10^{-12} ft^2), Fick's law is adequate. If the permeabilities are lower than 10^{-13} m^2 (1.1×10^{-12} ft^2), an alternative model such as the Dusty Gas Model should be employed (Webb and Pruess, 2002). The site project team subsequently reviewed the permeability of the sediments and found that the majority of the sediments were greater than 10^{-13} m^2 (1.1×10^{-12} ft^2).

   e. Diffusion coefficient. The diffusion coefficient used in the conceptual model is for gas only; liquid diffusion is neglected. As discussed in Jury et al., 1984a, the effective diffusion coefficient may be influenced by the liquid diffusion value even at low values of moisture content, depending on the value of Henry's constant. The effective diffusion coefficient should be evaluated.

2. The conclusions cited in Site Project Team reports are adequately supported by the work performed.

3. In some instances, determinations of the practical limits of detection are insufficient. While the best-fit simulation shows that the vapor plume is unlikely to reach the water table, the vertical extent of the plume as illustrated by field data is not presented in the report. Two issues are of concern:

   - The New Mexico Environment Department (NMED), the U.S. Environmental Protection Agency (EPA) Region 6, and the public may require site-specific data before they accept that the vapor plume has not and will not reach the water table; and
   - While the imposition of a zero concentration condition appears justified, its exact location as determined by field data or a comparison of modeling results to field data is not known.

   Installation of deeper wells capable of providing concentration data at the bottom of the plume is recommended. Data from such wells will directly address the first concern and can also be used to refine the modeling of transport processes at the bottom of the plume.

   At the time the report was written, no core sample measurements were available for the Cerros del Rio Basalts (Figure 2). Therefore, the numerical model was formulated using a surrogate porosity and a modeled saturation value. Further refinements to the numerical simulations can be realized if property measurements can be made on the basalts via the deep wells.

4. Site conditions offer some unique features in terms of characterization and modeling. Some of the units are known to have fractures, yet the conceptual model developed by Stauffer et al., 2000, is a porous media approach without fractures. Because many of the

fractures are vertical, they would enhance the vertical migration of the plume and could conceivably increase the calculated migration of the plume.

5. LANL ER has collected a considerable amount of site characterization data, much of it directly related to constructing the site conceptual model, responding to anticipated regulatory and stakeholder concerns, and understanding risks associated with site remediation. However, LANL ER should be aware that, in at least a couple of situations, the data may be considered insufficient by regulators and stakeholders. For example, the depth of the plume is not adequately defined, and the predicted surface flux of the contaminants seems inconsistent with the data.

6. Many of the technical uncertainties associated with the model have been adequately identified and addressed. The diffusion model was selected for this site after analysis of the available site characterization data and in consideration of the magnitude of the plume, the objectives of the model (determine a remediation strategy and predict gross behavior of the plume), and the complexity of the geology. In general the model seems to predict the current characterization data set. There are, however, some technical uncertainties that need to be addressed, such as the boundary layer modeling and the effect of fractures on plume growth or dissipation, and contaminant transport.

   The conceptual model described in (Stauffer et al., 2000) does not provide sufficient background information regarding

   a. Surface flux predictions. The surface flux predictions by the model are based on two assumptions that need to be further justified.

      The first one is the thickness of the boundary layer. The model assumes this to be 1 m (39 in) thick: What is the basis for this assumption?

      The second one is the overall mass transfer coefficient or diffusion coefficient used in this calculation.

   b. Treatment of fractures. It has been reported that some of the geological units at the MDA L are vertically fractured, which can enhance the release of the vapors. The manner in which fractures are included in the conceptual model needs to be described in more detail or evaluated further.

7. The model seems to give reasonable answers compared to the field data. However, some of the details are insufficiently explained, and some additional data or modeling studies are needed. Appendices to the Stauffer report (Stauffer et al., 2000) of the available concentration data would be useful. The current model can be used to select and implement some remediation field tests and develop general strategies for contaminant control and remediation. The current model can also be used to focus the next set of characterization data needs and identify areas for more refined numerical modeling.

4.2 REMEDIATION OPTIONS

1. The subteam believes the Site Project Team has adequately reviewed the pertinent, current technical literature in the area. Given the conceptual model based on the characterization data to date, they have reviewed the available remedial alternatives and have focused on strategies that are likely to be successful. These are generally technologies based on either active or passive soil vapor extraction (SVE).

2. The Site Project Team's proposal for remediation is a logical extension of existing technology. However, specific aspects of the technology and the configuration of the cleanup have not been determined. There are techniques within SVE that could be used, but these are yet to be determined.
3. Site conditions at MDA L offer unique opportunities in terms of characterization and remediation. Site characterization data indicate that air is found in the formation below the mesa and flows upward. This effect produces a zero-boundary condition for contaminant concentrations. LANL has already used these characteristics in their modeling, but they may also be able to capitalize on this condition for cleanup opportunities.
4. LANL ER has addressed some of the technical uncertainties associated with the application of this technology. Soil vapor extraction is commercially available and appropriate for this application, and it is the presumptive cleanup remedy of the EPA. However, the Site Project Team has not yet provided a formal proposal for the technology design. Soil vapor extraction has been tried in various modes and it will work, but the exact configuration for MDA L has not been determined. Some of the specific aspects of SVE that must be considered are
   - Passive/active venting
   - Off-gas treatment
   - Surface flux
   - Type of mass removal to be achieved
   - Location (impact on site operations)
   - Risk assessment
   - Specific design parameters
5. The subteam believes that LANL ER will be unable to measure the success of the technology until the regulator and the site reach consensus on clear performance metrics. LANL ER undertook this project even though quarterly monitoring and sampling indicate the vapor plume at MDA L poses no current threat to either human health or the environment. LANL ER and the NMED need to work together to identify the regulatory requirements that will guide the process. One possibility is a risk-based corrective action (RBCA) study showing the remaining contaminant sources are below some threshold after the bulk of the contaminants have been removed.
6. The technology was examined to evaluate benefits in terms of (a) cost effectiveness and (b) environmental safety and health risk reduction for workers and safety and risk reduction for the public and the environment:
   - The technology screening performed by this subteam (see Appendix A) indicates that SVE is generally a cost-effective cleanup remedy. However, for application to MDA L, the overall cost will depend on the technology design, which has not yet been determined for MDA L.

    - Soil vapor extraction has been used safely and successfully in many different applications. However, for application to MDA L, the overall safety and risk will depend on the technology design. Some general comparisons to alternatives may provide insight into general risks, such as comparisons to excavating the source and comparisons between active and passive systems with respect to disruptions in site operations. Risk and safety may also depend on choices of system components, such as the strategy for off-gas treatment.

7. The Site Project Team has collected sufficient data to adequately support most of its conceptual modeling assumptions and its proposal for remediation. However, additional data collection for a few parameters could strengthen the site’s case for using SVE. For example, additional data could be collected for
    - Flux to the water table (also an NMED concern)
    - Surface flux to the atmosphere
8. Based on site characterization data and modeling for the site, the subteam believes the Site Project Team proposal to use SVE at MDA L should be initiated. However, the subteam can give only a qualified endorsement until it has an opportunity to examine the site-specific design for MDA L.

5. RECOMMENDATIONS

Sections 5.1 (Conceptual Modeling) and 5.2 (Remediation Options) contain the recommendations of the Peer Review Subteams. Some of the recommendations in Section 5.1 generated considerable discussion between LANL ER and the Conceptual Modeling Subteam. Several exchanges of comments and responses have resulted in no substantial changes to the original TAG recommendations from the draft May 2002 reports, but some text has been modified to provide clarification of the recommendations in the context of the continued discussion and more recent work. The comments and responses are included in this report as Appendix C to indicate that there was a diversity of opinion that was not resolved within the TAG report.

5.1 CONCEPTUAL MODELING

Based on a careful assessment of the information presented to the TAG and the findings developed in response to the review criteria, the Peer Review Subteam provides the following recommendations:

1. Surface emission measurements. The TAG has agreed that the quarterly monitoring at TA 54 MDA L can be relaxed. However, the TAG recommends that additional surface flux measurements be made, preferably by perforating the impermeable cap at some locations. The rationale for this recommendation is as follows:

   It is being proposed by the Remediation Sub-committee of TAG to use the conceptual model in evaluating and designing remediation alternatives. Before the model can be used for this purpose, it needs to be further validated. Previous validations have compared measured subsurface vapor phase concentrations and surface emissions against model predictions.

   While the agreement between measured and predicted subsurface concentrations were reasonable, there were notable differences between the corresponding surface fluxes. By perforating the cap, two "data points" can be obtained to further calibrate and/or validate the conceptual model: sampling of the gas phase concentration as well as measurement of the flux.

   In response to the original TAG report on the conceptual model (Appendix A to this report), Don Neeper of LANL suggested that CO_2 measurements could be correlated to VOC emissions due to barometric pumping. This is a reasonable approach; however, the correlation between CO_2 emissions and VOC emissions has to be first demonstrated.

   A further benefit of surface flux measurements will be in risk evaluation that is being recommended by the two subteams of the TAG.

   The parameters used in the model to predict the surface emissions (viz. the boundary layer thickness and the diffusion coefficient) need to be re-evaluated (see Recommendation 2 below).

2. Surface flux. The size of the contaminant plume, including whether or not the plume continues to grow or shrink, is based on a balance between the estimated source of the

contaminants and the loss to the atmosphere, or the surface flux. Therefore, the surface flux is a significant factor in the long-term behavior of the plume.

The modeled surface flux is based on a porous media diffusion coefficient and a 1-m (39-in) transition to a zero concentration in the atmosphere, or boundary layer. This approach is extremely simplified. A more accurate representation of the boundary layer thickness is suggested by Jury et al. (1984b) to be typically 0.5 cm (0.2 in), although values can range up to 1 m (39 in) for very low wind speeds and stable conditions (Webb et al., 1999). The diffusion coefficient should also be that for open conditions, not for a porous media, which would tend to increase flux to the atmosphere.

Surface flux measurements that were made at x discrete points showed much lower flux (up to 300 times less) than indicated by the model. The discrepancy raises concern with the accuracy of the model. However, these measurements were not made according to standard methods for quantitative flux measurement and were made at a limited number of locations. Given the natural and anthropogenic heterogeneities of the surface and shallow subsurface, it is likely that these small numbers of flux measurements are not representative of an average flux over the waste site area. They are therefore of limited value in model validation. Further model runs were completed using reduced surface flux values (similar to those measured), which provided dramatically different plume shape and extent results that conflicted with subsurface gas concentration measurements. Given the larger data set and higher accuracy of the subsurface concentration measurements, it is important that the model faithfully simulate these data. Nevertheless, since the growth of the plume is significantly affected by the value of surface flux, efforts should be made to devise a strategy for quantifying this parameter.

To more closely represent the dynamics of the surface/subsurface processes, it is recommended that the model be modified in the future to correct boundary behavior and that additional quantitative flux measurements eventually be made to reconcile and verify the model. These recommendations would be appropriately implemented to support work on the selection of remedial alternatives.

3. Presence of Fractures. Some of the units are known to have fractures, yet the conceptual model developed by Stauffer et al., 2000, is a porous media approach without fractures. This approach may be justified if the fractures are filled with porous media. However, if the fractures are of a higher permeability than the bulk formation and because many of the fractures are vertical, they could enhance downward vertical migration of the plume or increase flux of the contaminant out through the surface.

   Apparently vertical fractures are mainly found in the welded section of TSH Unit 2 and much less commonly below; therefore these fractures may not impose a significant additional plume migration risk. However, it is recommended that the effect of fractures on plume migration and potential remedial strategies be investigated when evaluating the selection of remedial alternatives.

4. Alternative Methods for Gas Sampling and Analysis at MDA L Site. The TAG recommends continuing to acquire more concentration data at the site using inexpensive but accurate field screening or simple laboratory techniques to support the selection of remedial alternatives as well as to evaluate the effectiveness of the performance of the remediation technique.

To obtain a more accurate conceptual model of the subsurface contamination at the MDA L site, more soil gas measurements are required. Current protocol calls for analysis using Summa Canister collection and contract lab analysis by EPA protocol. This procedure is expensive and not well suited for obtaining a better conceptual understanding of the gas plume at the site. To understand the dynamic behavior that is characteristic of subsurface contaminant gas phase plumes, many inexpensive measurements would be most useful. There are a variety of field and local laboratory (i.e., on site or mobile lab) gas sampling and analysis methods available for deployment. These methods range from standard laboratory methods brought to the field (e.g., gas chromatography/mass spectrometry) to simple detectors sensitive primarily, but not exclusively, to the species of interest (e.g., photoionization detectors, portable acoustic wave sensors, chemiresistors, etc.). Any of these methods may be appropriate depending on the analytes in the gas stream, the detection levels required, the frequency of measurement, etc.

LANL site personnel have been using a method that falls between these types of sensors (Innova Model 1312 infrared photoacoustic spectrometer). This instrument is species selective based on the infrared absorption spectrum of the target analyte(s). The instrument is capable of simultaneously and accurately measuring concentrations of 5 different species so long as their infrared spectra have no significant overlaps. The instrument is capable of detecting gas concentrations of the species of interest (volatile chlorinated organic compounds) to approximately 1 ppmv and can cover a dynamic range that approaches the vapor pressure limits of many of the compounds. It is also capable of semi-continuous monitoring (every 1 to 4 minutes) and unattended field deployment. Comparisons of the instrument with the baseline gas chromatography (GC) methods show that the Model 1312 is at least as stable, repeatable, and accurate as GC. One significant issue that may affect the selection of this technology for gas sampling and analysis at a site is the error introduced by analytes with interfering infrared (IR) spectra. Even low concentrations of some compounds with rich IR absorption spectra may affect accurate analyses of species with nearby IR peaks. Some of the freon compounds (Freon 11, 12, and 113) have particularly rich IR spectra and can interfere with measurements of PCE, TCE, and TCA. Freons have been detected at MDA L, and the site has performed measurements comparing results from the B&K Model 1312 and baseline Summa canister gas chromatography. The comparisons show a strong correlation between the two analytical methods for the contaminants of concern (TCA and TCE). The B&K model 1312 is therefore a satisfactory technique for tracking plume behavior.

Other gas analysis technologies may also be suitable for the characterization and monitoring needs of the site and should be evaluated on the basis of the data objectives of the owners, regulators, and other stakeholders of the site.

Some percentage of split samples should be sent for analysis by the baseline method to ensure the analysis performed using an alternative technique to the baseline protocol is an adequate representation. Often, the ratio of alternative method to baseline analyses is 90:10. For the MDA L, the ratio of alternative method samples to baseline may be more or less depending on the performance of the method, the characteristics of the gas sample, the number of samples needed and other issues decided by a consensus of the site and regulators.

5.2 REMEDIATION OPTIONS

Based on a careful assessment of the information presented to the TAG and the findings developed in response to the review criteria, the Peer Review Subteam provides the following eight recommendations. The supporting details for the recommendations are included in Appendix B.

Site Hydrogeologic Conditions and Contaminant Distribution

1. Identify a small number of extraction well configurations, perhaps three alternatives each for an active system and three for an atmospheric pumping system, and use the model to evaluate contaminant removal from the subsurface environment for each of these alternatives.
2. Due to the large body of knowledge that has already been collected (as discussed in Appendix B), additional pump testing of vapor extraction wells is not needed at this site.

Characterization of the Source Term

3. Perform a corrective measures study to determine the feasibility of removing the waste materials from the disposal shafts or stabilize them in place.
4. The remedial system design should include consideration of future drum burst events and provide assurance that contaminant release does not pose an excessive risk to human health and the environment.

Nature of Site Operational Activities

5. Technical Area (TA)-54 site managers should be contacted and asked to identify facility operations that might be impacted by an SVE system. A map of the site should be prepared which delineates structures or areas that cannot have wells, piping or SVE equipment located near them. Areas where site personnel spend large amounts time should also be identified so that the system design can minimize work place hazards.
6. Once a preferred SVE option has been determined, TA-54 site managers should review the plan and the construction phasing to be sure that its impact on site operations will be acceptable. As construction progresses, this coordination should be maintained.

Regulatory Constraints

7. LANL and NMED should continue to work together and identify the regulatory requirements that will affect the design and implementation of the soil vapor remediation process at TA-54. In particular, the following information must be identified: off-gas emission requirements, SVE process monitoring requirements, contaminant plume monitoring requirements, required soil vapor cleanup levels, final monitoring requirements, acceptable public and work risk levels, and public participation requirements.

Cost

8. LANL should conduct a design study that includes variations of the SVE remediation process—specifically, the use of active, passive, and combinations of the two vapor

extraction methods along with active or passive soil gas flushing (clean air or other). Each design should incorporate all of the components needed to comply with regulatory requirements including off-gas emission treatment as needed. The length of time needed to achieve site remediation or achieve the consensus environmental goals (e.g., limit flux to the receptors) should be determined for each. The annualized and total costs of each alternative and the benefit with respect to the goals should be determined and used in selection of a final remediation process.

6. BIOGRAPHICAL SUMMARIES OF THE MEMBERS OF THE PEER REVIEW SUBTEAMS

N. Nirmala Khandan (Subteam Chair) [NMSU] - N. Nirmala Khandan, Ph.D., P.E., is a Professor of Environmental Engineering at the New Mexico State University in Las Cruces, NM. He received his undergraduate degree in mechanical engineering from the University of Ceylon, Sri Lanka and his graduate degrees (M.S. & Ph.D.) in environmental engineering from Drexel University, Philadelphia, PA. Dr. Khandan has had over ten years of turnkey engineering experience in system designs, project implementation, R&D services in water supply and treatment and has had consulting appointments with over twenty-five U.S. industrial, chemical municipal, biotechnical, environmental, and consulting companies. He has also served internationally – training, presenting papers, giving workshop/short-course presentations, and demonstrating pilot research projects throughout the world. Dr. Khandan has co-written over fifty journal articles and twenty-six-conference proceedings. Amongst the many awards and recognitions that he has received are the following: Founders Award for the Outstanding Research Paper published in Water Research (1991), Instructor, General Motors Distance Education Program (1998) and El Paso Natural Gas Foundation Faculty Achievement Award (1996); and Bromilow Award for Outstanding Research (2001) at New Mexico State University.

John Kupar [TechCon] - John M. Kupar (B.S., Geology and Economics, Syracuse University, June 1979) has over 17 years of experience in international and domestic environmental project implementation with emphasis on technical management and project development. Several of the technologies he has successfully deployed include; *in situ* and *ex situ* chemical fixation, thermal desorption, groundwater treatment, wetlands treatment, and dredging. His current interests include the characterization and remediation of contaminated sediments. Since 2000, he has served as a staff member of Argonne National Laboratory's Environmental Assessment Division where he supports the Department of Energy's TechCon program. In this role, he provides technical assistance to DOE environmental restoration project teams in the identification and selection of environmental technologies. Mr. Kupar is a registered Professional Geologist in the Commonwealth of Pennsylvania.

Joe Rossabi [SRTC] - Joe Rossabi is a fellow engineer in the Environmental Sciences and Technology Division of the Savannah River Technology Center where he performs applied research and development of environmental characterization and remediation technologies and strategies. His research involves field-testing and implementation of cone penetrometer-based characterization and remediation methods, multiphase flow processes including dense non-aqueous phase liquid (DNAPL) fate and transport, and passive methods for characterization and remediation of subsurface contaminants. Dr. Rossabi was part of a team that deployed a cone penetrometer-based spectral gamma probe to characterize the Cesium plume at the R Reactor Seepage Basin site at SRS. He was also the principal investigator of Department of Energy projects that successfully developed innovative DNAPL characterization methods and implemented barometric pumping for subsurface characterization and remediation of volatile contaminants. Rossabi has numerous publications on subsurface characterization and remediation and has served on national committees (DOE and EPA) to review characterization and sensing technologies. Before coming to the Savannah River Technology Center eleven years ago, Rossabi performed research and development in the areas of laser communications and atmospheric transmission and spectroscopy for Bell Laboratories in Holmdel, NJ, and a defense contractor in McLean, VA. He has a Ph.D. in Environmental Engineering from Clemson University, an MS in Environmental Engineering from the University of North Carolina at Chapel Hill, and MS and BA degrees in Physics from the State University of New York at Binghamton.

Malcolm Siegel [SNL] - Dr. Malcolm D. Siegel (BA, Chemistry, Columbia University; MA, Ph.D., Geological Sciences, Harvard University) is the Technical Coordinator of the Innovative Treatment Remediation Demonstration program and a Principal Member of the Technical Staff at Sandia National Laboratories. He has had over 21 years of research and project management experience involving geochemical laboratory studies, reactive transport simulations, and performance assessment calculations in support of the Waste Isolation Pilot Plant program, the proposed Yucca Mountain high level nuclear waste repository, design of reactive treatment zones and studies of natural attenuation. He is the author of over 45 scientific articles, chapters and peer-reviewed reports.

Mike Smith [TechLaw, Inc.] - As an environmental engineer and researcher, Mr. Smith possesses 21 years of experience in the analysis and modeling of transport processes, the assessment of human health and environmental risks, and the collection and analysis of worker health and safety information. For the past eleven years, Mr. Smith has performed analyses related to human health and ecological risk assessments ranging from the dispersion and deposition of constituents emitted from open burn/open detonation processes to the impact of hazardous constituents on indoor air quality. He has reviewed a variety of multi-media/multi-pathway risk analyses submitted to EPA under RCRA and CERCLA. He has conducted permit reviews and analyses and presented training information in support of EPA's RCRA program. Current areas of concentration include dispersion modeling of air emissions and the assessment of human health and environmental risks for hazardous waste combustion units.

Bruce Thomson (Subteam Chair) [UNM] - Bruce Thomson is a Professor in the Department of Civil Engineering at the University of New Mexico. He has a B.S. degree in Civil Engineering from the University of California at Davis, and M.S. and Ph.D. degrees in Environmental Science and Engineering from Rice University, Houston, TX. He is a registered Professional Engineer in the State of New Mexico. His research interests focus on the chemical behavior and treatment of radioactive and inorganic water contaminants in both surface and ground water systems. He has worked onremediation of contamination from uranium mining and milling activities, biological transformation of arsenic and other metals, development of treatment technologies for arsenic removal, evaluation of point-of-use treatment systems, and estimation of the costs of treatment. He was a member of the National Research Council's Committee on Mixed Waste and is currently a member of the NM Mining Commission, the City of Albuquerque Technical Standards Comm

Steve Webb [SNL] - Stephen W. Webb is from Sandia National Laboratories in Albuquerque, New Mexico. He is a Principal Member of the Technical Staff in the Environmental Technology Department and received his Ph.D. in Mechanical Engineering from Lehigh University where he specialized in heat transfer and fluid flow modeling and analysis. He has performed fluid flow and heat transfer research in such varied fields as nuclear reactor accident analysis, gas flow in porous media, the effect of weather boundary conditions on transport in soil, explosive chemical movement in soil, natural convection in underground caverns and repositories, and plume dispersion in the atmosphere. He has over 75 publications including journal articles and conference proceedings.

7. REFERENCES

Jury, Spencer, and Farmer, 1984a, “Behavior Assessment Model for Trace Organics in Soil: II. Chemical Classification and Parameter Sensitivity,” J. Environ. Quality, 13:567-572.

Jury, Spencer, and Farmer, 1984b, “Behavior Assessment Model for Trace Organics in Soil: IV. Review of Experimental Evidence,” J. Environ. Quality, 13:580-586.

Ong, S.K., and L.W. Lion, 1991, “Effects of Soil Properties and Moisture on the Sorption of Trichloroethylene Vapor,” Wat. Res., 25:29-36.

Stauffer, P., K. Birdsell, M. Witowski, T. Cherry, and J. Hopkins, 2000, “Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions,” Technical Report LA-UR-00-2080, Los Alamos National Laboratory, Los Alamos, NM.

Webb, S.W., 1998, “Gas-Phase Diffusion in Porous Media – Evaluation of an Advective-Dispersive Formulation and the Dusty Gas Model for Binary Mixtures,” J. Porous Media, 1:187-199.

Webb, S.W., and K. Pruess, 2002, “Evaluation of Fick’s Law for Trace Gas Diffusion in Porous Media,” submitted to Transport in Porous Media.

Webb, S.W., K. Pruess, J.M. Phelan, and S.A. Finsterle, 1999, “Development of a Mechanistic Model for the Movement of Chemical Signatures From Buried Landmines/UXO,” Proceedings of SPIE Conference on Detection and Remediation Technologies for Mines and Minelike Targets IV, April 5-9, 1999, Orlando, Fl.

APPENDIX A: OVERVIEW OF THE CONCEPTUAL MODEL

OF SUBSURFACE VAPOR-PHASE PLUMES AT TA54- MDA L AT LANL

ITRD Conceptual Modeling Subteam
Dr. Nirmala Khandan, Chair

Executive Summary

Evaluation of the alternatives for restoration of the Material Disposal Area L, (MDA- L) in Technical Area 54 (TA54) is an Innovative Treatment and Remediation Demonstration (ITRD) project at Los Alamos National laboratory (LANL). The major concern at this site has been identified to be organic solvent vapors in the subsurface resulting from disposal of mixed liquid wastes during 1975 -1985. Under LANL's Environmental Restoration Project, extensive sampling and pilot extraction studies have been undertaken at this site to-date; a conceptual model to characterize the subsurface plume has also been developed.

In mid-2001, a Technical Advisory Group (TAG) was formed by ITRD to provide technical assistance in the selection of remedial actions for MDA L. The specific goals of the TAG are to evaluate the site and assess passive and active venting versus other applicable technologies to remediate the site. The first meeting of TAG was held in Dec 2001. The objectives of this meeting were to provide background information on the project to TAG members; to review the conceptual model; and to identify innovative technologies that could be adapted at MDA L.

This report is a follow-up to the TAG's first meeting, documenting the discussions relating to the conceptual model developed by LANL's Environmental Restoration Project Group. Included in this report are: the background to the contamination at MDA- L TA 54 as it relates to the conceptual model; the reasons for developing the model; the simplifying assumptions behind the model; the modeling approach; model simulation results; and conclusions and suggestions.

Background

The MDA L facility has been receiving hazardous and radioactive liquid wastes from the late 1950s until its closure in 1986. Up to 1975, the materials were disposed of in bulk liquid form in open pits, allowing high vapor pressure constituents to evaporate into the atmosphere. From 1975 onwards, organic liquids were disposed of in a series of 20-m (65-ft) deep shafts, ranging in diameters from 1 m to 2 m (3 ft to 6 ft). The bottom of these shafts were ~300 m (~980 ft) above the regional aquifer. These shafts received organic liquids in free liquid form as well as in containerized form. Upon closure, most of the 2.5 acres of the site were covered with asphalt.

Based on the analysis of core samples and pore gases at the site, the following conclusions have been made:

- 34 disposal shafts are the Potential Release Sites (PRS) at MDA L;

- free organic liquid is not found below the shafts;
- sorbed organics are not found below the shafts;
- pore gases are contaminated with volatile organic compounds (VOCs);
- the VOC vapor plume has migrated over 100 m (330 ft) laterally from the shafts;
- the total mass of VOCs in the plume is approximately 1000 kg (2200 lbs);
- the primary constituents of the plume are 1,1,1-trichloroethane (75%); trichloroethene (12.5%); and Freon (11%).

The conceptual model was built upon the above conclusions; hence the validity of the conceptual model is highly dependent upon these conclusions.

Reasons for Modeling

A mathematical model of MDA L at TA 54 may be a valuable tool for one or more of the following functions:

- to analyze the current state of the plume
- to evaluate sensitivity of characteristics of the medium and/or contaminants
- to predict the state of the plume in the future
- to predict surface fluxes and emissions
- to optimize sampling and monitoring
- to evaluate impacts of catastrophic releases
- to evaluate the effectiveness of alternate remediation technologies

Mathematical models are approximations of the real world. They are constructed based on (1) simplifying assumptions; (2) understanding of the processes involved; and (3) the characteristics of the medium and the contaminants. It is, therefore, prudent to make appropriate and valid assumptions in developing the model. It is also necessary to calibrate and validate the model using past data from the site to justify the assumptions, so that the model can be used confidently for predictive purposes.

Assumptions in Modeling

Based on historic data as well as pore gas and core sampling data obtained at site, the following simplifying assumptions have been made in developing the conceptual model for MDA L at TA 54:

- Infiltration is negligible and the subsurface is therefore unsaturated.
- Since 75% of the plume averaged over 140 sampling locations is 1,1,1-trichloroethane (TCA), it is chosen as the target contaminant.
- Since the maximum observed concentration of TCA (~ 3,400 ppmv) is almost two orders of magnitude less than its vapor pressure (~150,000 ppmv), and 170 core samples from

18 boreholes did not reveal any liquid form, no free liquid form of VOCs is present anywhere within the model boundaries.

- Barometric pumping is included in the model as enhanced diffusion, with no air flow through the bulk soil medium.
- Since no air flows through the bulk soil medium, transport of the VOC vapors within the model boundaries is by diffusion only and not by advection.
- The contaminants are nonreactive (as demonstrated in a study at UNM).

Modeling Approach

The conceptual model for MDA L at TA 54 is a 3-D finite element formulation based on conservation of mass. Following the assumptions listed above, the general advective-diffusive transport equations reduce to a diffusion equation in this case. The model requires inputs for soil and contaminant characteristics; contaminant sources; and numerical discretization and appropriate boundary conditions.

Soil and contaminant characteristics:

The subsurface at the site has been simplified into seven stratigraphic units. The primary hydrogeologic properties relevant to the conceptual model are the porosity and the saturation; the transport property is the diffusion coefficient. The values used in the model are tabulated below.

Unit	**Thickness** [m]	***In situ* Saturation** [–]	**Effective Porosity** [–]	**Effective Diffusion Coefficient** [10^{-6} m^2/s]
Unit 2	13	0.05	0.48	4
Unit 1v	28	0.04	0.51	4
Unite 1g	38	0.2	0.48	4
Cerro	9	0.3	0.473	4
Otowi	28	0.25	0.435	4
Cerros del Rio Basalts	104	0.25	0.23	4
Puye Formation	74	0.25	0.25	4

The shafts, asphalt cover, and the uncovered surfaces are modeled with the following base characteristics:

Unit	**Effective Porosity** [–]	***In situ* Saturation** [–]	**Effective Diffusion Coefficient** [m^2/s]
Shafts	0.5	0.05	4.0E-06
Asphalt Cover	0.5	0.05	1.0E-14
Uncovered Surfaces	0.48	0.05	4.0E-06

The porosity and saturation values for the Puye Formation are estimated. Corresponding values for the basalt are from similar soils studied elsewhere. All other hydrogeologic data had been measured at site from core samples. Diffusion coefficient for TCA vapor measured on core samples of Bandelier Tuff at TA 54 is used for all the units. A value for the diffusion coefficient in asphalt was assumed.

To evaluate the reliability of the above data, sensitivity analyses were conducted by running the model at various values around the above base values. The model results were relatively insensitive to the properties of the Puye Formation and the basalt.

Contaminant sources:

Based on historic data, one pit, three surface impoundments, and 34 disposal shafts had been in use at MDA L for varying purposes over varying periods of time. Out of these, the surface pit and impoundments had not received any organic liquids; the 34 shafts are known to have received organic liquids, in pure liquid form as well as in containerized form. Hence, only the shafts are included in the model as contaminant sources. Shafts 1 through 28 were in operation from 1975 through 1985; shafts 29 to 34 were in operation from 1983 through 1985.

In the model, organic liquids are assumed to leak slowly from the containers (55-gal drums) and volatilize immediately. The migration of the vapors through the subsurface is modeled as a time-release phenomenon. Because of the coarse node spacing in the model, each shaft is not identified as an individual source; rather, they are grouped into two clusters: cluster #1 with shafts 1 through 28, and cluster # 2 with shafts 29 through 34.

Typical model simulations begin in 1975 with a constant TCA concentration of 3,000 ppmv in cluster # 1; the simulation is then paused in 1983, and cluster # 2 is added, with a constant TCA concentration of 3,000 ppmv; simulations are then continued till 1985, at which point the asphalt cover is added to the model by changing the diffusion coefficient at the surface.

Numerical discretization and boundary conditions:

The model domain is rectangular in plan view, 411 m (1350 ft) in the east-west direction and 290 m (950 ft) in the north-south direction. Vertically, the model domain extends from the land surface to below the water table. The top surface is modeled after the topography of the site while the bottom surface is horizontal. The volume of model domain is 43 x 10^6 m^3 (1.5 x 10^9 ft^3). The node spacing is set at 15.24 m (50 ft) in both horizontal directions; in the vertical direction, it varies from 1 m to 15.24 m (3 ft to 50 ft). These spacings were chosen to achieve a reasonable computation time, with a total of 25,456 nodes and 147,438 tetrahedral elements.

At the top boundary, the atmosphere is fixed at a constant temperature of 10ºC (50ºF) and a pressure of 0.078 Mpa (1630 lb/ft^2). The TCA concentration at the nodes above the surface is fixed at zero. The bottom boundary is set as a no flow boundary, at a constant temperature of 25ºC (77ºF). The vertical side boundaries are set as no flow boundaries.

Model Simulation Results

The conceptual model has been run under various conditions for calibration, validation, and sensitivity analyses. Model results have been compared against observed data in terms of TCA concentrations and surface fluxes.

TCA concentrations:

Following accepted practice, a modified percentage error and an outlier deletion algorithm have been proposed to demonstrate the goodness of fit between the predicted and observed TCA concentrations. Measured data from the second quarter of FY 99 were used to compare against the model predictions. After deleting 29 data points from a total of 142, a reasonable agreement ($R = 0.84$) was found between measured data and the model predictions with baseline input data.

The best fit between simulation results and measured data was found for the following conditions: zero TCA concentration along the north and west boundaries, and the basalt unit at all times. When compared on the basis of amount of TCA in the subsurface as a function of time, the results predicted with base line data indicate that the system will taker longer than the best fit simulation to reach steady state. Also, it will result in a larger mass of TCA in the subsurface. This result is as expected because of the zero-concentration boundary conditions imposed for the best fit simulations.

Surface flux:

Surface concentrations predicted by the base line model were used to estimate surface flux assuming a D value of 4×10^{-6} m^2/s (4.3×10^{-5} ft^2/s) and a transition zone of 1 m (39 in) thick. The predicted flux was about 300 times greater than the measured flux (0.1 kg/m^2 yr vs. 0.00034 kg/m^2 yr [0.02 lb/ft^2 yr vs. 0.00007 lb/ft^2 yr]). A simple estimate of the flux assuming a TCA concentration of 1000 ppmv, however, results in a flux of 0.144 kg/m^2 yr (0.03 lb/ft^2 yr) with the same D value. This anomaly has been ascribed to rain fall during the sampling period.

Conclusions and Suggestions

The TCA concentrations predicted by the model are in reasonable agreement with the measured data. Thus, the basic assumptions upon which the model has been constructed, as well as the boundary conditions and the model inputs seem to be appropriate for MDA L at TA 54. Consequently, the model can be used with confidence for predicting future state of the TCA plume as well as the effectiveness of any remedial actions.

The best fit model indicates that the plume is currently reaching near steady state conditions, implying that the mass of TCA released by the sources is balanced by the atmospheric emissions. This condition is expected to last until 2060, when all the liquid TCA will be depleted; thereafter, the plume will begin to shrink. Based on this prediction, subsurface sampling frequency may be reduced.

The development of a statistical technique to demonstrate that the plume is not growing is recommended. Ways to estimate mass of TCA in the plume using the measured data are also recommended. In addition, monitoring of emissions, instead of subsurface sampling, may be beneficial in further validating the model.

[This page intentionally left blank]

APPENDIX B: SUMMARY OF REMEDIATION TECHNOLOGIES

DEVELOPED FOR HALOGENATED VOLATILE ORGANIC COMPOUNDS AT LANL TECHNICAL AREA 54

ITRD Remediation Subteam
Dr. Bruce Thomson, Chair

Introduction

Los Alamos National Laboratory (LANL) has developed a proposed process for remediating volatile organic compound (VOC) contamination from unsaturated formations at Technical Area (TA) 54, Material Disposal Area (MDA) L. The contaminants of concern principally consist of chlorinated solvents including tetrachloroethene (PCE), trichloroethene (TCE),1,1,1-trichloroethane (TCA) and vinyl chloride (VC). Lesser amounts of other solvents, freons and other contaminants were also disposed at this site (LANL, 2001a). The contaminated formations are primarily unsaturated soils and volcanic tuff in which the contaminants are believed to be present in the vapor phase and adsorbed to soil materials; no phase separated liquid is believed to be present. Four sites within TA 54 are contaminated. Details of the site geology, hydrology, and extent of contamination were presented at a meeting on 12/12/01 of the Innovative Treatment and Remediation Demonstration (ITRD) project team. Additional information has been summarized on a CD-ROM prepared by LANL (2001b).

The remediation strategies proposed by LANL focus on passive and active extraction of subsurface soil gas. Much work has been conducted to model vapor phase transport at this site to support this strategy (Stauffer, et al. 2000). In addition, some field scale pilot testing has been performed to develop preliminary estimates of the performance of potential vapor extraction alternatives (Neeper, 2001).

One of the objectives of the ITRD process is to evaluate innovative technologies in the context of existing and more established remediation methods. Significant experience has been gained over the past 15 years in remediation of soil and ground water contamination from chlorinated aliphatic hydrocarbons (CAH or halogenated VOCs) such as those present at TA-54 MDA-L. The objective of this paper is to identify other options that have been used for remediating unsaturated soils contaminated with halogenated VOCs and briefly to consider their applicability at LANL.

Methods

It is beyond the scope of the ITRD program or this evaluation to provide a review of all candidate technologies that might have application at LANL. Instead, the Technical Advisory Group (TAG) used a remediation technologies screening matrix that was originally developed by the U.S. Environmental Protection Agency (EPA) and U.S. Air Force in 1993 (US EPA, 1993) and has subsequently been updated and revised twice. The most recent version (Van Deuren et al, 1997) was revised by the Federal Remediation Technologies Roundtable consisting of representatives from the EPA, Department of the Energy, Department of the Interior, Department of Defense, Department of the Air Force, Department of the Army, and the Department of the Navy. An on-line version of this report is available at http://www.frtr.gov/matrix2/top_page.html. The remediation technologies screening matrix identifies processes that have been used to clean up contaminated soil and ground water with some degree of success. The technologies are briefly described, and information is presented to assist in evaluating them for potential application at a site. This review considers only technologies that are applicable to remediation of unsaturated formations contaminated with halogenated VOCs, which is the situation at TA-54.

The evaluation described in this document is based on application of the remediation technologies screening matrix by Van Deuren et al. (1997). Information on the geology and hydrology of the TA-54 MDA L site, on the nature of contaminants and on the extent of the plume was provided to the ITRD and is in the references cited.

Review of the Remediation Technologies Screening Matrix

Van Deuren et al. (1997) identified 14 categories of treatment technologies for soil and ground water remediation. They are:

(For soil, sediment, and sludge:)

- *In situ* biological treatment
- *In situ* physical/chemical treatment
- *In situ* thermal treatment
- *Ex situ* biological treatment (assuming excavation)
- *Ex situ* physical/chemical treatment (assuming excavation)
- *Ex situ* thermal treatment (assuming excavation)
- Containment
- Other treatment processes

(For ground water, surface water, and leachate:)

- *In situ* biological treatment
- *In situ* physical/chemical treatment
- *Ex situ* biological treatment (assuming pumping)
- *Ex situ* physical/chemical treatment (assuming pumping)
- Containment

Air emissions/off-gas treatment

64 technologies were considered in the remediation technologies screening matrix. A brief description of each treatment technology is presented at the beginning of each process description. The information provided for each technology includes the following:

Technology Profile number (refers to Section 4)
Scale status (full scale vs. pilot scale)

Availability
Residuals produced
Typical treatment train
Contaminants treated
System reliability/maintainability
Cleanup time
Overall cost
Capital or operation-and-maintenance (O&M) intensive

A brief description of each treatment technology is presented at the beginning of each process description. The technologies applicable to remediation of halogenated VOCs are listed in Table 1. Explanations of the terms in the table are presented in Table 2 and Table 3.

Table 1. Treatment Technologies Screening Matrix: Treatment of halogenated volatile organic compounds (numbers refer to technologies described by Van Deuern et al., 1997)**.**

Technology	Devel. Status	Use Rating	Applicability	Reliability	Cleanup Time	Function
SOIL, SEDIMENT AND SLUDGE						
3.1 *IN SITU* BIOLOGICAL TREATMENT						
4.1 Bioventing	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
4.2 Enhanced Biodegradation	Full	Limited	Better	Refer to profile	Refer to profile	Destruct
4.3 Land Treatment	Full	Limited	Better	Refer to profile	Refer to profile	Destruct
4.4 Natural Attenuation	Full	Limited	Refer to profile	Refer to profile	Worse	Destruct
4.5 Phytoremediation	Pilot	Limited	Average	Average	Worse	Destruct
3.2 *IN SITU* PHYSICAL/CHEMICAL TREATMENT						
4.6 Electrokinetic	Full	Limited	Average	Average	Average	Destruct
4.8 Soil Flushing	Pilot	Limited	Better	Average	Long	Extract
4.9 Soil Vapor Extraction	Full	Wide	Better	Better	Average	Extract
4.10 Solidication/ Stabilization	Pilot	Limited	Better	Below Average	Average	Extract/ Destruct
3.3 *IN SITU* THERMAL TREATMENT						
4.11 Thermally Enhanced SVE	Full	Limited	Average	Better	Worse	Extract
3.4 *EX SITU* BIOLOGICAL TREATMENT (ASSUMING EXCAVATION)						
4.12 Biopiles	Full	Limited	Better	Better	Average	Destruct
4.13 Composting	Full	Limited	Better	Better	Average	Destruct
4.15 Landfarming	Full	Limited	Better	Better	Worse	Destruct
4.16 Slurry Phase Bio. Treatment	Full	Limited	Better	Average	Average	Destruct

Technology	Devel. Status	Use Rating	Applicability	Reliability	Cleanup Time	Function
3.5 *EX SITU* PHYSICAL/CHEMICAL TREATMENT (ASSUMING EXCAVATION)						
4.17 Chemical Extraction - Solvent Extraction	Full	Limited	Average	Below Average	Worse	Extract/ Destruct
4.18 Chemical Reduction/ Oxidation	Full	Limited	Average	Better	Better	Destruct
4.19 Dehalogenation	Full	Limited	Average	NA	NA	Destruct
4.21 Soil Washing	Full	Limited	Average	Average	Better	Extract
4.22 Soil Vapor Extraction	Full	Limited	Better	Better	Average	Extract
4.23 Solar Detoxification	Pilot	Limited	Better	Average	Average	Destruct
4.24 Solidification/ Stabilization -Vitrification/ Molten Glass	Full	Limited	Average	Better	Short	Extract/ Destruct
3.6 *EX SITU* THERMAL TREATMENT (ASSUMING EXCAVATION)						
4.26 Incineration	Full	Wide	Better	Average	Better	Destruct
4.28 Pyrolysis	Full	Limited	Average	Inadequate	Better	Destruct
4.29 Thermal Desorption (High & Low)	Full	Wide	Better	Average	Better	Extract
3.8 OTHER TREATMENT						
4.32 Excavation and Off-Site Disp.	NA	Limited	Average	Better	Short	Extract/ Immob.
GROUND WATER, SURFACE WATER AND LEACHATE						
3.9 *IN SITU* BIOLOGICAL TREATMENT						
4.33 Co-Metabolic Treatment	Pilot	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
4.34 Enhanced Biodegradation	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
4.35 Natural Attenuation	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
4.36 Phytoremediatin	Pilot	Limited	Average	Better	Worse	Extract/ Destruct
3.10 *IN SITU* PHYSICAL/CHEMICAL TREATMENT						
4.38 Air Sparging	Full	Limited	Better	Better	Better	Extract
4.39 Bioslurping	Full	Limited	Average	Average	Average	Destruct
4.41 Dual Phase Extraction	Full	Limited	Better	Average	Average	Extract
4.42 Fluid Vapor Extraction	Full	Limited	Better	Average	Average	Extract
4.43 Hot Water or Steam Flush/Strip	Pilot	Limited	Average	Worse	Better	Extract
4.45 In Well Air Stripping	Pilot	Limited	Better	Better	Average	Extract
4.46 Passive Treatment Walls	Full	Limited	Better	NA	Worse	Destruct
3.11 *EX SITU* BIOLOGICAL TREATMENT (ASSUMING PUMPING)						
4.47 Bioreactors	Full	Limited	Better	Average	Average	Destruct
3.12 *EX SITU* PHYSICAL/CHEMICAL TREATMENT (ASSUMING PUMPING)						
4.50 Air Stripping	Full	Wide	Better	Better	Average	Extract
4.51 Liquid Phase Carbon Adsorp.	Full	Wide	Better	Better	Better	Extract
4.54 Separation	Full	Limited	Better	Average	Better	Extract

Technology	Devel. Status	Use Rating	Applicability	Reliability	Cleanup Time	Function
4.56 UV Oxidation	Full	Limited	Better	Worse	NA	Destruct
3.13 CONTAINMENT						
4.57 Deep Well Injection	Full	Wide	Average	Average	NA	Immob.
4.58 Ground Water Pumping	Full	Limited	Average	Better	NA	Extract
4.59 Slurry Walls	Full	Limited	Average	Better	Better	Immob.
AIR EMISSIONS/OFF-GAS						
3.14 AIR EMISSIONS/OFF-GAS						
4.60 Biofiltration	Full	Limited	Refer to profile	Refer to profile	Better	Extract/ Destruct
4.61 High Energy Corona	Pilot	Limited	Better	Worse	NA	Destruct
4.62 Membrane Separation	Pilot	Limited	Better	Worse	NA	Extract
4.63 Oxidation	Full	Wide	Better	Better	NA	Destruct
4.64 Vapor Phase Carbon Adsorp.	Full	Wide	Better	Better	NA	Extract

[b] Presumptive remedy - A presumptive remedy is a technology EPA believes, based on its past experience, generally will be the most appropriate remedy for a specified type of site. EPA established presumptive remedies to accelerate site-specific analysis of remedies by focusing the feasibility study efforts. EPA expects a presumptive remedy, when available, will be used for all Comprehensive Environmental Response Compensation Act (CERCLA) sites except under unusual circumstances.

NA = Not Available.

NOTE: Specific site and contaminant characteristics may limit the applicability and effectiveness of any of the technologies and treatments listed below. This matrix is optimistic in nature and should always be used in conjunction with the referenced text sections, which contain additional information that can be useful in identifying potentially applicable technologies.

Table 2. Definition of legends used in the treatment technologies screening matrix.

<table>
<tr><th>Factors</th><th colspan="4">Definitions</th></tr>
<tr><td>Development Status
Scale status of an available technology</td><td colspan="2">F
Full scale technology has been used in real site remediation</td><td colspan="2">P
Pilot Scale: studies conducted in the field or the laboratory to fine tune the design of the technology</td></tr>
<tr><td>Treatment Train
Is the technology only effective as part of the treatment train?</td><td colspan="2">Y
Technology must be used with the combination of other technologies as a treatment train</td><td colspan="2">N
Technology can be used as a stand alone one.</td></tr>
<tr><td>Residuals Produced
Residuals need to be treated</td><td>S
Solid</td><td>L
Liquid</td><td>V
Vapor</td><td>N
None</td></tr>
<tr><td>O&M or Capital Intensive
Main cost intensive parts</td><td>O&M
Operations & maintenance intensive</td><td>Cap
Capital intensive</td><td>B
Both O&M & capital intensive</td><td>N
Neither O&M or capital intensive</td></tr>
</table>

Table 3. Definition of criteria used in the treatment technologies screening matrix.

Factors and Definitions	Worse	Average	Better	Other
Availability Number of vendors that can design, construct, and maintain the technology.	< 2 vendors	2 – 4 vendors	> 4 vendors	NA
Contaminants Treated Contaminants are classified into the following eight groups: - Nonhalogenated VOCs; - Halogenated VOCs; - Nonhalogenated SVOCs; - Halogenated SVOCs; - Fuels; - Inorganics; - Radionuclides; - Explosives.	No expected effectiveness	Either limited effectiveness or nontarget (e.g., VOC treatment by thermally enhanced SVE)	This contaminant group is a treatment target of this technology.	This technology is effective only to certain contaminants, but not all others in the group.
System Reliability /Maintainability The degree of system reliability and level of maintenance required when using the technology.	Low reliability and high maintenance	Average reliability and average maintenance	High reliability and low maintenance	NA
Cleanup Time Time required to clean up a "standard" site using the technology. The "standard" site is assumed to be 20,000 tons (18,200 metric tons) for soils and 1 million gallons (3,785,000 liters) for ground water.	> 3 years for *in situ* soil	1-3 yr	< 1 yr	Contaminant specific
	> 1 year for *ex situ* soil	0.5-1 yr	<0.5 yr	Contaminant specific
	> 10 years for water	3-10 years	< 3 years	Contaminant specific
Overall Cost Design, construction, and operations and maintenance (O&M) costs of the core process that defines each technology, exclusive of mobilization, demobilization, and pre- and post-treatment. For *ex situ* soil, sediment, and sludge technologies, it is assumed that excavation costs average $55.00/metric ton ($50/ton). For *ex situ* ground water technologies, it is assumed that pumping costs average $0.07/1,000 liters ($0.25/1,000 gallons).	> $330/metric ton (>$300/ton) for soils	$110-$330/metric ton ($100-$300/ton)	<$110/metric ton (<$100/ton)	Contaminant specific
	>$2.65/1000 L (>$10/1000 gal) for water	$0.79-$2.64/1000 L ($3-$10/1000 gal)	<$0.79/1000 L (<$3/1000 gal)	Contaminant specific
	>$11.33/kg ($25/lb) for air emissions & off gases	$3.17-$133/kg ($7-$25/lb)	<$3.17/kg (<$7/lb)	Contaminant specific

Application of the Screening Matrix to TA-54

There are several considerations at the TA-54 MDA L disposal area that are particularly relevant in evaluating technologies that may be applicable for remediation. These include:

- Absence of phase separated liquid (free product)
- Large depth to bottom of VOC plume (~100 m or 330 ft)
- Very low organic carbon in tuff resulting in easy desorption of adsorbed VOCs
- Large distance between bottom of VOC plume and underlying aquifer (~200 m or 660 ft)
- The presence of 34 waste disposal shafts, each about 20 m (65 ft) deep, which likely represent a continuing source of contaminants
- The presence of asphalt pavement on much of the site that serves as a cover and LANL would prefer to not move
- High permeability of tuff and corresponding presence of fractures

These conditions are used to evaluate the technologies in the screening matrix.

Technologies Eliminated from Consideration

The fact that contamination is limited to unsaturated formations 200 m (660 ft) above the aquifer eliminates any technology involving ground water (technologies 3.9 through 3.13 in Table 1). The very large depth to the bottom of the plume eliminates any remediation strategy that would require excavation from further consideration. Eliminating excavation is due in part to the costs associated with removing large volume of material, the difficulty and hazards associated with excavating tuff, and the environmental impact that would be incurred by an excavation of this magnitude. These considerations eliminate all *ex situ* remediation options from further consideration (technologies 3.4 through 3.6 in Table 1).

In Situ Biological Treatment Technologies

Van Deuren et al. (1997) identify five *in situ* biological treatment technologies that are applicable to remediation of halogenated VOCs: bioventing, enhanced biodegradation, land treatment, natural attenuation, and phytoremediation. All are based on biological destruction of the contaminants. Their appropriateness for application at TA-54 MDA L is considered below.

<u>4.1 Bioventing</u>: Bioventing involves use of injection and extraction wells to deliver oxygen to contaminated unsaturated soils by forced air movement that increases biodegradation of the contaminants by aerobic soil microorganisms. This process is widely used at leaking underground storage tank (LUST) sites to achieve degradation of petroleum hydrocarbons. Because air is used, bioventing is appropriate only for contaminants that degrade under aerobic conditions. It is well established that the more halogenated VOCs such as TCA, TCE and PCE will degrade only under strongly reducing conditions (Rittmann and McCarty, 2001). Therefore, bioventing is not an appropriate technology for remediation of chlorinated VOCs.

4.2 Enhanced Bioremediation: In this process, the activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance *in situ* biological degradation of organic contaminants or immobilization of inorganic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials. Enhanced bioremediation may be used to achieve degradation under either aerobic or anaerobic conditions.

The principal constraint to enhanced bioremediation is that it is based on the ability to circulate water through the contaminated formation; therefore, it is not applicable to contaminants present in the vadose zone. Since the contaminant plume at TA-54 is located in unsaturated tuff, it is therefore not an appropriate remediation technology at this site.

4.3 Land Treatment: Land treatment is used to treat contaminated surface soil in place by tilling to achieve aeration, and if necessary, by addition of amendments. Periodically tilling, to aerate the waste, enhances the biological activity. The contaminants at TA-54 are very deep, hence this technology is not appropriate for application.

4.4 Natural Attenuation in Soils: Natural attenuation relies upon natural processes in soil to reduce contaminant concentrations to acceptable levels. These processes may include dilution, dispersion, volatilization, biodegradation, adsorption, and chemical reactions with soil materials. Natural attenuation may be considered for remediation of contaminants in soils if site-specific factors support its use. The factors include (van Deuren et al, 1997):

- Protection of potential receptors during attenuation
- Favorable geological and geochemical conditions
- Documented reduction of degradable contaminant mass in a reasonable time frame in the surface and subsurface soils
- Confirmation in microcosm studies of contaminant cleanup
- For the persistent or conserved contaminants, ensured containment during and after natural attenuation

Natural attenuation was developed for application at LUST sites in which soil and/or ground water hydrocarbon pollution was noted to persist for many years, yet due to hydrogeologic conditions and the absence of an exposure pathway, there was minimal risk of human exposure to these contaminants. Furthermore, it was observed that in many cases, the size of the contaminant plume actually decreased with time as a result of natural degradation and dilution processes. At sites with very low risk, regulatory agencies have allowed application of this management approach as a way to provide a high degree of protection of health and the environment through relatively modest expenditure of remediation funds.

Natural attenuation is not itself a technology, but rather a management strategy in which the nature and extent of the contaminant plume is determined, potential pathways by which the contaminants might be transported to human receptors or the environment are identified, and then a combination of modeling and monitoring is developed to assure that the risk of exposure is below some acceptable level. Incorporation of modeling in the natural attenuation strategy is important to its success because site managers must convince the regulatory agencies and the public that pollutants will remain below appropriate standards forever and for a variety of future developments. Because the model results are used to quantify risk assessment, a much higher degree of confidence is needed in the modeling than with other remediation strategies. In some states including New Mexico, ground water regulatory agencies will allow compliance with relaxed alternate ground water standards for selected pollutants at LUST sites at which the risk of exposure is especially low. These alternate standards are established based on the results of a formal risk assessment calculation.

Another factor that is very important in evaluating natural attenuation as a management strategy is incorporation of a monitoring program in the remediation system design. The purpose of the monitoring program is two-fold. First, it will provide data used to validate the models used in the risk assessment. Second, the monitoring program will provide data to confirm that the contaminant plume is behaving as expected and to determine whether contaminants are moving towards a receptor (usually a water supply well).

Use of the natural attenuation management strategy is frequently controversial as it has been characterized as a “do nothing” strategy. In contrast to active remediation methods, it is frequently difficult to convince stakeholders that it is in fact a viable strategy with adequate protection of human health and the environment. Though it has been widely used at LUST sites for hydrocarbon contaminants, the use of natural attenuation for halogenated VOCs has been limited. A DOE site such as LANL will have to include an extensive public participation program to identify its remediation strategy; hence site managers must be able to quantify the risks associated with this option and clearly explain them to the public.

Factors that may limit application of natural attenuation include (Van Deuren et al. 1997):

1. Toxicity of degradation and transformation products may exceed that of the original contaminants.
2. High risks occur at sites where geological characteristics such as fracture bed rock or karst landscapes may prevent assessment of stable plume control for contaminants leached from soil.
3. Contaminants may migrate (erosion, leaching, volatilization) before they are degraded or transformed.
4. Ground water at the site contaminated by the soil source will not be available for an extended period of time.
5. Extensive free product, as nonaqueous phase liquids, may have to be removed before natural attenuation can restore soil in a reasonable time frame.
6. Conservative metals may be only temporarily immobilized with remobilization when natural attenuation reestablishes oxygenated soil conditions.

Only the fifth criterion, the presence of a continuing source of contaminants, appears to be present at TA-54. LANL staff have indicated that a Corrective Measures Study (CMS) for the TA-54 MDA L will eventually be performed, and that this study will evaluate the technical feasibility and risks associated with removing the potential source terms remaining in the waste disposal shafts. However, this study is not expected to be initiated for one to two years. Thus, the magnitude of the source term and the contaminant release characteristics are at present unknown.

Based on the large depth to ground water, the large distance to the nearest water supply well, and the apparent lack of other credible exposure pathways, natural attenuation may be a viable alternative at TA-54. A further consideration is that the extensive modeling done to date can be used to support a risk assessment.

4.5 Phytoremediation: Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. Contaminants may be either organic or inorganic. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. Much of the TA-54 MDA L site is covered with asphalt; hence there is no plant growth. More importantly, most of the contaminants at TA-54 are well below the root zone; hence phytoremediation is not expected to be a viable remediation process at this site.

4.6 Electrokinetic Separation: The Electrokinetic Remediation (ER) process removes metals and organic contaminants from low permeability soil, mud, sludge, and marine dredging. ER uses electrochemical and electrokinetic processes to desorb, and then remove, metals and polar organics. This *in situ* soil processing technology is primarily a separation and removal technique for extracting contaminants from soils. Targeted contaminants include metals, anions, and polar organics. The contaminants at TA-54 are mostly volatile organics of low polarity.

Contaminants in the soil are mobilized through eletromigration and/or electroosmosis. Electromigration is movement of ionic constituents as a result of electrostatic attraction to an oppositely charged electrode placed in the soil. Electroosmosis is movement of water due to ionic concentration gradients resulting from electromigration and generally, is a much less important contaminant transport mechanism than electromigration.

Electrokinetic separation is almost certainly not feasible at TA-54 for two primary reasons. First, the contaminants are not electrostatically charged, hence their mobility in an electrostatic field would be due only to electroosmosis, which is very small and requires a large amount of energy. Second, this process requires high water contents in the soil. Van Deuren (1997) report that performance drops off dramatically at moisture contents below 10%. Physical parameters used in LANL's modeling effort consist of gravimetric moisture contents of less than 2% in the Tshirege member (top 41 m or 135 ft) and about 20% in underlying formations.

Electrokinetic separation is in an early stage of development and has seen very limited application at field scale. The contaminants are not those that are readily amenable to mobilization by electrokinetic methods. The site conditions at TA-54 are not well suited for this process. Therefore, it does not appear that electrokinetic separation is an appropriate remediation technology for application at TA-54.

4.8 Soil Flushing: *In situ* soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. Soil flushing is accomplished by passing the extraction fluid through in-place soils using an injection or infiltration process. Extraction fluids must be recovered from the underlying aquifer, and when possible, they are recycled. Because the contaminant plume at TA-54 is in unsaturated tuff at a distance of ~200 m (660 ft) above the water table, soil flushing is not an appropriate technology for application at this site.

4.9 Soil Vapor Extraction: Soil vapor extraction (SVE) is an *in situ* unsaturated zone soil remediation technology in which a vacuum is applied to the formation to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on local and state air discharge regulations. Vertical extraction vents are typically used at depths of 1.5 meters (5 feet) or greater and have been successfully applied as deep as 91 m (300 ft). Horizontal extraction vents (installed in trenches or horizontal borings) can be used as warranted by contaminant zone geometry, drill rig access, or other site-specific factors. Soil vapor extraction is widely used to remove volatile petroleum hydrocarbons at LUST sites.

Factors that may limit the effectiveness of SVE include (Van Deuren et al., 1997):

- Soil that has a high percentage of fines and a high degree of saturation will require higher vacuums (increasing costs) and/or hindering the operation of the *in situ* SVE system.
- Large screened intervals are required in extraction wells for soil with highly variable permeabilities or stratification, which otherwise may result in uneven delivery of gas flow from the contaminated regions.
- Soil that has high organic content or is extremely dry has a high sorption capacity of VOCs, which results in reduced removal rates.
- Exhaust air from *in situ* SVE system may require treatment to eliminate possible harm to the public and the environment.
- As a result of off-gas treatment, residual liquids may require treatment/disposal. Spent activated carbon will definitely require regeneration or disposal.
- SVE is not effective in the saturated zone; however, lowering the water table can expose more media to SVE (this may address concerns regarding light non-aqueous-phase liquids [LNAPLs]).

Because of the low organic carbon content of the tuff, halogenated VOCs are not strongly adsorbed to the soil. Furthermore, the low solubility of the contaminants at TA-54 suggests that the bulk of their mass is in the vapor phase. These two factors lead to the expectation that the VOC concentration in the off-gas from an SVE system would be high, and in fact this was confirmed for an abbreviated pilot scale vapor extraction test reported by Neeper (2001). Accordingly, it should be expected that application of SVE at TA-54 will require an off-gas treatment system. While this will add to the cost of remediation, it will also increase public acceptability by ensuring that all contaminants are captured and managed properly.

Based on current knowledge of the site, it would appear that conditions at TA-54 are well suited for application of SVE to achieve remediation. The high volatility and low sorption of the halogenated VOCs at TA-54 suggest that contaminant removal rates by some form of vapor extraction would be very high and that the site could rapidly be remediated by this process.

4.10 Solidification/Stabilization: *In situ* solidification/stabilization (S/S) involves addition of a stabilizing compound such as a cement grout or wax to a contaminated subsurface zone to achieve immobilization of the pollutants. Immobilization may be achieved through both physical and chemical mechanisms. This technology is at a very early stage of development and has been demonstrated at the pilot scale at a limited number of field sites. Its target contaminant group is inorganics including radionuclides. Conditions at TA-54 that limit application of *in situ* S/S include:

- *In situ* S/S requires drilling wells and injecting the stabilization media to the bottom of the contaminant plume, which is not feasible at MDA L.
- The most common media used for *in situ* S/S are based on cement grouts. This material has limited effectiveness for immobilizing halogenated VOCs.
- Maximum effectiveness of *in situ* S/S requires a high degree of mixing of the stabilization media and the soil. Mixing can be achieved with an auger or through use of high pressure jets to penetrate the surrounding soil. The principal subsurface materials at TA-54 consist of welded tuff that will limit mixing.

A variation of the *in situ* S/S process described by Van Deuren et al. (1997) is the *in situ* vitrification process. In this process electrodes are placed in the ground and sufficiently high current is passed between them that resistive heating melts the soil. Volatile contaminants are either combusted, pyrolyzed, or volatilized and captured by an off-gas collection and treatment system. There are many challenges associated with this process including:

- It is limited to a maximum depth of about 10 m for practical reasons.
- Containment of escaping volatile contaminants is difficult and expensive.
- There are many operational problems that complicate the technology and present appreciable risk to workers.

Based on the large depth of the contaminant plume and the difficulty of stabilizing halogenated VOCs in place, it is apparent that *in situ* S/S is not an appropriate process for application at TA-54.

<u>4.11 Thermally Enhanced Soil Vapor Extraction:</u> Thermally enhanced SVE is similar to conventional SVE but includes the addition of a heat source to increase the volatility of organic contaminants and thus accelerate their removal by vapor extraction. Methods of heating subsurface soils that have been used include electrical resistance heating, application of radio frequency electromagnetic fields and injection of hot air or steam. Except when steam is applied, the heating provides the additional benefit of drying the soil, thereby increasing its permeability, which in turn facilitates passage of air through the formation.

Thermally enhanced SVE is primarily intended to remediate semi-volatile organic compounds such as heavy oils, pesticides, and PCBs. It may also have application to increase the extraction rate of VOCs in soils containing high concentration of natural organic material that, because of its high adsorption capacity, limits their volatility.

Because the contaminants at TA-54 are highly volatile and because there is very little adsorption of these contaminants onto the subsurface soil materials, thermally enhanced SVE does not offer any significant benefit over conventional SVE at this site. Furthermore, because of the large depth and extent of the contaminant plume, it would be difficult and expensive to heat the subsurface soils.

Summary of the Results of the Screening Analysis

The results of the screening analysis are summarized in Table 4. Only two of the technologies identified by Van Deuren et al.(1997) appear to have application for remediation at TA-54 MDA L: natural attenuation and soil vapor extraction. There are two obvious limitations to natural attenuation. First, the presence of wastes in the 34 waste disposal shafts constitutes a source term for the contaminants that is likely to continue to release pollutants into the formation for many years or decades. Thus, although the extent of the contaminant plume appears to be static based on both modeling efforts (Stauffer et al., 2000) and monitoring results (LANL, 2001a), it is likely that a natural attenuation management strategy would require extensive and costly site monitoring for many decades to assure that the plume did not pose a threat to human health or the environment. The second concern with natural attenuation is that associated with public acceptability. This management strategy is commonly perceived by the public as a “do nothing” alternative and will certainly draw extraordinary scrutiny from citizen activist groups.

Soil vapor extraction is the other process that appears to be feasible for remediation of TA-54. This document constitutes a screening analysis, so details of the process, costs, and duration of remediation activities have not been considered. The preliminary field testing and analyses performed by Neeper (2001) show that large masses of contaminants can readily be removed from deep formations at this site and that air flow through these formations can be easily achieved. Use of atmospheric pumping to achieve air flow through the formation may be feasible at this site. However, an engineering design and economic analysis should be conducted to determine whether the cost savings of no pumping offset the additional costs associated with closer well spacing and longer remediation schedule. A further consideration that needs to be addressed is the design and cost of the off-gas treatment system.

Table 4. Summary of screening analysis of technologies for remediation of contaminants at TA-54 MDA L (numbers refer to technologies described by Van Deuern et al., 1997)

Technology	**Suitability for Application at TA-54 MDA L**	**Comments**
3.1 *In situ* Biological Treatment		
4.1 Bioventing	Low	• Halogenated VOCs are not aerobically degradable
4.2 Enhanced Biodegradation	Low	• Halogenated VOCs are not aerobically degradable
4.3 Land Treatment	Low	• Plume is deeper than can be treated by land application
4.4 Natural Attenuation	High	• Possible because of large depth to ground water & limited exposure pathways • Will require modeling & monitoring for long duration • Questionable public acceptability
4.5 Phytoremediation	Low	• Contaminants deeper than root zone
3.2 *In situ* Physical/Chemical Treatment		
4.6 Electrokinetic mobilization	Low	• VOCs not mobilized by electrokinetic effects
4.8 Soil Flushing	Low	• Feasibility limited by large distance between bottom of plume & aquifer
4.9 Soil Vapor Extraction	High	• High mobility of VOCs due to volatility & low sorption • High permeability of tuff • Success of limited pilot testing • Off-gas treatment needed
4.10 *In situ* Solid./Stab.	Low	• Limited by depth of plume • Formation not conducive to grouting
3.3 *In situ* Thermal Treatment		
4.11 Thermally Enhanced SVE	Moderate	• Enhancement not needed due to volatility & mobility of VOCs
Technologies Which Are Not Applicable at TA-54		
3.5 *Ex situ* Biological Treatment		Excavation is not feasible at TA-54
3.6 *Ex situ* Thermal Treatment		Excavation is not feasible at TA-54
3.9 *In situ* Biological Treatment		Ground water not contaminated at TA-54
3.10 *In situ* Physical/Chemical Treatment		Ground water not contaminated at TA-54
3.11 *Ex situ* Biological Treatment		Ground water not contaminated at TA-54
3.12 *Ex situ* Physical/Chemical Treatment		Ground water not contaminated at TA-54
3.13 Containment		Ground water not contaminated at TA-54

References

LANL (2001a). Quarterly Pore Gas Sampling at TA-54 MDA L, MDA G, and TA-50 MDA C, Fourth Quarter, FY 2001, Draft, Los Alamos, NM

LANL (2001b). Subsurface Vapor-Phase Plumes at Technical Area 54, LA-UR-00-4164, Los Alamos, NM.

Neeper, D. (2001). RFI Investigation, presentation to ITRD, Pojoaque, NM, 50 p.

Rittmann, B.E., McCarty, P.L. (2001). Environmental Biotechnology: Principles and Applications, McGraw-Hill, New York, NY, 754 p.

Stauffer, P., Birdsell, K., Witkowski, M., Cherry, T., Hopkins, J. (2000). Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions, LA-UR-00-2080, Los Alamos, NM.

US EPA, 1993. Remediation Technologies Screening Matrix**.** Reference Guide. Version 1. EPA 542-B-93-005. U.S. Environmental Protection Agency, Solid Waste and Emergency Response.

Van Deuren, Julie, Wang, Zhao, Ledbetter, John, (1997). "Remediation Technologies Screening Matrix and Reference Guide," 3rd Ed., U.S. Army Environmental Center, Federal Remediation Technologies Roundtable, Aberdeen Proving Ground, MD. (see also http://www.frtr.gov/matrix2/top_page.html)

Attachment to Appendix B

LANL TA-54 MDA L
INFORMATION NEEDED FOR DESIGN OF SOIL VAPOR EXTRACTION SYSTEM

Introduction

Based on the current understanding of site hydrogeology, including the nature and distribution of contaminants and the hydrologic characteristics of the contaminated formations, the ITRD group conducted an evaluation of remediation technologies that might be appropriate for application at TA-54. This evaluation was done using information and procedures developed by the Federal Remediation Technologies Roundtable consisting of representatives from the EPA, Department of the Energy, Department of the Interior, Department of Defense, Department of the Air Force, Department of the Army, and the Department of the Navy (Van Deuren, 1997). The Roundtable developed a screening matrix that contains 64 remediation technologies that have been developed for cleanup of subsurface contaminated soils, vapors, and ground water. The ITRD group used this screen matrix to determine whether any other technologies, in addition to those considered by LANL, might be appropriate for remediation of the TA-54 MDA L.

The analysis by the ITRD group suggested that two technologies might be appropriate for application at TA-54: monitored natural attenuation and soil vapor extraction. The comparative merits of each process are summarized in Table 1. The uncertainties associated with monitored natural attenuation appear to be much more significant than for SVE, especially the public acceptability of the process. Accordingly, the ITRD group has recommended that LANL conduct a more formal analysis of the SVE process to determine the system design, whether off-gas treatment is needed and how it might be configured, and identify the risks to workers and the public that would be associated with this process.

Table 1. Summary comparison of monitored natural attenuation and soil vapor extraction for remediation of TA-54 MDA L

Process	Positive Attributes	Concerns
Monitored Natural Attenuation	• Reduced remediation costs • Limited impact on TA-54 site activities	• Public acceptance: It is perceived as “do nothing” approach. • May require very long term monitoring • Will require risk assessment • Poorly quantified source term may complicate process.
Soil Vapor Extraction	• Contaminants & site hydrogeology are conducive to efficient SVE remediation. • Use of atmospheric pumping may reduce costs. • Should achieve rapid remediation	• Off-gas treatment may be required. • Disruption of TA-54 site activities may occur. • May increase risk to workers • Poorly quantified source term may complicate process.

This section identifies the major aspects that would be needed to complete the design of an SVE system that would contain sufficient detail to enable determination of the costs; to compare atmospheric pumping to use of mechanical blowers; to determine potential disruption of TA-54 site operations; and to provide information necessary to conduct an analysis of the risks associated with the remediation activities including both contaminant exposure to workers and the public, and occupational risks to the workers. The recommendations in this section are based on common practice for SVE systems; however, it must be recognized that design of these systems is very site specific. Hence, it is likely that there are other factors that will influence the implementation of this process at LANL.

Information Needed for System Design

There are five major factors that are likely to determine the design of an SVE system at TA-54: 1) site hydrogeologic conditions, including the nature and distribution of the contaminants, and the hydrologic properties of the contaminated formation; 2) the magnitude and characteristics of the source term; 3) the nature of site operational activities which may be affected by the remediation process; 4) regulatory constraints that may be imposed on the site and 5) costs. The discussion in the following sections are presented in the context of two possible variations of the SVE process: an active system based on use of mechanical blowers, and a passive system which removes soil vapors through atmospheric pumping.

It should be recognized that design of any type of soil remediation system is an iterative process that consists of proposing a design, analyzing its effectiveness and costs, and then refining the design. All four factors will influence the design, and it is to be expected that development of an optimal system will require two or more iterations.

Site Hydrogeologic Conditions and Contaminant Distribution

Much of the information needed for the design of an SVE system has already been collected and analyzed by LANL staff through their monitoring programs and in the process of developing a contaminant transport model. The accuracy and completeness of this information has been reviewed by the ITRD team. The well-developed contaminant transport model is of special value in designing an SVE system because it will facilitate evaluation of a variety of extraction alternatives.

Neeper (2001) presented the results of a brief SVE experiment. Data from this test can be used in conjunction with the transport model to estimate the effectiveness of different pumping strategies for contaminant removal. At this point, LANL staff should be able to identify and evaluate the effectiveness of various contaminant extraction alternatives. The effectiveness of each alternative would be considered primarily in terms of contaminant removal rate and the time needed to complete remediation. However, other important factors to be considered include the number, size and depth of wells needed; the air flow rates and pressure drops; the location of the wells relative to surface activities; and the contaminant concentrations in the off-gas and their evolution with time.

Recommendation 1: Identify a small number of extraction well configurations, perhaps three alternatives each for an active system and three for an atmospheric pumping system, and use the model to evaluate contaminant removal from the subsurface environment for each of these alternatives.

Recommendation 2: Due to the large body of knowledge that has already been collected, additional pump testing of vapor extraction wells is not needed at this site.

Characterization of the Source Term

The wastes that are present in the 34 disposal shafts represent a significant uncertainty for any remediation process because it is not possible to predict what the magnitude of future contaminant release rates might be. While it is possible to do bounding calculations that will predict the effects of a drum burst scenario on soil vapor contaminant concentrations, the number of intact drums, bottles or other containers is not known, nor is it possible to know when or if they will burst.

There are at least four ways in which this uncertainty may be addressed. First, it may be possible to remove the source term. LANL staff have indicated that a future corrective measures study will consider the practicality, the costs, and the risks associated with source term removal. A second possibility may be to stabilize the contaminants in place. This might be done through physical methods such as *in situ* grouting or by using thermal methods such as thermally enhanced vapor extraction. Third, it may be possible to design the SVE system so that in can operate for the foreseeable future if contaminants continue to be detected. For instance, an active system would be designed and operated to remove all of the halogenated VOCs presently in the subsurface environment. Once this is completed, an atmospheric pumping system might be left in place to remove residual contaminants from future drum bursts. Fourth, it may be possible to show that once the existing vapor plume has been removed, natural attenuation becomes a credible method of remediating contaminant releases from future drum burst events. Such an analysis would show that contaminant concentrations and surface release rates would be so low that they did not pose an excessive risk to human health or the environment.

Recommendation 3: Perform a corrective measures study to determine the feasibility of removing the waste materials from the disposal shafts or stabilize them in place.

Recommendation 4: The remedial system design should include consideration of future drum burst events and provide assurance that contaminant release does not pose an excessive risk to human health and the environment.

Nature of Site Operational Activities

The intention has been conveyed to the ITRD team that TA-54 will continue to remain an operational facility that is integral to waste management activities at LANL for the foreseeable future. These activities have already affected the ability to characterize the site by preventing installation of monitoring wells at some desirable locations. Examples of remediation components that may be constrained by site operational activities include: siting of SVE and monitoring wells, location of SVE pumping and off-gas treatment equipment, and routing of surface piping leading to the vapor extraction (or injection) wells. In addition to the actual components of an SVE system, the installation of monitoring and extraction wells involves use of large equipment such as drill rigs, water trucks, flat bed trucks, and boom trucks. Thus, installation of the wells will result in a large surface disruption for times ranging from many weeks to many months, depending on the number of wells. In addition, the risk to site operations personnel must be considered. This risk may include exposure to contaminants from the extraction wells as well as usual work place hazards associated with any industrial process.

The impact on site operational activities can be minimized by clearly identifying the nature of these activities and conveying this information to system designers. During the preliminary design phase of an SVE system, the designers will develop a good estimate of the number and location of wells needed for the process, along with the approximate sizes and characteristics of the piping, pumping, and off-gas treatment system. It will then be necessary for managers and remediation system designers to compare the site's operational activities with the SVE system design and collaboratively develop an SVE system design that will achieve remediation having an acceptable impact on TA-54 operations.

Recommendation 5: TA-54 site managers should be contacted and asked to identify facility operations that might be impacted by an SVE system. A map of the site should be prepared which delineates structures or areas that cannot have wells, piping or SVE equipment located near them. Areas where site personnel spend large amounts time should also be identified so that the system design can minimize work place hazards.

Recommendation 6: Once a preferred SVE option has been determined, TA-54 site managers should review the plan and the construction phasing to be sure that its impact on site operations will be acceptable. As construction progresses, this coordination should be maintained.

Regulatory Constraints

The regulatory constraints that must be met by the remediation system are likely to be important factors in process selection and final design. They must be clearly identified early in the design process, and regulators must continue to be included in discussions involving the remediation system.

Some of the information that system designers need to obtain from regulators include:

- Emission limitations
- Process monitoring requirements
- Site monitoring requirements
- Required cleanup levels
- Long term site monitoring requirements
- Acceptable risk criteria for workers and the public
- Public participation requirements

One of the most important regulatory issues that must be resolved early on is determination of the limitations that may be applied to process emissions, as this will determine whether an off-gas treatment process is required. This limit will likely affect both the concentration of VOCs in the exhaust gas as well as the total mass that may be discharged each day. If the emission limits are not too strict, it may allow use of a slower remediation process such as atmospheric that doesn't require an off-gas treatment process. Slower remediation would involve a trade-off in which a less expensive process is operated for a longer period of time, in contrast to operation of a more expensive, aggressive SVE system that includes off-gas treatment.

From a regulatory perspective, it is likely that the only process monitoring requirements will be off-gas monitoring. However, it will be necessary to determine what types and frequency of monitoring will be required.

During remediation periodic monitoring of the subsurface contaminant distribution will be required to assess the remediation process and to provide assurance that the contaminant plume is not expanding. The type and frequency of this monitoring must be determined.

The required cleanup level is the residual soil vapor chlorinated VOC concentration that must be met to achieve remediation of the site. The target cleanup levels must be determined. The NMED should clearly identify the cleanup levels and monitoring requirements that LANL must meet in order achieve cleanup of this site. If soil vapor monitoring is to be continued after remediation is complete, the nature, extent and frequency of this monitoring should be identified.

If a risk-based corrective action strategy such as monitored natural attenuation is chosen for application at TA-54, LANL must be informed of the level of risk that is acceptable to the public and to site workers.

A public participation process will be required prior to selection of a final remediation process for this site. NMED and LANL should agree to the nature and scope of this process soon to facilitate development of an effective process and to allow LANL managers to develop an accurate estimate of its cost.

Recommendation No. 7: LANL and NMED should continue to work together and identify the regulatory requirements that will affect the design and implementation of the soil vapor remediation process at TA-54. In particular, the following information must be identified: off-gas emission requirements, SVE process monitoring requirements, contaminant plume monitoring requirements, required soil vapor cleanup levels, final monitoring requirements, acceptable public and work risk levels, and public participation requirements.

Cost

The major costs associated with any remediation process can be categorized as either capital costs or operations and maintenance costs. For a soil vapor remediation system, the major capital costs include:

- Drilling and construction of monitoring and extraction wells
- Piping costs associated with connecting extraction wells to the pump system
- Pumping system
- Off-gas treatment system
- Monitoring and control systems
- Civil costs associated with access, utilities, security, etc.

Operations and maintenance (O&M) costs include:

- Personnel costs
- Power costs (electricity, natural gas, water)
- Equipment maintenance
- Process monitoring
- Contaminant plume monitoring

Typical cost estimation practice is to combine the capital costs and the O&M costs to generate an annualized cost. This is done by amortizing the capital costs over the life of the project using an appropriate interest rate that is available to the owner of the process. The annual O&M costs are adjusted for inflation. The two costs are then added to get the annual cost per year. The total cost can be determined by summing the annualized costs over the life of the project. This approach allows direct comparison of systems that have different capital costs, O&M costs, and require different times to achieve remediation.

It is apparent that two general approaches to SVE may be appropriate for this site: an active SVE system that relies upon use of mechanical blowers to circulate air through the formation, and a passive SVE system that relies upon atmospheric pumping for air circulation. Based on the limited pilot work by Neeper (2001), the active system would be expected to move large volumes of air through the formation and have a large radius of influence. Thus, fewer wells would be required and remediation would be accomplished more quickly. However, an active system would require one or more blower systems, an off-gas treatment system, and more extensive piping to connect all of the wells. A passive system relying upon atmospheric pumping would require more wells, less piping, and less or possibly no off-gas treatment, if chlorinated VOC emissions were sufficiently low. The downside of this option is that it would require much longer to achieve cleanup due to the lower contaminant removal rates.

Recommendation No. 8: LANL should conduct a design study that includes two variations of the SVE remediation process: one that uses blowers to circulate air through the formation and another that uses atmospheric pumping to circulate air through the formation. Each design should incorporate all of the components needed to comply with regulatory requirements including off-gas emission treatment. The length of time needed to achieve site remediation should be determined for each. The annualized and total costs of each alternative should be determined and used in selection of a final remediation process.

References

Neeper, D. (2001). RFI Investigation, presentation to ITRD, Pojoaque, NM, 50 p.

Van Deuren, Julie, Wang, Zhao, Ledbetter, John, (1997). “Remediation Technologies Screening Matrix and Reference Guide,” 3rd Ed., U.S. Army Environmental Center, Federal Remediation Technologies Roundtable, Aberdeen Proving Ground, MD. (see also http://www.frtr.gov/matrix2/top_page.html)

[This page intentionally left blank]

APPENDIX C: COMMENTS AND RESPONSES ABOUT THIS REPORT

One of the purposes of the ITRD program is to provide an independent evaluation of remediation approaches and applicable technologies on a site-specific basis. The “target audience” for ITRD reports includes both the specific site’s Technical Advisory Group, which includes DOE site project managers, M&I/O scientists and engineers, regulators, public stakeholders, and technology experts, and also interested parties with similar challenges at other sites throughout the DOE complex. The intent of the program is to provide technical assistance by developing treatment and deployment information on potentially useful innovative technologies, and to make recommendations in conjunction with all of the parties to a remedial action decision. It has been demonstrated that this inclusive process can help build consensus on a site’s eventual technology selection and treatment approach.

Because the ITRD process is inclusive, it seeks to present information to all interested parties in a fair manner. Some of the material and recommendations in this Summary Report for LANL MDA L generated controversy. To capture the discussion about these issues, this appendix contains a series of comments and responses between members of the Technical Advisory Group and LANL Environmental Restoration personnel involved with the project.

Although there were several exchanges of comments and responses, the text of this report includes no changes to the original Technical Advisory Group findings and recommendations from the draft May 2002 reports. However, inclusion of the comments and responses seeks to indicate that there were some areas of dissension that were not resolved within the Technical Advisory Group report.

Comments Topic:	ITRD LANL MDA L TAG Subteam Report: Conceptual Modeling for MDA L, Draft Rev. 2, April 4, 2002			April 25, 2002
#	**COMMENT SOURCE**	**COMMENT**	**RESPONSE SOURCE**	**RESPONSE**
1.	TAG Subteam Recommendation #1 *[see Section 5.1 in the report]*	Surface emission measurements. The TAG has agreed that the quarterly monitoring at TA 54 MDA L can be relaxed. However, the TAG recommends that additional surface flux measurements be made, preferably by perforating the impermeable cap at some locations. The rationale for this recommendation is as follows: It is being proposed by the Remediation Sub-committee of TAG to use the conceptual model in evaluating and designing remediation alternatives. Before the model can be used for this purpose, it needs to be further validated. Previous validations have compared measured subsurface vapor phase concentrations and surface emissions against model predictions. While the agreement between measured and predicted subsurface concentrations were reasonable, there were significant differences between the corresponding surface fluxes. By perforating the cap, two "data points" can be obtained to further calibrate and/or validate the conceptual model: sampling of the gas phase concentration as well as measurement of the flux. In response to the original TAG report on the conceptual model (Appendix to this report), Don Neeper suggested that CO2 measurements could be correlated to VOC emissions due to barometric pumping. This is a reasonable approach; however, the correlation between CO2 emissions and VOC emissions has to be first demonstrated. A further benefit of surface flux measurements will be in risk evaluation that is being recommended by the two subteams of the TAG. The parameters used in the model to predict the surface emissions (viz. the boundary layer thickness and the diffusion coefficient) need to be re-evaluated (see Recommendation 2 below).	Phil Stauffer, LANL ER	LANL will undertake further analysis of the surface flux enigma during revision of the Modeling document LA-UR 2080. I have implemented Henrys Law with H = 1.5 for TCA and the results are interesting. The basic conclusions of the model do not change, however the presence of a dissolved component could affect calculations made in support of remediation. As per Jury et al, alluvium and surface organics may have affected the measurements of TCA surface flux and these effects should be included in any further modeling associated with remediation. Further measurements of surface flux would provide additional data, however at this time there are no plans to do this sampling. This would be a data need written into the remediation work scope.

Comments Topic: ITRD LANL MDA L TAG Subteam Report: Conceptual Modeling for MDA L, Draft Rev. 2, April 4, 2002

April 25, 2002

#	COMMENT SOURCE	COMMENT	RESPONSE SOURCE	RESPONSE
2.	TAG Subteam Recommendation #2 *[see Section 5.1 in the report]*	Surface flux. The size of the contaminant plume, including whether or not the plume continues to grow or shrinks, is based on a balance between the estimated source of the contaminants and the loss to the atmosphere, or the surface flux. Therefore, the surface flux is a significant factor in the long-term behavior of the plume. The modeled surface flux is based on a porous media diffusion coefficient and a 1-meter transition to a zero concentration in the atmosphere, or boundary layer. This approach is extremely simplified and is not realistic. The boundary layer thickness at the surface is typically 0.5 cm (Jury et al., 1984b), although values can range up to 1 meter for very low wind speeds and stable conditions (Webb et al., 1999). The diffusion coefficient should also be that for open conditions, not for a porous media. The admission that the maximum surface flux from the model is nearly 300 times the maximum values reported from sampling (pg. 23 of Stauffer et al., 2000) is also a concern. Although the differences are rationalized, they should be further evaluated. If the losses are indeed considerably less than predicted by the current model, the growth of the plume will be significantly affected, which may influence the remediation option selected for this site. It is recommended that the surface boundary layer model be changed to be similar to that given by Jury et al., 1984b, and that the simulations be rerun to evaluate the change in surface modeling on the plume behavior. Additionally, data should be collected to support the surface loss component of the model as discussed elsewhere in this report.	Phil Stauffer, LANL ER	The surface flux issue is beyond the scope of the revised LA-UR 2080, however this would be included any modeling performed in support of the remediation alternatives. I have read the Jury documents and agree that the surface flux on any parts of the flat topography (mesa tops) containing alluvium (which contains organics/water) could reduce plume loss to the atmosphere. However, the sides of the mesa generally contain much less alluvium and should continue to be conceptualized as sinks for the VOC vapors. Furthermore, the surface is not blanketed by alluvium and distribution and thickness would need to be measured before using this concept. Finally, the boundary layers reported in Jury et al do not seem appropriate for highly porous, non-soil Bandier Tuff that is actively breathing to the atmosphere. I will continue to look into this topic and will definitely add text to discuss this concept in the revised LA UR 2080.

#	COMMENT SOURCE	COMMENT	RESPONSE SOURCE	RESPONSE
3.	TAG Subteam Recommendation #2 *[see Section 5.1 in the report]*	<u>*Surface flux*</u>*. [See above]*	Dennis Newell, LANL ER	Regarding the surface flux. That study was prior to the new and improved EMFLUX that Beacon Environmental provides (that we used at MDA B and C), and it should really be considered qualitative. To really compare the modeling results to the flux study would require conducting a new flux study. The question is whether or not that is necessary. It is not currently a data need for the RFI. It should also be noted that the surface of the mesa has other heterogeneities like asphalt, trailers, domes, gardens, etc. on and in the vicinity of the source.
4.	TAG Subteam Recommendation #3 *[see Section 5.1 in the report]*	<u>Presence of Fractures</u>. Some of the units are known to have fractures, yet the conceptual model developed by Stauffer et al., 2000, is a porous media approach without fractures. Because many of the fractures are vertical, they would enhance the vertical migration of the plume and could conceivably increase the calculated migration of the plume. It is recommended that the effect of fractures on the plume migration be investigated.	Phil Stauffer, LANL ER	Fractures are mainly found in the more welded section of TSH Unit 2. Below this horizon, fractures are much less common and do not generally cut through units. The near surface fractures are often filled with calcite and/or clay. We will include this discussion in the report, with references, however modeling of fractures will have to be done in association with the remediation efforts.

Comments Topic:		ITRD LANL MDA L TAG Subteam Report: Conceptual Modeling for MDA L, Draft Rev. 2, April 4, 2002		April 25, 2002
#	**COMMENT SOURCE**	**COMMENT**	**RESPONSE SOURCE**	**RESPONSE**
5.	TAG Subteam Recommendation #4 *[see Section 5.1 in the report]*	Alternative Methods for Gas Sampling and Analysis at MDA L Site. We recommend acquiring more concentration data at the site using inexpensive but accurate field screening or simple laboratory techniques. To obtain a more accurate conceptual model of the subsurface contamination at the MDA L site, more soil gas measurements are required. Current protocol calls for analysis using Summa Canister collection and contract lab analysis by EPA protocol. This procedure is expensive and not well suited for obtaining a better conceptual understanding of the gas plume at the site. To understand the dynamic behavior that is characteristic of subsurface contaminant gas phase plumes, many inexpensive measurements would be most useful. There are a variety of field and local laboratory (i.e., on site or mobile lab) gas sampling and analysis methods available for deployment. These methods range from standard laboratory methods brought to the field (e.g., gas chromatography/mass spectrometry) to simple detectors sensitive primarily, but not exclusively, to the species of interest (e.g., photoionization detectors, portable acoustic wave sensors, chemiresistors, etc.). Any of these methods may be appropriate depending on the analytes in the gas stream, the detection levels required, the frequency of measurement, etc.	Phil Stauffer, LANL ER	The sampling plan for MDA L is being revisited as part of the TA-54 RFI and these comments will be used to help guide the construction of a more appropriate sampling plan for the VOC plume.

Comments Topic:	ITRD LANL MDA L TAG Subteam Report: Conceptual Modeling for MDA L, Draft Rev. 2, April 4, 2002			April 25, 2002
#	**COMMENT SOURCE**	**COMMENT**	**RESPONSE SOURCE**	**RESPONSE**
6.	TAG Subteam Recommendation #4 *[see Section 5.1 in the report]*	<u>Alternative Methods for Gas Sampling and Analysis at MDA L Site</u>. *[See above]*	Dennis Newell, LANL ER	Also regarding … the utilization of additional screening methods such as a Field GC. Numerous methods were used and evaluated in the past, and the B&K was settled on as the best method. Additionally, we have done some correlations between the B&K TCA and TCE results vs the SUMMA analytical. We are getting linear correlation with an R^2 of ~.90; therefore the B&K is an excellent method for tracking plume behavior (trends), and showing extent; the SUMMAs provide us the "ground truth". With respect to the quantification of TCA and TCE; the B&K appear to read ~70% of the analytical results for TCA, and ~60 % for TCE. A better quantification could be obtained with a two point calibration of the B&K; however, this is much more expensive than a single point calibration (which is what we currently do). If better quantification is really a data need (not in my opinion) then we should spend more on the B&K calibration rather than different methods. It should be possible to address this by documenting a review of all possible methods and their potential application to MDA L environment and data needs. Either one method would be determined best or a comparative study could be recommended.

Steve Webb proposed adding the following text at the end of Section 4.1 (Findings) of the TAG report:

> Subsequent to these findings, the original model report (Stauffer et al., 2000) was revised (Stauffer, et al., 2002). This revised report addressed many of the concerns in items 1, 4, and 6. Specifically, the revised model considers the following processes not included in the original report. The adequacy of the model revision in resolving the concern is summarized below.
>
> 1. Henry's law for dissolved gas (Finding 1e above) - finding resolved.
> 2. Boundary layer effects (Finding 1a and 6a) - finding not resolved as discussed in the Recommendation section.
> 3. Gas-Liquid Diffusion Coefficient (Finding 1a and 6a) - finding resolved.
> 4. Higher source concentrations pre-1985.
> 5. Fractures (Findings 4 and 6b) - finding not resolved.
> 6. Gas diffusion model (Finding 1d) - discussion added - no model modifications made - finding not important in present application.
> 7. Gas-Solid sorption (Finding 1b) - discussion added - no model modifications made - finding not important in present application.

He also proposed adding the following text at the end of Section 5.1 (Recommendations) of the TAG report:

> Subsequent to the above original recommendations, the original model report (Stauffer et al., 2000) was revised (Stauffer, et al., 2002) as mentioned earlier. We do not believe that the revised model adequately addresses any of the above recommendations. There has been limited progress on the surface flux issue (Recommendation 2), but much more work remains before the issue is adequately addressed. Therefore, the original recommendations remain unchanged by the revised model report.

Dennis Newell and Phil Stauffer (LANL ER) provided the following information: Below are mine and Phil's responses to the TAG conceptual model recommendations and Steve Webb's suggested additions to the report. The report reads as if a great deal of work is recommended, which is contrary to what we have been getting from the conference calls.

Section 5.1
[Recommendations] 1 and 2. <u>Surface Emission measurements and Surface Flux</u> (we are evaluating these together due to their similarity): Further validation of the model is recommended. Comparison of the model the subsurface concentrations shows that the model is adequate; however surface flux measurement vary significantly from predicted values.

We believe the subteam is assuming that the measure flux values are "correct". In reality, the surface flux will vary with the permeability of the surface. The surface footprint of the plume in very heterogeneous; it is covered with soil, asphalt, base coarse, and has areas of bare, weathered tuff. Additionally, the effective porosity of most of these materials varies due to fluctuating near surface moisture conditions. A "point-in-time" flux measurement is unlikely to correspond with the predictions. The near surface in the model is greatly simplified.

The team recommends further measurements including penetrating the asphalt cap and taking measurements. We do not understand what that will provide as far as further validation. We have sub-asphalt measurements in the pore gas wells at depths of ~20 ft that agree well with the model. Additional surface flux measurements could be made, but the same surface heterogeneity will impact the agreement with the model. The previous measurements were taken after rain, which will not provide a maximum flux. Measurements would have to be made during dry surface conditions; measurements of the asphalt cap would have to be made.

However, how important are surface flux measurements? We primarily use surface flux to provide a surface expression of the subsurface plume to aid in extent determination. The model fits the subsurface extent. As far as risk assessment of vapors, the surface flux method we used is not accepted; expensive EPA flux chambers would have to be used followed by modeling of the emissions to human receptors. However, for the RFI, SUMMA canister samples of atmosphere at the site were collected to evaluate present day risk, and no such risk was found.

Additionally, surface flux was reduced in the model with the result showing that the goodness of fit becomes poor when surface flux is reduced by even one order of magnitude. Given that the measured surface flux is more than 2 orders of mag. lower than the model predicts, the modeling suggests that surface flux measurements should be used only qualitatively.

[Recommendation] 3. Presence of Fractures. The uppermost unit (Unit 2) at MDA L is moderately welded and hosts near vertical fractures. This unit contains the upper ~50 ft of the vapor plume and is in contact with the atmosphere at the surface and mesa sides. One consideration is that the fractures are likely filled to partially filled in the near surface by translocated soils/fill, clay, and carbonates. This would limit vertical movement of vapors through fractures. The geologic unit beneath the uppermost unit is poorly welded and does not host many fractures, and thus any influence of fractures on vapor transport would be insignificant. If the fractures in Unit 2 are included in the model as increased vertical diffusion, much greater loss to the atmosphere would result (which limits the lateral extent of the plume), preventing matching of the model to the data.

Given that the plume is larger than if the upper unit fractures were increasing vapor movement, we do not think additional studies on fractures are warranted. Fracture spacing may need to be included in detailed passive venting studies where fractures could have a profound 'short circuit' effect on vent wells that are open in the Unit 2 interval. The current analysis being reviewed, however, is the model of the site-wide plume.

[Recommendation] 4. Alternative Methods for Gas Sampling and Analysis at MDA L site. I have previously provided comments on this topic. The early pore gas monitoring program explored different methods of pore gas detection, including tedlar bags and GCs. The present day methodology has proved to be the most reliable and cost effective method, providing consistent, quality results.

Yes, the B&K results for TCA, TCE, etc can be impacted by the presence of freons. However, we include freon screens in our B&K set-up to compensate for this potential problem. We have not seen a significant problem with interference, except with water vapor at certain times of the year. Over the last few years the correlation between the B&K and associated SUMMA analytical results has been very good, measuring within the expected error in the B&K. The B&K screening has been used primarily to get a very large data set for extent definition. SUMMAs are the ground truth and are used to define nature. Our proposed future monitoring phases out the B&K and moves towards limited SUMMA samples at key locations.

We do not agree with this recommendation and do not think experimentation with additional pore gas methodologies will improve our data set. More likely, it would be costly and take several years of data before an evaluation could be made.

<u>In response to Steve Webb's additional comments:</u>
We state again that the main purposes of the modeling are to show that we have a reasonable understanding of the mechanisms that have created the VOC plume, and that our numerical model of the plume can be used to predict its behavior into the future.

In light of purpose of the model, we disagree with Steve Webb's additional comments. We do not believe that the surface flux issues and the fracture subject are significant enough to warrant additional efforts.

The model has incorporated second order effects, which improve the data/model correlation significantly. We feel that the work performed in support of the ITRD review has shown that the basic modeling was sound, and that the revised model can be used as a starting point for analysis of future plume behavior and remediation options.

We need to consider the scale of the problem. Given the magnitude of the plume (relatively small) and the risk it poses (minimal), we need to ask the question, does the existing model adequately describe the plume for the purposes of proposing and implementing remediation options. We do not need to explore details unless they significantly alter the outcome, with respect to risk to the environment and public. The characterization phase of this project has passed, and we need to move towards a conclusion.

Steve Webb responded to the above comments as follows:

1. <u>Surface Flux</u>
If a mechanistic model of the surface flux had been included, such as Jury's model, I might agree with their assessment. However, the current model is not mechanistic and is ad hoc. Because the decrease in the plume size is predominantly due to losses to the atmosphere, I feel this process should be modeled mechanistically and in more detail. It shouldn't be a large effort to include this effect.

2. <u>Fractures</u>
Isn't the Cerros del Rio Basalts formation fractured in places? Inclusion of these fractures could significantly increase vertical migration towards the water table. I seem to recall that there a very few measurements under the plume in this formation - please correct me if I'm wrong.

Dennis Newell responded to Steve Webb's comments:

RE: #2. Fractures. Yes, the Cerros del Rio basalts are highly fractured, with other features such as breccia zones and rubble zones, as well as massive, unfractured zones. However, the monitoring near and within the basalts has shown that the plume decreases to detection limit concentrations before the basalt contact. Any vapors entering the basalt are at extremely low, at or below detection limit concentrations. With the extremely high air permeability of the basalt, these are flushed away essentially instantly. The basalt appears to act much like the atmosphere.

As far as the amount of data within the basalt. We have two angle boreholes that penetrate the basalt; they are located directly beneath the two major source areas at MDA L. We have ~5 sample ports in each borehole within the basalt. We have a good data set from these ports, but only sporadic, near detection limit hits, and that is why the data looks sparse.

Joe Rossabi had the following comments about the discussion among Dennis Newell and Phil Stauffer (LANL ER) and Steve Webb:

I think we are getting away from the general agreement (from the NM meeting) that the numerical model and conceptual understanding of the site was adequate to move on to the next phase but that there were some things that could be done to improve both the numerical and conceptual models. We're not using the right words that express our agreements, areas for improvement, and perhaps the priority or value of the suggestions for improvement.

Specifically to Dennis and Phil's responses:

I believe the subteam recognizes that the surface flux measurements to date are probably not representative. They are, however, field measured data and are assumed to be reasonably accurate. The issue of disparity between the measurements and the model predictions was not raised as an indictment of the model, it merely indicated an opportunity for better understanding of the system. The suggested additional measurements by quick cutting through the asphalt were an attempt to help resolve the disparity at minimal cost. I believe everyone recognizes that we will be subject to the same heterogeneity issues as were encountered in the previous flux measurements; however, the measurements would add to the data set and may be able to provide a better understanding of the surface flux disparity. The fact that the previous surface flux measurements were made under conditions that may have biased the flux rate low strengthens the argument for additional flux measurements. Although the model may indeed be more representative of how the system is behaving than the point measurements indicate, I think we need to be careful with statements that have the flavor of "the data don't match the model".

The inclusion of fractures might also be a nice addition to the model if the cost for incorporating them is not too great.

Frankly, I like the B&K method and would prefer to use it precisely for the reasons that you all have been using it, i.e., large, very accurate data set. I am familiar with the cross-compensation methods that the B&K folks use to deconvolute overlapping spectra (as occur with some freons and other VOCs) and have had mixed results in accuracy depending on the amount and type of freon in the soil gas mix when compared with standard GC results. The final arbiter of the use of B&K are the comparisons that you all have made using analytical equipment that is not subject to interference from overlapping spectra (e.g., GC). If the B&K is doing the job, that's good enough for me. With respect to onsite GC (Tedlar bags or whatever) versus Summa and offsite, if the Summas are accurate and more cost effective (or more defensible, would not require costly training or change in protocol, etc.) in comparison to on site GCs or other methods – go for it.

Despite these somewhat long winded responses to responses, I agree that we need to bear in mind the purpose and scope of the model, i.e., to have a reasonable first order understanding of the plume and its behavior to determine the next step in treating or monitoring the plume. Given this, the suggestions for additional work on improving the numerical and conceptual model should be balanced with the activities planned for the next phase of the project. If the value of the additional work is of low priority with respect to other planned activities, then it should be placed in its proper position on the list.

Michael Smith provided comments on two sections of text in the report. ***Dennis Newell*** provided responses to these comments:

[M. Smith]: I'd also like to suggest two small changes to the text.

1. Section 2 (Background Information on MDA L) of the final ITRD report on MDA L contains the following sentence:

> The pore gas monitoring provided sufficient data for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to estimate the nature and extent of the VOC vapor plume at MDA L.

I don't think NMED has "accepted" or "approved" the estimate. As I recall, NMED wants some more data taken. I'm proposing the following revision to the sentence:

> The pore gas monitoring provided data for LANL to estimate the nature and extent of the VOC vapor plume at MDA L as part of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI).

[D. Newell]: I agree; however if the TAG also feels that N&E can be estimated with some confidence, then it would be useful if the report reflected that.

[M. Smith]:
2. I'm also recommending adding some wording to our Findings under point 7 of Section 4.1. I've typed in the paragraph below with my changes in bold italics.

> The model seems to give reasonable answers ***when compared to a single field data set***. However, some of the details are open to question, and some additional data or modeling studies are needed. Appendices of the available concentration data would be useful. Confidence in the model would increase through successful comparisons to additional field data sets. The current model can be used to select and implement some remediation field tests and develop general strategies for contaminant control and remediation. The

> current model can also be used to focus the next characterization data needs and areas for more refined numerical modeling.

[D. Newell]: It is true that the model is compared to one, representative quarter of data. However, the plume is relatively static, which implies that the model compares well to other quarters. The RFI report for MDA L that is being modified goes into depth on the behavior of the plume over time with respect to both nature and extent. I think this report would be too lengthy to provide that discussion also. Again, the RFI report will provide all the data used to assess the plume.

Also, providing concentration in an appendix does not seem appropriate in this case. The analytical data is provided to NMED in quarterly reports from LANL, and the RFI report will provide the entire data set.

Appendix K

Stratigraphy and Surface Water Assessment

APPENDIX K STRATIGRAPHY AND SURFACE WATER ASSESSMENT

K-1.0 STRATIGRAPHY

Bandelier Tuff

Figure K-1 shows the generalized stratigraphy of the Bandelier Tuff beneath TA-54. In the discussions below, the term *welding* is used to differentiate between tuffs that are uncompacted and porous (nonwelded) and those 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 tuff whose volcanic glass has crystallized.

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 2

Unit 2 of the Tshirege Member of the Bandelier Tuff is competent, resistant caprock that forms the surface of Mesita del Buey. Its thickness varies from 35 ft (10.7 m) to 40 ft (12.2 m) at MDA L (Appendix H). Where it is exposed, unit 2 forms nearly vertical cliffs 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 [sanidine] and quartz [Broxton and Reneau 1995, 49726]).

Unit 2 is extensively fractured as a consequence of contraction during postdepositional cooling. The cooling-joint fractures are visible on mesa edges and on the walls of 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 8.8 m), and fracture width ranges between less than 0.03 in. and 0.51 in (1 mm and 13 mm) with a median of 0.12 in. (3 mm). 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 transport of radionuclides 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 water 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

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 (Broxton and Reneau 1995, 49726).

Unit 1vu. The uppermost portion of unit 1v is devitrified and vapor-phase-altered ash-fall and ash-flow tuff and has been designated unit 1vu, where u signifies upper. Its thickness varies from 60 ft (18.3 m) to 75 ft (22.9 m) at MDA L. 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.

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, and becomes more welded in its interior. Unit 1vc is approximately 25 ft (7.6 m) thick at MDA L.

Tshirege Member Unit 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 suggests 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. It is about 140 ft (42.7 m) thick at MDA L. 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.

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. It is about 3 ft (1 m) thick at MDA L.

Cerro Toledo Interval

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. This interval varies between 15 ft (4.6 m) and 30 ft (9.1 m) thick at MDA L.

Otowi Member

The Otowi Member tuffs are about 80 ft (24.4 m) thick at MDA L. 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 at 10 ft (3.1 m) beneath MDA L. The pumice bed is nonwelded but brittle. Pumice tubes are partially filled with silica cement.

Cerros del Rio Basalts (Tb4)

In the vicinity of TA-54, the Cerros del Rio basalts lie directly beneath the Otowi Member of the Bandelier Tuff (Figure K-1). In R-32, the basalts are 636 ft (193.9 m) thick; in R-22 the basalts are 983 ft (299.6 m) thick. In both wells, the regional water table occurs within these basalts. 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. Deeper drilling at R-22 demonstrated wide variety of lithologies within the basalts, including massive flows, interflow rubble or scoria zones, sediments and paleosols.

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 plateau confirm that the unit is very heterogeneous with both high and low permeability zones present (Nylander et al 2002). The formation is poorly lithified, and as such is unlikely to sustain open fractures.

As shown in Figure K-1, the Puye Formation thins from west to east beneath TA-54. At PM-2, the Puye (including fanglomerate, pumiceous units and ancestral Rio Grande deposits) is approximately 800 ft (243.8 m) thick; at R-23 the Puye is completely absent. Recent drilling across the plateau has suggested that the Puye is frequently underlain by alluvial fan deposits, similar in lithology to the Puye, yet considerably older. These deposits are of considerable thickness at PM-2, were penetrated at R-22 (approximately 80 ft [24.4 m] thick) and were absent at R-23. The Puye Formation was also encountered at R-16 (351 ft [106.9 m] thick); the water table occurs within the Puye Formation at this location.

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 (Reneau 1995, 50143) 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).

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 (Kelly 1978, 11659). Santa Fe Group rocks are deep below MDA G (1500 ft [457.2 m] below ground surface at PM-2) and were not penetrated by R-20, R-32, or R-22. 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.

Basaltic lava flows occurred during the time that the Santa Fe Group was deposited; these basalts occur both within the Santa Fe Group and within the Pre-Puye sands, gravels, and conglomerates that were penetrated by R-20 and R-22. These old basalts appear to have fewer open fractures than the younger Cerros Del Rio basalts.

Geochemistry

Certain minerals present in Bandelier Tuff are important in terms of sorption of chemical species from water. Among them are alkali feldspar and a combination of three silica polymorphs (i.e., quartz, cristobalite, and tridymite). These minerals are found throughout the thickness of the Bandelier Tuff, and their absolute abundance throughout the tuff can have a significant effect on the retardation of several constituents in the TA-54 MDA inventories. Less important in terms of transport are organic materials, which can react with certain constituents to form relatively mobile compounds. The organic content of geologic materials on the Pajarito Plateau mesas is typically less than 1 wt %. However, the fractures can contain higher organic concentrations than the tuff matrix.

In addition to the minerals found in the tuff matrix, clay minerals are found in abundance in fractures and interbeds in the Bandelier Tuff. The primary clay minerals are smectites, with lesser amounts of kaolinite. The clay minerals have high sorptive capacity for many TA-54 inventory constituents. Hematite (i.e., iron oxide) coatings are also found but with less frequency than clay coatings. Hematite has a very large surface area for binding certain metals and is therefore also important when considering transport in fractures.

Clay, iron oxide, carbonate minerals, and solid organic matter are known to be present in ancient, buried soils (paleosols) found elsewhere across the Laboratory. In particular, the Cerro Toledo interval, Guaje Pumice Bed, and Puye Formation are known to have buried soils. The occurrence of clay-rich horizons in the subsurface is not known beneath TA-54; however, they may be important (e.g., the Cerro Toledo interval commonly contains paleosol horizons). Vertical water flow may be inhibited and lateral flow enhanced by clay layers; clay has a low permeability. Furthermore, certain inventory constituents would be sorbed onto or complexed with the soil minerals and organic matter present in such zones. Because of these potentially important effects, field and laboratory investigations are underway to identify and characterize clay-rich soil horizons beneath Mesita del Buey.

K-2.0 SURFACE WATER ASSESSMENT

The surface water assessment for MDA L, dated July 25, 2001, is attached at the end of this appendix.

K-3.0 REFERENCES

The following list includes all references cited in this document. Parenthetical information following each reference provides the author, publication date, and a record identification (ER ID) number, when available. These numbers can be used to locate copies of actual documents at the RRES-RS Records Processing Facility.

Broxton, D. E., and S. L. Reneau, August 1995. “Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory,” Los Alamos National Laboratory report LA-13010-MS, Los Alamos, New Mexico. (Broxton and Reneau 1995, 49726)

Kelley, V. C., 1978. “Geology of Espanola Basin, New Mexico,” Geologic Map 48, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico. (Kelley 1978, 11659)

Nylander, C. L., K. A. Bitner, G. Cole, E.H. Keating, S. Kinkead, P. Longmire, B. Robinson, D.B. Rogers, and D. Vaniman, March 2003. “Groundwater Annual Status Report for Fiscal Year 2002,” Los Alamos National Laboratory document LA-UR-03-0244, Los Alamos, New Mexico. (Nylander et al. 2003, 76059)

Reneau, S. L., June 1995. "Geomorphic Studies at DP Mesa and Vicinity," in *Earth Science Investigation for Environmental Restoration Los Alamos National Laboratory Technical Area 21*, Los Alamos National Laboratory report 12934-MS, Los Alamos, New Mexico. (Reneau 1995, 50143)

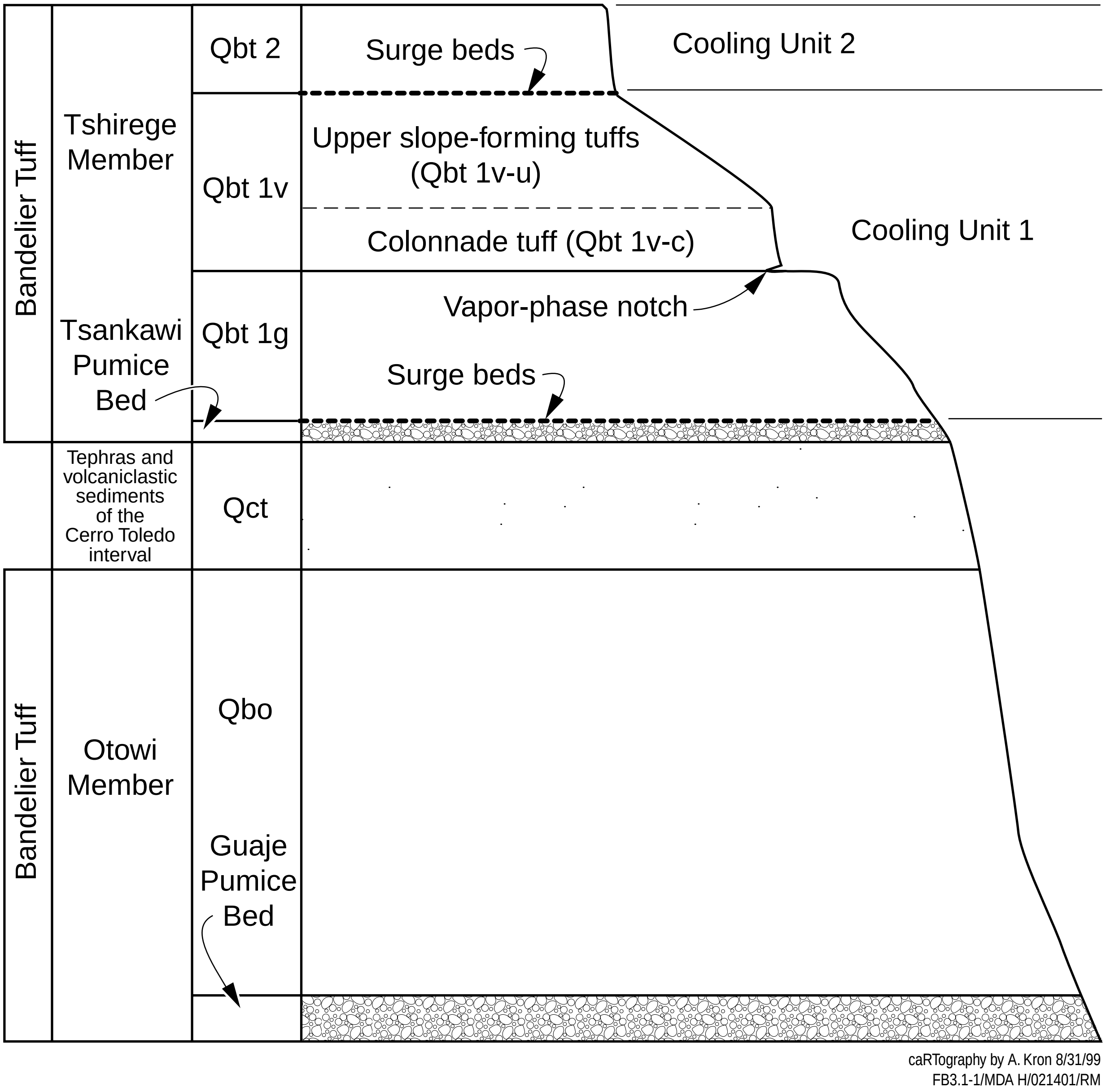
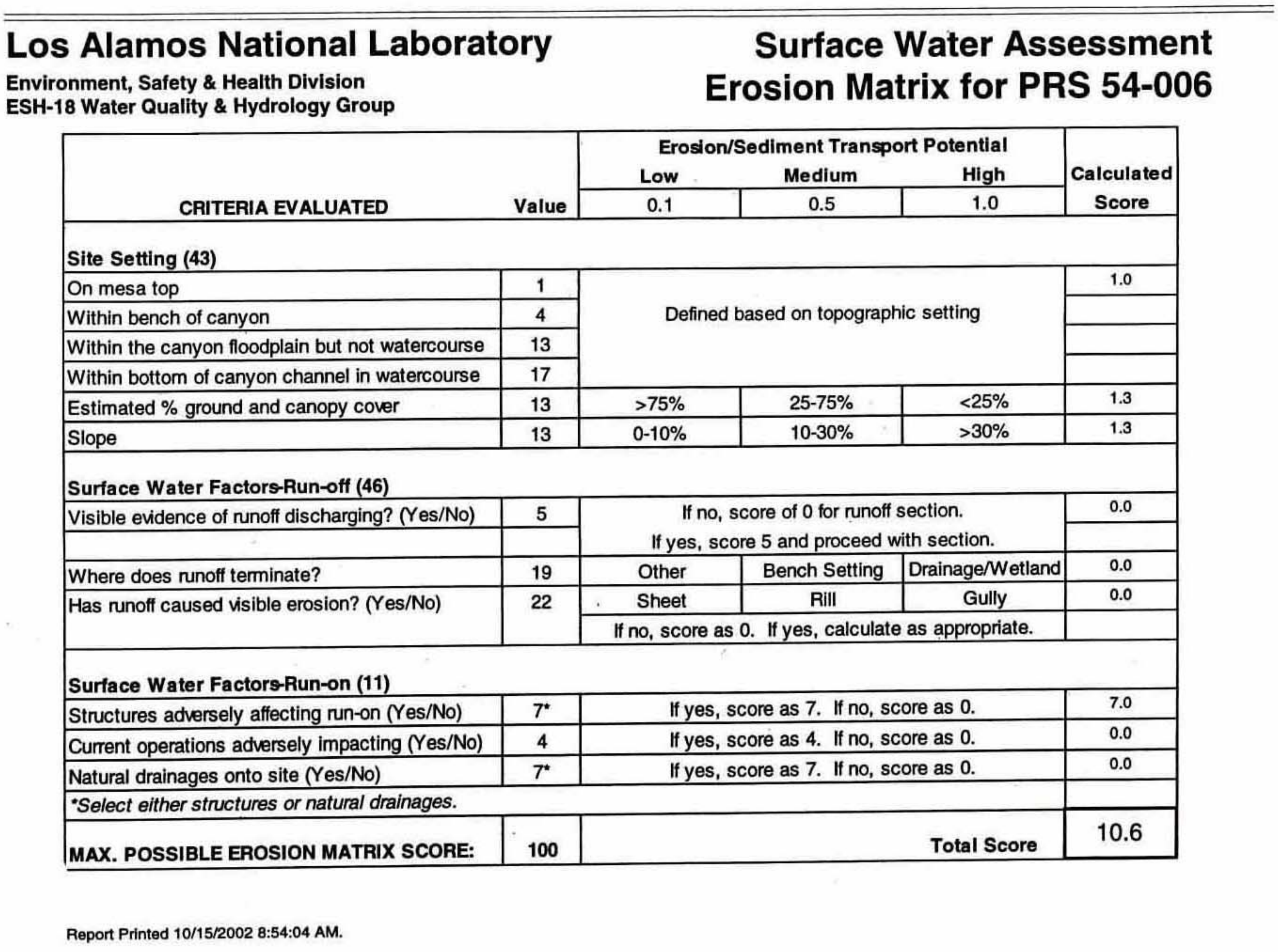


Figure K-1. **Generalized stratigraphy of Bandelier Tuff at TA-54**



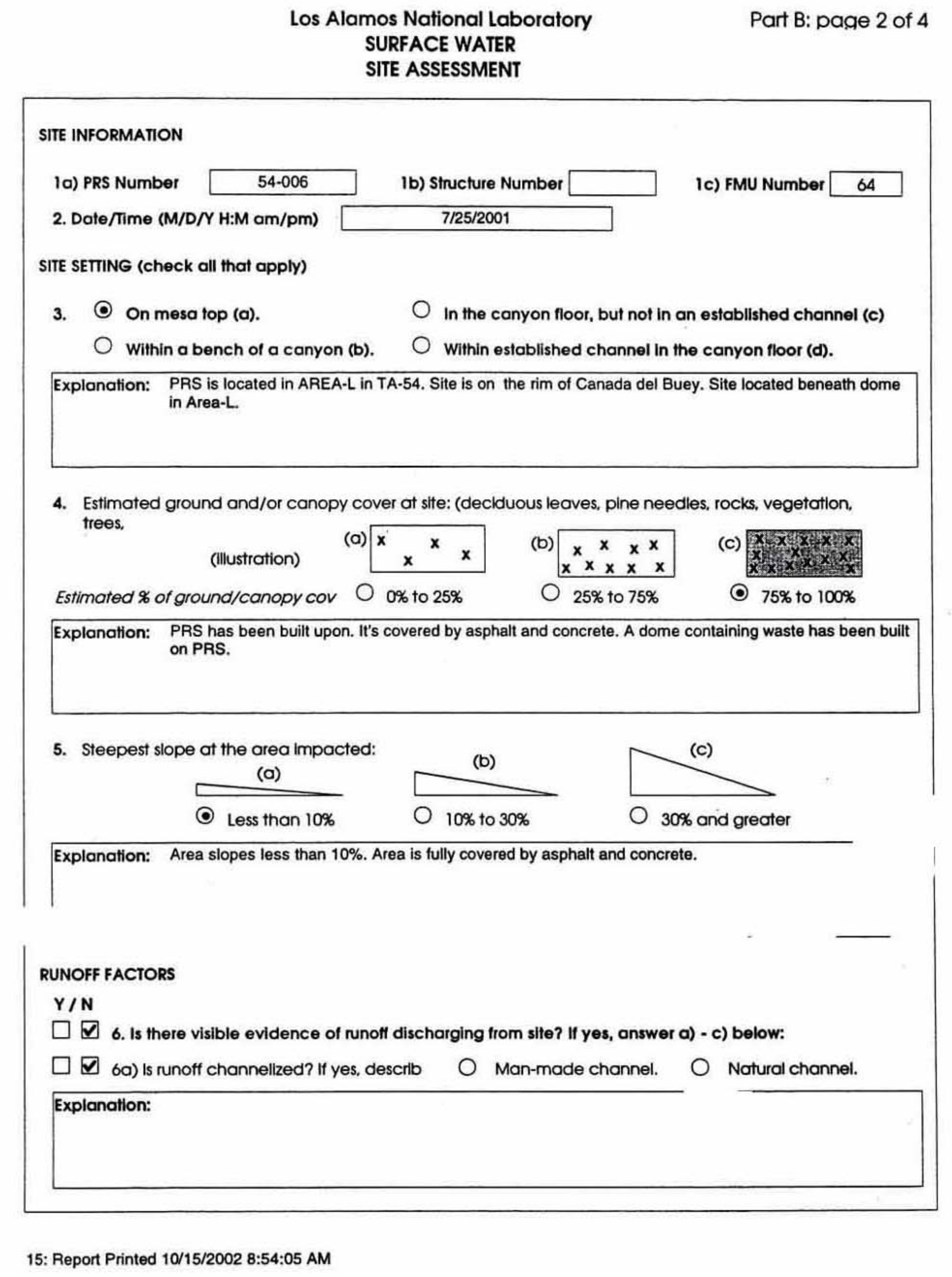
Los Alamos National Laboratory

Environment, Safety & Health Division
ESH-18 Water Quality & Hydrology Group

Surface Water Assessment
Erosion Matrix for PRS 54-006

CRITERIA EVALUATED	Value	Erosion/Sediment Transport Potential Low 0.1	 Medium 0.5	 High 1.0	Calculated Score
Site Setting (43)					
On mesa top	1	Defined based on topographic setting			1.0
Within bench of canyon	4				
Within the canyon floodplain but not watercourse	13				
Within bottom of canyon channel in watercourse	17				
Estimated % ground and canopy cover	13	>75%	25-75%	<25%	1.3
Slope	13	0-10%	10-30%	>30%	1.3
Surface Water Factors-Run-off (46)					
Visible evidence of runoff discharging? (Yes/No)	5	If no, score of 0 for runoff section.			0.0
		If yes, score 5 and proceed with section.			
Where does runoff terminate?	19	Other	Bench Setting	Drainage/Wetland	0.0
Has runoff caused visible erosion? (Yes/No)	22	Sheet	Rill	Gully	0.0
		If no, score as 0. If yes, calculate as appropriate.			
Surface Water Factors-Run-on (11)					
Structures adversely affecting run-on (Yes/No)	7*	If yes, score as 7. If no, score as 0.			7.0
Current operations adversely impacting (Yes/No)	4	If yes, score as 4. If no, score as 0.			0.0
Natural drainages onto site (Yes/No)	7*	If yes, score as 7. If no, score as 0.			0.0
**Select either structures or natural drainages.*					
MAX. POSSIBLE EROSION MATRIX SCORE:	100			**Total Score**	10.6

Report Printed 10/15/2002 8:54:04 AM.



Los Alamos National Laboratory
SURFACE WATER
SITE ASSESSMENT

Part B: page 2 of 4

SITE INFORMATION

1a) PRS Number 54-006 **1b) Structure Number** **1c) FMU Number** 64

2. Date/Time (M/D/Y H:M am/pm) 7/25/2001

SITE SETTING (check all that apply)

3. ● **On mesa top (a).** ○ **In the canyon floor, but not in an established channel (c)**

○ **Within a bench of a canyon (b).** ○ **Within established channel in the canyon floor (d).**

Explanation: PRS is located in AREA-L in TA-54. Site is on the rim of Canada del Buey. Site located beneath dome in Area-L.

4. Estimated ground and/or canopy cover at site: (deciduous leaves, pine needles, rocks, vegetation, trees,

(illustration) (a) (b) (c)

Estimated % of ground/canopy cov ○ 0% to 25% ○ 25% to 75% ● 75% to 100%

Explanation: PRS has been built upon. It's covered by asphalt and concrete. A dome containing waste has been built on PRS.

5. Steepest slope at the area impacted:

(a) (b) (c)

● Less than 10% ○ 10% to 30% ○ 30% and greater

Explanation: Area slopes less than 10%. Area is fully covered by asphalt and concrete.

RUNOFF FACTORS

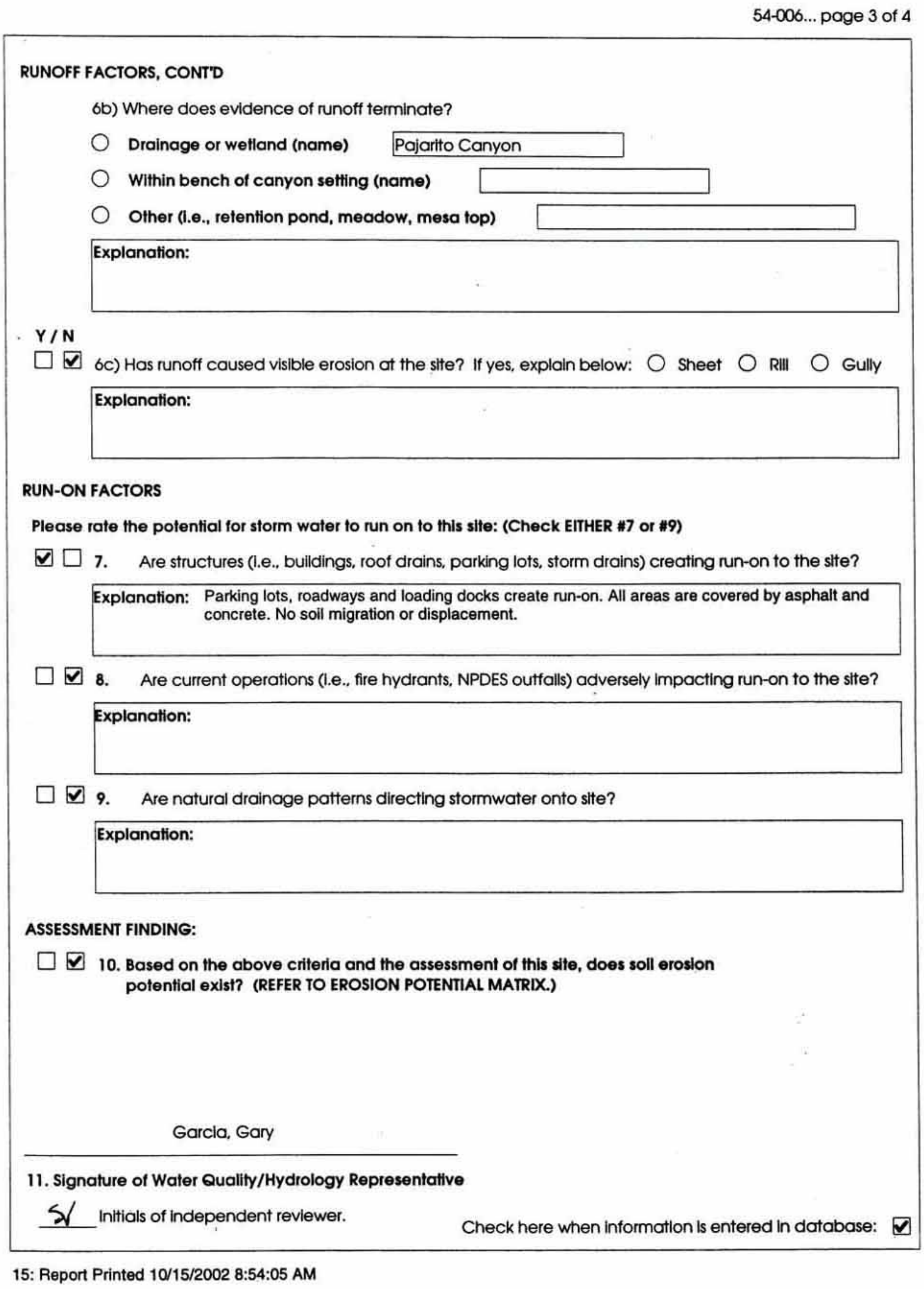
Y / N

☐ ☑ **6. Is there visible evidence of runoff discharging from site? If yes, answer a) - c) below:**

☐ ☑ 6a) Is runoff channelized? If yes, describ ○ Man-made channel. ○ Natural channel.

Explanation:

15: Report Printed 10/15/2002 8:54:05 AM



54-006... page 3 of 4

RUNOFF FACTORS, CONT'D

6b) Where does evidence of runoff terminate?

○ **Drainage or wetland (name)** Pajarito Canyon

○ **Within bench of canyon setting (name)**

○ **Other (i.e., retention pond, meadow, mesa top)**

Explanation:

Y / N

☐ ☑ 6c) Has runoff caused visible erosion at the site? If yes, explain below: ○ Sheet ○ Rill ○ Gully

Explanation:

RUN-ON FACTORS

Please rate the potential for storm water to run on to this site: (Check EITHER #7 or #9)

☑ ☐ **7.** Are structures (i.e., buildings, roof drains, parking lots, storm drains) creating run-on to the site?

Explanation: Parking lots, roadways and loading docks create run-on. All areas are covered by asphalt and concrete. No soil migration or displacement.

☐ ☑ **8.** Are current operations (i.e., fire hydrants, NPDES outfalls) adversely impacting run-on to the site?

Explanation:

☐ ☑ **9.** Are natural drainage patterns directing stormwater onto site?

Explanation:

ASSESSMENT FINDING:

☐ ☑ **10. Based on the above criteria and the assessment of this site, does soil erosion potential exist? (REFER TO EROSION POTENTIAL MATRIX.)**

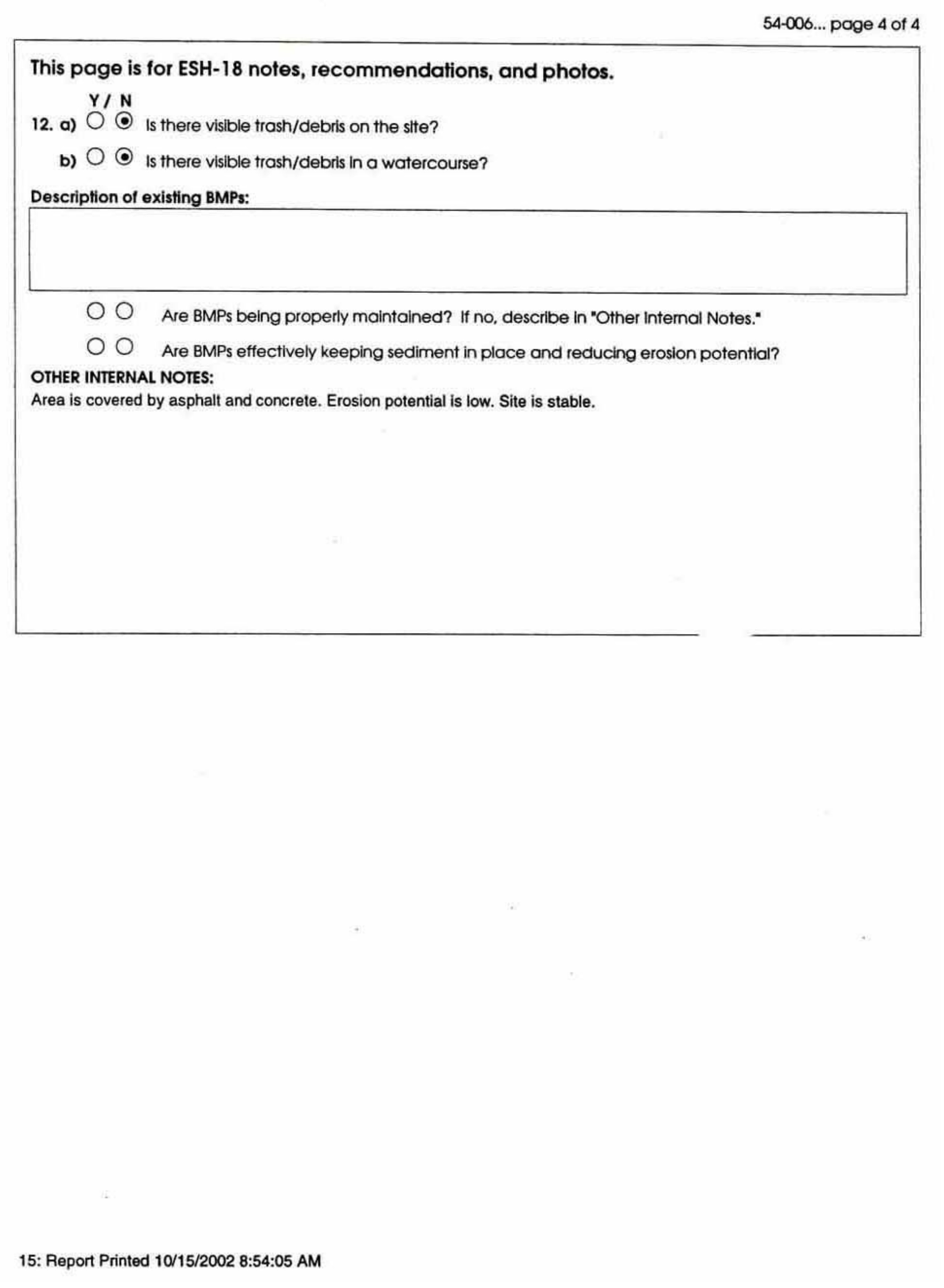
Garcia, Gary

11. Signature of Water Quality/Hydrology Representative

SV Initials of independent reviewer.

Check here when information is entered in database: ☑

15: Report Printed 10/15/2002 8:54:05 AM



54-006... page 4 of 4

This page is for ESH-18 notes, recommendations, and photos.

Y / N

12. a) ○ ● Is there visible trash/debris on the site?

b) ○ ● Is there visible trash/debris in a watercourse?

Description of existing BMPs:

○ ○ Are BMPs being properly maintained? If no, describe in "Other Internal Notes."

○ ○ Are BMPs effectively keeping sediment in place and reducing erosion potential?

OTHER INTERNAL NOTES:

Area is covered by asphalt and concrete. Erosion potential is low. Site is stable.

15: Report Printed 10/15/2002 8:54:05 AM

Appendix L

Source Term and Batch Waste Source Term Databases

OPERABLE UNIT 1148 DATA REPORT

Prepared for:

Los Alamos National Laboratory
Los Alamos, New Mexico

Prepared by:

IT Corporation
557 Oppenheimer Rd., Suite 200
Los Alamos, New Mexico 87544

September 1992

3.0 Technical Area 54, Area L

3.1 Source Term Data Base Information

3.1.1 Assumptions

The TA-54, Area L, source term data base was constructed from the original waste disposal records found in the TA-54, Area L, logbooks. The inconsistent and often incomplete nature of the original logbook entries required that assumptions be made in order to build the data base effectively. The assumptions used in this section are as follows:

1. Shafts were "active" (i.e., receiving waste) during the entire month they were being drilled.
2. Shafts were "inactive" during the entire month they were being capped.
3. Logbook entries indicating disposal of a material into an inappropriate shaft (e.g., oil into an inorganic shaft) were considered valid.
4. An entry of "0.0000" under "VOLCUFT" indicated a value of zero or a volume of <0.0001 ft^3.
5. When two disposal dates were given, the date associated with the disposal site was used.
6. Disposal locations from logbook entries indicating disposal into a pit or shaft that was not "active" on the date of disposal were considered invalid.
7. When a logbook entry listed only one volume for disposal of multiple items and no disposal location was specified, only one record with a single volume amount was entered in the data base.
8. When a logbook entry listed only one volume for disposal of multiple items and a disposal location was specified for at least one of the multiple items, the volume amount was equally divided between all of the items and multiple records were entered in the data base.
9. When a logbook entry listed only one date with multiple items and provided a volume amount for each item, multiple records were entered in the data base.
10. When a logbook entry indicated disposal of acids or bases into Shaft No. 1, at a time when Shaft No. 1 was "inactive," Shaft No. 2 was entered into the data base.

11. Only logbook entries that specified a unique disposal location were assigned a "Y" in the location field.

3.1.2 Definitions

The definitions of the fields and field variables used in the TA-54, Area L, source term data base are as follows:

ID	The sequential number assigned to a record.
MO	The month of the record; "00" indicates no month was given.
DY	The day of the record; "00" indicates no day was given.
YR	The year of the record; "00" indicates no year was given.
VOLCUFT	The volume of material disposed of (in cubic feet).
WGT	The weight of material disposed of (in pounds).
ITM	The number of cylinders or waste items disposed of.
SHAFT	Specific shaft number.
PIT	Specific pit letter.
DESCRIP	Description of the waste material.
CHEM TYPE	Indicates chemical type—"I" for inorganics, "O" for organics, "M" for metals, or "NA" for insufficient information. A star ("*") indicates an assumed designation.
RCRA CHAR	Indicates Resource Conservation and Recovery Act (RCRA) designation—"I" for ignitable, "C" for corrosive, "R" for reactive, "T" for EP toxic, "NA" for insufficient information, or "TBD" for not yet determined. A star ("*") indicates an assumed designation.
PHYS PHAS	Indicates physical form—"S" for solid, "L" for liquid, "V" for vapor, or "NA" for insufficient information. A star ("*") indicates an assumed designation.
LOC	"Y" indicates that a disposal unit was designated; "N" indicates no disposal unit was not designated.

3.1.3 Data Base

The TA-54, Area L, source term data base is provided at the end of this section.

3.2 Batch Waste Source Term Data Base Information

3.2.1 Assumptions

All available waste disposal records were used to compile the information contained in the TA-54, Area L, batch waste source term data base. In most cases, information was entered into the data base as it appears in logbook records. In some cases an interpretation of original record information was necessary to derive the maximum amount of information from existing records. Where interpretations were necessary (e.g., some chemical compound names required examination to discern the intended meaning of the technician), notes were inserted in the original records. The assumptions used for this section are as follows:

1. When only one volume was written in an entry line and that entry line was followed by others that did not indicate a volume, volume was entered for the first entry only.

2. An entry "0.0000" in the volume field indicates that no volume was given for that record or that the procedure outlined in Item 1 above had been followed. The same procedure applies to MO, DY, and YR fields, as indicated by "00".

3. The date entered in the data base is the <u>date of disposal</u> unless the date of disposal was not listed. In the event that date of disposal was not listed in the records, the <u>date received</u> was used if it was available.

4. If a pit or shaft number was indicated, a "Y" was entered in the LOCATION field indicating that the disposal location is known. If no pit or shaft number was given in the record, an "N" was entered in the LOCATION field indicating that the disposal location is not known.

5. Discrepancies exist between column headings used for information entry in the original records. There are two different forms used to record waste disposal information. The following assumptions were made to correlate information from one recording format to the other.

   - A column heading "SOURCE" is equivalent to "ORIGIN".
   - A column heading "CONTENT" is equivalent to "ANALYSIS".
   - A column heading "REMARKS" is equivalent to "AMOUNT".

3.2.2 Definitions of the Fields and Field Variables

ID	The sequential number assigned to a record.
MO	The month of the record ("00" was entered if no month was given).

DY	The day of the record ("00" was entered if no day was given).
YR	The year of the record ("00" was entered if no year was given).
VOLCUFT	Volume of material disposed of (in cubic feet).
SOURCE	Source location of material disposed of.
PIT	Specific pit letter.
SHAFT	Specific shaft number.
CONTENT	Description of the waste material.
WASTE TYPE	Indicates waste type—"I" for inorganics, "O" for organics, and "M" for metals.
PHYSPHASE	Denotes physical form—"S" for solid or "L" for liquid.
LOCATION	This logical field returns a "Y" if a disposal unit was designated or an "N" if a disposal unit was not designated.
HAZCHAR	RCRA characteristic designation.
RADIOACTIV	"YES" indicates radioactive material.
TREATMENT	Treatment applied to the waste.

3.2.3 Data Base

The TA-54, Area L, batch waste source term data base follows the source term data base at the end of this section.

SOURCE TERM DATA BASE

Page No. 1
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1	7	00	80	0.0000	120.0000	0			CAPACITORS	O	TBD	L	N
2	8	00	80	2.4100	0.0000	0			INORGANIC	I	NA	NA	N
3	8	00	80	3.8900	0.0000	0			ORGANIC	O	NA	L	N
4	08	00	80	68.0700	0.0000	0			ACIDS & BASES	I/O	C*	L	N
5	08	00	80	22.3800	0.0000	0			OIL	O	TBD	L	N
6	08	00	80	2.8000	0.0000	0			CARCINOGEN WASTE	O*	TBD	NA	N
7	08	00	80	4.0000	0.0000	0			BERYLLIUM WASTE	M	TBD	S	N
8	08	00	80	0.0500	0.0000	0			MERCURY	M	T	S*	N
9	08	00	80	16.7500	0.0000	0			POTASSIUM CYANIDE	I	R	S	N
10	08	00	80	0.0000	2.2000	0			SODIUM	I/M	R	S	N
11	09	00	80	11.0000	0.0000	0			INORGANICS	I	NA	NA	N
12	09	00	80	22.0000	0.0000	0			ORGANICS	O	NA	L	N
13	09	00	80	73.7000	0.0000	0			OIL	O	TBD	L	N
14	09	00	80	9.0000	0.0000	0			ACIDS & BASES	I/O	C*	L	N
15	09	00	80	2.0100	0.0000	0			WATER/ASBESTOS	I/M	TBD	L	N
16	09	00	80	2.0000	0.0000	0			FLUORINE CYLINDERS	I	TBD	V	N
17	09	00	80	2.0000	0.0000	0			SODIUM	I/M	R	S	N
18	10	00	80	16.0000	0.0000	0			INORGANIC	I	NA	NA	N
19	10	00	80	29.5000	0.0000	0			ORGANIC	O	NA	L	N
20	10	00	80	14.7400	0.0000	0			OIL	O	TBD	L	N
21	10	00	80	7.9100	0.0000	0			ACIDS & BASES	I/O	C*	L	N
22	10	00	80	14.0000	0.0000	0			ASBESTOS	I	TBD	S	N
23	10	00	80	14.0000	0.0000	0			METAL	M	NA	S	N
24	10	00	80	0.0100	0.0000	0			MERCURY	M	T	S*	N
25	10	00	80	14.7400	0.0000	0			HYDROGEN CYANIDE	I	I/R	L	N
26	10	00	80	2.8000	0.0000	0			CARCINOGEN	O*	TBD	NA	N
27	11	00	80	3.0000	0.0000	0			INORGANIC	I	NA	NA	N
28	11	00	80	5.0000	0.0000	0			ORGANIC	O	NA	L	N
29	11	00	80	4.8200	0.0000	0			ACID	I/O	C*	L	N
30	11	00	80	8.0000	0.0000	0			OIL	O	TBD	L	N
31	11	00	80	0.0000	0.0000	5			CYLINDERS	NA	NA	V	N
32	11	00	80	0.0500	0.0000	0			MERCURY	M	T	S*	N
33	11	00	80	0.0000	0.0000	1			IGNITRON	M	T	S*	N
34	11	00	80	0.0000	0.0000	3			PLASTIC & PYREX CONTAINERS	I	TBD	S	N
35	03	00	80	99.2900	0.0000	0			OIL	O	TBD	L	N
36	03	00	80	17.0000	0.0000	0			ASBESTOS	I	TBD	S	N
37	03	00	80	0.0000	0.0000	112			CYLINDERS	NA	NA	V	N
38	03	00	80	0.1600	0.0000	0			MERCURY	M	T	S*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 2
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
39	03	00	80	20.0000	0.0000	0			MISC.	NA	NA	NA	N
40	04	00	80	2.6800	0.0000	0			ORGANIC	O	NA	L	N
41	04	00	80	2.6800	0.0000	0			INORGANIC	I	NA	NA	N
42	04	00	80	0.0000	7400.0000	0			METAL	M	NA	S	N
43	04	00	80	28.1400	0.0000	0			ACID	I/O	C*	L	N
44	04	00	80	0.0900	0.0000	0			MERCURY	M	T	S*	N
45	04	00	80	0.0000	0.0000	5			CYLINDERS	NA	NA	V	N
46	04	00	80	20.0000	0.0000	0			ASBESTOS	I	TBD	S	N
47	04	00	80	53.6000	0.0000	0			OIL	O	TBD	L	N
48	05	00	80	13.2700	0.0000	0			ORGANIC	O	NA	L	N
49	05	00	80	0.0000	265.0000	0			INORGANIC	I	NA	NA	N
50	05	00	80	19.0000	0.0000	0			BERYLLIUM	M	TBD	S	N
51	05	00	80	73.0300	0.0000	0			ACIDS	I/O	C*	L	N
52	05	00	80	0.1700	0.0000	0			MERCURY	M	T	S*	N
53	05	00	80	118.5900	0.0000	0			OIL	O	TBD	L	N
54	05	00	80	0.0000	0.0000	7			CYLINDERS	NA	NA	V	N
55	06	00	80	11.5200	0.0000	0			ORGANICS	O	NA	L	N
56	06	00	80	7.7700	0.0000	0			INORGANICS	I	NA	NA	N
57	06	00	80	0.0000	55.0000	0			METAL	M	NA	S	N
58	06	00	80	73.7000	0.0000	0			OIL	O	TBD	L	N
59	06	00	80	0.0000	43.0000	0			MERCURY	M	T	S*	N
60	06	00	80	7.0000	0.0000	0			ASBESTOS	I	TBD	S	N
61	06	00	80	15.8100	0.0000	0			ACID	I/O	C*	L	N
62	07	00	80	10.3200	0.0000	0			ORGANIC	O	NA	L	N
63	07	00	80	3.3500	0.0000	0			INORGANIC	I	NA	NA	N
64	07	00	80	0.1000	0.0000	0			LITHIUM	M	R	S*	N
65	07	00	80	0.0170	0.0000	0			BERYLLIUM	M	TBD	S	N
66	07	00	80	67.0000	0.0000	0			OIL	O	TBD	L	N
67	07	00	80	3.0000	0.0000	0			ASBESTOS	I	TBD	S	N
68	07	00	80	33.6300	0.0000	0			ACID	I/O	C*	L	N
69	09	00	79	24.0000	0.0000	0			ORGANICS	O	NA	L*	N
70	09	00	79	10.0000	0.0000	0			INORGANICS	I	NA	NA	N
71	09	00	79	0.1400	0.0000	0			MERCURY	M	T	S*	N
72	09	00	79	4.0000	0.0000	0			ASBESTOS	I	TBD	S	N
73	09	00	79	0.0000	21.0000	0			METAL	M	NA	S	N
74	09	00	79	22.0000	0.0000	0			OIL	O	TBD	L	N
75	09	00	79	3.0000	0.0000	0			ACID	I/O	C*	L	N
76	09	00	79	3.0000	0.0000	0			CARAOE ZINC LIQUID	I	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

age No.   3
/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
77	11	00	79	3.6200	0.0000	0			ACID	I/O	C*	L	N
78	11	00	79	9.6500	0.0000	0			ORGANICS	O	NA	L*	N
79	11	00	79	0.3000	0.0000	0			INORGANICS	I	NA	NA	N
80	11	00	79	76.2500	0.0000	0			OIL	O	TBD	L	N
81	11	00	79	7.0000	0.0000	0			ASBESTOS	I	TBD	S	N
82	12	00	79	1.8800	0.0000	0			ACIDS & BASES	I/O	C*	L	N
83	12	00	79	6.7000	0.0000	0			ORGANICS	O	NA	L*	N
84	12	00	79	40.0000	0.0000	0			INORGANICS	I	NA	NA	N
85	12	00	79	69.6800	0.0000	0			OIL	O	TBD	L	N
86	12	00	79	1.0000	0.0000	0			MAGNESIUM	M	TBD	S	N
87	12	00	79	1.0000	0.0000	0			MERCURY	M	T	S*	N
88	12	00	79	1.0000	0.0000	0			LITHIUM	M	R	S	N
89	12	00	79	16.0000	0.0000	0			ASBESTOS	I	TBD	S	N
90	01	00	80	600.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
91	01	00	80	150.0000	0.0000	0			BERYLLIUM, LITHIUM, MAGNESIUM, SODIUM	M	R	S	N
92	01	00	80	0.0000	0.0000	225			1 GAL EMPTY CYLINDERS	NA	NA	S	N
93	02	00	80	216.1400	0.0000	0			ORG & INORG LIQUID WASTE	I/O	NA	L	N
94	02	00	80	0.0000	328.0000	0			BARIUM NITRATE	I	T	S	N
95	02	00	80	17.0000	0.0000	0			BERYLLIUM, LITHIUM, MAGNESIUM	M	R	S	N
96	02	00	80	20.0000	0.0000	0			ASBESTOS	I	TBD	S	N
97	02	00	80	16.3500	0.0000	0			OIL	O	TBD	L	N
98	03	00	80	327.0000	0.0000	0			ORGANIC	O	NA	L*	N
99	03	00	80	234.0000	0.0000	0			INORGANIC	I	NA	NA	N
100	03	00	80	300.0000	0.0000	0			BARIUM NITRATE	I	T	S	N
101	03	00	80	0.0000	58.0000	0			METAL	M	NA	S	N
102	03	00	80	180.7700	0.0000	0			ACID	I/O	C*	L*	N
103	07	16	79	3.0000	0.0000	0			CHEMICALS	I/O	NA	NA	N
104	07	17	79	2.0000	0.0000	0			LEAD NITRATE	I	TBD	S	N
105	07	18	79	5.0000	0.0000	0			CHEMICALS; PIPE CONTAMINATED WITH SODIUM	I	R	NA	N
106	07	19	79	3.0000	0.0000	0			ORGANICS	O	NA	L	N
107	07	19	79	2.0000	0.0000	0			INORGANICS	I	NA	NA	N
108	07	19	79	0.1100	0.0000	0			MERCURY	M	T	S*	N
109	07	23	79	20.0000	0.0000	0			SULFURIC ACID	I	C	L	N
110	07	23	79	20.0000	0.0000	0			ORGANICS	O	NA	L	N
111	07	25	79	0.0350	0.0000	0			MERCURY	M	T	S*	N
112	07	25	79	24.0000	0.0000	0			ORGANICS	O	NA	L	N
113	07	25	79	1.0000	0.0000	0			ACID	I/O	C	L	N
114	07	25	79	2.0000	0.0000	0			INORGANICS	I	NA	NA	N

BENCHMARK ENVIRO

age No. 4
0/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
115	07 25 79	2.0000	0.0000	0			ORGANICS	O	NA	L	N
116	08 00 79	24.0000	0.0000	0			OIL	O	TBD	L	N
117	08 00 79	38.0000	0.0000	0			ORGANIC	O	NA	L	N
118	08 00 79	11.0000	0.0000	0			INORGANIC	I	NA	NA	N
119	08 00 79	1.0000	0.0000	0			METAL	M	NA	S	N
120	08 00 79	27.0000	0.0000	0			ASBESTOS	I	TBD	S	N
121	08 00 79	48.0000	0.0000	0			OIL	O	TBD	L	N
122	10 00 79	31.8900	0.0000	0			ACID	I/O	C	L	N
123	10 00 79	3.0000	0.0000	0			INORGANICS	I	NA	NA	N
124	10 00 79	0.0000	500.0000	0			BARIUM NITRATE	I	T	S	N
125	10 00 79	21.3100	0.0000	0			ORGANICS	O	NA	L	N
126	10 00 79	2.0000	0.0000	0			MERCURY	M	T	S	N
127	10 00 79	10.0000	0.0000	0			ASBESTOS	I	TBD	S	N
128	10 00 79	2.0000	0.0000	0			BERYLLIUM CONTAMINATED WASTE	M	TBD	S	N
129	10 00 79	0.0000	0.0000	10			10 EMPTY DRUMS	NA	NA	S	N
130	10 00 79	29.4800	0.0000	0			CHROMIC ACID SOLUTION	I	C	L	N
131	05 01 79	3.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
132	05 03 79	2.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
133	05 04 79	6.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
134	05 09 79	5.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
135	05 14 79	7.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
136	05 14 79	33.0000	0.0000	0			NITRIC ACID	I	C	L	N
137	05 14 79	454.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
138	05 23 79	5.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
139	05 24 79	9.0000	0.0000	0			METAL	M	NA	S	N
140	05 25 79	5.0000	0.0000	0			CHEMICALS & BERYLLIUM CONTAMINATED WOOD	I/O/M	NA	S	N
141	05 29 79	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
142	05 30 79	130.0000	0.0000	0			OIL DRUMS, CHEMICALS	NA	NA	NA	N
143	05 31 79	20.0000	0.0000	0			ASBESTOS	I	TBD	S	N
144	06 05 79	31.0000	0.0000	0			OIL, SPECIAL TUBES, CAPACITORS	NA	NA	NA	N
145	07 02 79	4.0000	0.0000	0			ORGANICS	O	NA	L	N
146	07 02 79	2.0000	0.0000	0			INORGANICS	I	NA	NA	N
147	07 05 79	2.0000	0.0000	0			ASBESTOS	I	TBD	S	N
148	07 05 79	4.0000	0.0000	0			ORGANICS	O	NA		N
149	07 05 79	1.0000	0.0000	0			INORGANICS	I	NA	NA	N
150	07 10 79	5.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
151	07 10 79	21.0000	0.0000	0			BARIUM	M	T	S	N
152	07 11 79	1.0000	0.0000	0			MERCURY BOTTLE	M	T	S	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 5
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
153	07 11 79	30.0000	0.0000	0			BERYLLIUM METALS	M	TBD	S	N
154	07 13 79	4.0000	0.0000	0			GAS WITH WATER	O	TBD	L	N
155	07 13 79	4.0000	0.0000	0			MERCURY	M	T	S*	N
156	07 13 79	4.0000	0.0000	0			OIL	O	TBD	L	N
157	03 08 79	3.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
158	03 12 79	1.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
159	03 14 79	26.0000	0.0000	0	02		CHROMIC SULFURIC ACIDS	I	C	L	Y
160	03 14 79	10.0000	0.0000	0	02		STRIPPING SOLUTION	O	NA	L	Y
161	03 14 79	20.0000	0.0000	0			CHLORETHANE	O	I	V	N
162	03 21 79	9.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
163	03 27 79	330.0000	0.0000	0			OIL	O	TBD	L	N
164	04 06 79	30.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
165	04 06 79	0.0000	0.0000	1			ONE CYLINDER SULFURIC ACID	I	C	L	N
166	04 09 79	5.0000	0.0000	1			LITHIUM METAL	M	R	S	N
167	04 10 79	39.0000	0.0000	1			WASTE	NA	NA	NA	N
168	04 11 79	4.0000	0.0000	0			WASTE	NA	NA	NA	N
169	04 19 79	65.0000	0.0000	0			WASTE	NA	NA	NA	N
170	04 20 79	6.0000	0.0000	0			WASTE	NA	NA	NA	N
171	04 20 79	4.0000	0.0000	0			WASTE	NA	NA	NA	N
172	04 24 79	10.0000	0.0000	0			WASTE	NA	NA	NA	N
173	04 25 79	54.0000	0.0000	0			LITHIUM HYDRIDE DRUMS	I	R	S	N
174	04 25 79	10.0000	0.0000	0			ASBESTOS	I	TBD	S	N
175	04 26 79	6.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
176	04 30 79	20.0000	0.0000	0			BERYLLIUM CONTAMINATED TRASH	M	TBD	S	N
177	04 30 79	118.0000	0.0000	0			OIL	O	TBD	L	N
178	12 27 78	37.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
179	01 02 79	23.0000	0.0000	0			SHELL TRANSFORMER OIL	O	TBD	L	N
180	01 04 79	14.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
181	01 11 79	18.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
182	01 24 79	52.0000	0.0000	0			LITHIUM HYDRIDE	I	R	S	N
183	02 02 79	61.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
184	02 05 79	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
185	02 26 79	30.0000	0.0000	0			WASTE	NA	NA	NA	N
186	03 01 79	150.0000	0.0000	0			CHEMICALS, OIL	I/O	NA	L/S	N
187	03 01 79	5.0000	0.0000	0			METAL, MERCURY	M	T	S	N
188	03 01 79	2.0000	0.0000	0			BARIUM NITRATE ACID, METALS, CAUSTIC	I/M	T	S/L	N
189	03 05 79	2.0000	0.0000	0			MERCURY	M	T	S*	N
190	03 07 79	2.0000	0.0000	0			WASTE	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

age No. 6
0/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
191	08	11	78	10.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
192	08	23	78	8.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
193	09	20	78	10.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
194	10	04	78	14.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
195	10	12	78	12.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
196	10	24	78	78.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
197	11	08	78	35.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
198	11	09	78	37.0000	0.0000	0			BERYLLIUM CONTAMINATED ETHANOL	I	I	L	N
199	11	22	78	41.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
200	12	13	78	64.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
201	03	22	78	4.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
202	03	29	78	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
203	04	05	78	28.5000	0.0000	0			BERYLLIUM WASTE	N/I	TBD	S	N
204	04	05	78	28.5000	0.0000	0	02		MIXED CHEMICALS	NA	NA	NA	Y
205	04	11	78	9.0000	0.0000	0	11		DIRTY OIL	O	TBD	L	Y
206	05	01	78	95.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
207	05	17	78	7.0000	0.0000	0				NA	NA	NA	N
208	05	23	78	100.0000	0.0000	0				NA	NA	NA	N
209	06	07	78	37.0000	0.0000	0				NA	NA	NA	N
210	06	09	78	10.0000	0.0000	0			OLD CHEMICALS	NA	NA	NA	N
211	06	14	78	1.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
212	06	30	78	30.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
213	07	19	78	25.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
214	00	00	00	0.0000	0.0000	0			POLYCHLORINATED BIPHENYL RAGS (7/78)	O	TBD	S	N
215	08	09	78	28.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
216	08	09	78	0.0000	0.0000	1			HYDROGEN CHLORIDE CYLINDER	I	TBD	V	N
217	12	08	77	2.0000	0.0000	1	09		FLUORINE GAS CYLINDER	I	TBD	V	Y
218	12	15	77	46.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
219	12	21	77	4.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
220	12	29	77	1.0000	0.0000	0	02		OSMIUM TEROXIDE	I	TBD	S	Y
221	01	04	78	1.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
222	01	11	78	7.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
223	01	25	78	14.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
224	01	27	78	2.0000	0.0000	0	02		"NITRATED" PLEXIGLASS BOX	I	TBD	S	Y
225	02	02	78	2.0000	0.0000	0			ETCHING SOLUTION	O*	NA	L	N
226	02	14	78	16.0000	0.0000	0			SOLVENT	O	I*	L	N
227	02	22	78	19.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
228	02	24	78	8.0000	0.0000	0			TRICHLOROETHYLENE	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 7
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALSTS.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
229	03	02	78	2.0000	0.0000	0			BROKEN BATTERY	I	C	L/S	N
230	03	06	78	64.0000	0.0000	0			OIL	O	TBD	L	N
231	03	07	78	33.0000	0.0000	0			"SPECIAL PICKUP"	NA	NA	NA	N
232	03	17	78	3.0000	0.0000	0			SODIUM-POTASSIUM ALLOY CONTROLLERS; ORGANIC SOLVENT	I/O	TBD	S/L	N
233	10	21	77	200.0000	0.0000	0	10		OIL, 2 CAPACITORS, SMALL BOTTLE SULFURIC ACID	I/O	TBD	L/S	Y
234	11	03	77	1.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
235	11	04	77	40.0000	0.0000	0	10		DRUMS	NA	NA	NA	Y
236	11	09	77	5.2500	0.0000	0			MISC. ORGANIC CHEMICALS	O	NA	L/S	N
237	11	09	77	5.2500	0.0000	0	10		USED OIL	O	TBD	L	Y
238	11	14	77	32.0000	0.0000	0			SOLVENTS	O	I*	L	N
239	11	17	77	26.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
240	11	17	77	0.0000	0.0000	0	09		OLD GAS CYLINDERS	NA	NA	S	Y
241	11	18	77	22.0000	0.0000	0			DRUMS	NA	NA	NA	N
242	11	18	77	0.0000	0.0000	0	07		1 SMALL CAN/CARDBOARD BOX	NA	NA	S	Y
243	11	21	77	0.5000	0.0000	0	07		HEAT PIPE & LITHIUM	I	R	S	Y
244	11	22	77	53.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
245	11	23	77	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
246	12	01	77	45.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
247	12	02	77	1.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
248	08	10	77	26.0000	0.0000	0	10		DRUMS, SOLVENTS	I/O	NA	S/L	Y
249	08	12	77	24.0000	0.0000	0	10		DRUMS	NA	NA	NA	Y
250	08	15	77	1.0000	0.0000	0	06		2 SODIUM-POTASSIUM VALVES	I	TBD	S	Y
251	08	15	77	2.0000	0.0000	2	09		2 LECTURE SIZE TANKS	NA	NA	S	Y
252	08	17	77	18.5000	0.0000	0	06		CHEMICALS, BERYLLIUM OXIDE, LITHIUM	I/N	R	S	Y
253	08	29	77	26.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
254	09	07	77	3.0000	0.0000	0			SULFURIC ACID	I	C	L	N
255	09	07	77	3.0000	0.0000	0	10		TRANSFORMER OIL	O	TBD	L	Y
256	09	07	77	3.0000	0.0000	0	02		WHITE PHOSPHOROUS	I	TBD	S	Y
257	09	14	77	11.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
258	09	15	77	48.0000	0.0000	0			DRUMS W/SOLVENTS, PCB RAGS	O	TBD	S/L	N
259	09	21	77	12.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
260	09	29	77	0.1000	0.0000	0	06		SMALL PKG MAGNESIUM CHIPS	N	R	S	Y
261	09	30	77	18.0000	0.0000	0	10		OLD PHOTO CHEMICALS	NA	NA	L	Y
262	10	04	77	72.0000	0.0000	0	10		DRUMS	NA	NA	NA	Y
263	10	14	77	6.0000	0.0000	0	06		CHEMICALS, LITHIUM HYDRIDE	I/O	R	NA	Y
264	10	14	77	25.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS	O/I	NA	NA	N
265	10	19	77	1.0000	0.0000	0			ORGANICS	O	NA	L	N
266	07	13	77	16.0000	0.0000	0	10		BORIC ACID	I	TBD	S	Y

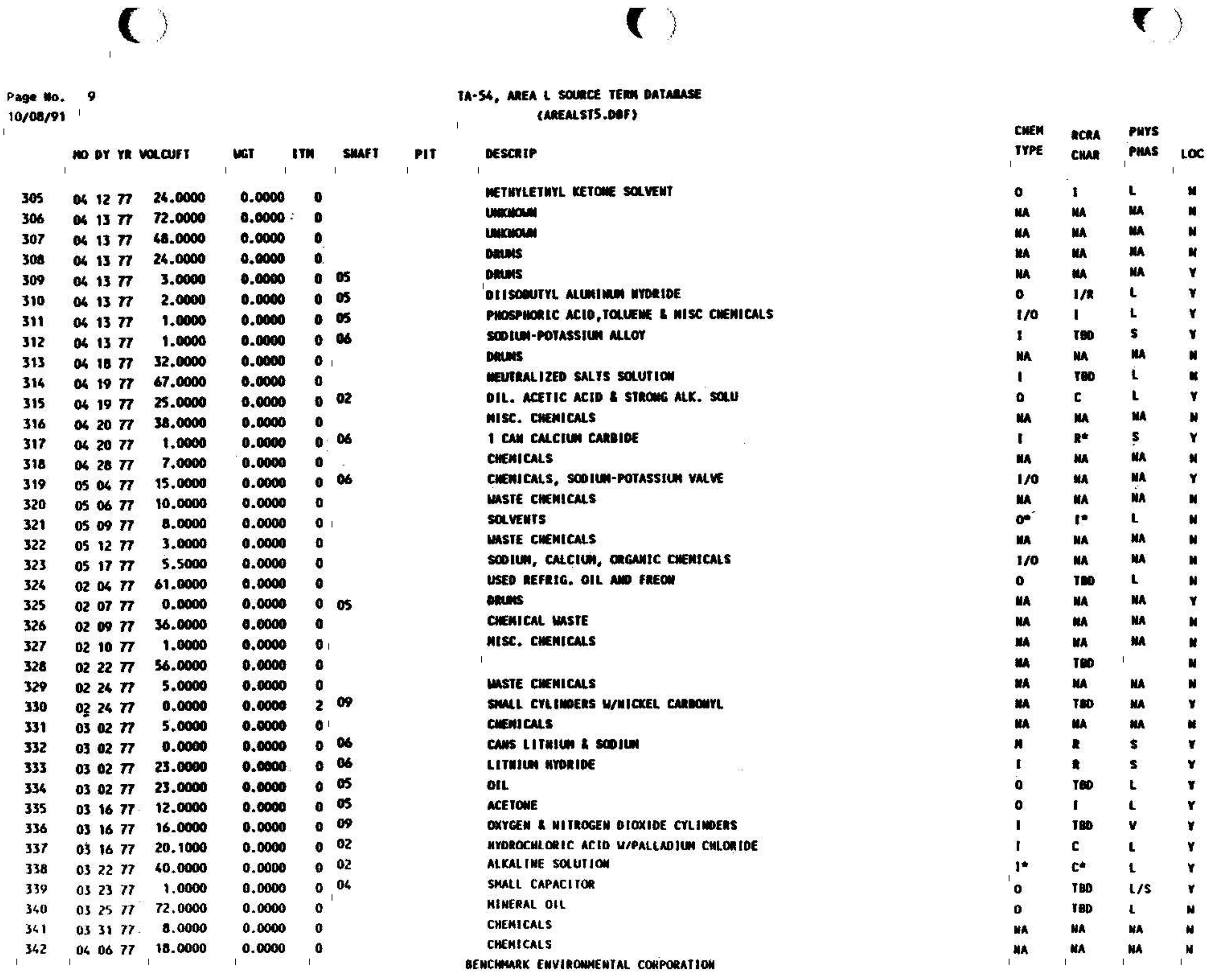
BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 8
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
267	07	14	77	7.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
268	07	14	77	2.0000	0.0000	0			MILD ACID PLATING SOLUTION	I*	TBD	L	N
269	07	18	77	32.0000	0.0000	4			SOLVENTS	O*	I*	L	N
270	07	20	77	7.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
271	07	21	77	2.0000	0.0000	0	02		CALCIUM CARBIDE	I	R	S	Y
272	07	25	77	1.0000	0.0000	0	06		2 SODIUM-POTASSIUM ALLOY VALVES	I	TBD	S	Y
273	07	25	77	1.0000	0.0000	0	06		SODIUM-POTASSIUM ALLOY VALVE	I	TBD	S	Y
274	07	27	77	0.5000	0.0000	0	06		SODIUM-POTASSIUM ALLOY VALVE	I	TBD	S	Y
275	07	28	77	0.0000	0.0000	0			(1) BOTTLE LEAKING THIOPHOSGENE	I	T	S	N
276	07	28	77	31.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
277	07	28	77	4.0200	0.0000	0	06		1 30 GALLON DRUM LITHIUM CHIPS	I	R	S	Y
278	07	28	77	21.4400	0.0000	0	02		ACID	I/O	C	L	Y
279	07	29	77	1.5000	0.0000	0	06		3 SODIUM-POTASSIUM ALLOY VALVES	I	TBD	S	Y
280	08	03	77	1.0000	0.0000	0	06		2 SODIUM-POTASSIUM ALLOY VALVES	I	TBD	S	Y
281	08	05	77	4.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
282	08	08	77	27.5000	0.0000	0	03		MAGNESIUM OXIDE	I	TBD	S	Y
283	08	08	77	27.5000	0.0000	0			SOLVENTS	O	I*	L	N
284	08	09	77	1.0000	0.0000	0	06		1 SODIUM-POTASSIUM ALLOY VALVE	I	TBD	S	Y
285	05	19	77	3.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
286	05	23	77	48.0000	0.0000	0			DRUMS	NA	NA	NA	N
287	05	25	77	12.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
288	05	25	77	0.0000	1.0000	0	06		LITHIUM	M	R	S	Y
289	06	02	77	10.0000	0.0000	0			CHEMICALS (SOLVENTS)	O	I	L	N
290	06	06	77	3.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
291	06	06	77	0.0000	0.0000	1	06		SMALL CYLINDER TRIETHYL ALUMINUM	O	I	L	Y
292	06	07	77	36.0000	0.0000	0	10		CHELATING AGENT	O	TBD	S	Y
293	06	07	77	0.0000	0.0000	0			DRUMS	NA	NA	NA	N
294	06	07	77	0.0000	0.0000	0		A	DRUMS	NA	NA	NA	Y
295	06	09	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
296	06	17	77	2.0000	0.0000	0			2 EMPTY DRUMS SODIUM HYDROXIDE; 2 CANS OF OIL	O/I	TBD	S/L	N
297	06	21	77	4.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
298	06	22	77	10.0000	0.0000	0			CALGON (SODIUM PHOSPHATE)	I	TBD	S	N
299	06	23	77	0.0000	0.0000	2	09		HYDROGEN CYANIDE TANKS	O	T	V	Y
300	06	23	77	3.0000	0.0000	0			SOLVENT	O	I*	L	N
301	06	24	77	8.0000	0.0000	0	02		PERCHLORIC ACID	I	R	L	Y
302	06	27	77	1.0000	0.0000	0	06		SODIUM-POTASSIUM ALLOY VLV ASSEMBLY	I	TBD	S	Y
303	07	12	77	8.0000	0000	0	02		SODIUM CHLORIDE	I	TBD	S	Y
304	04	11	77	48.0000	0000	0			USED OIL	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION



Page No. 9
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
305	04	12	77	24.0000	0.0000	0			METHYLETHYL KETONE SOLVENT	O	I	L	N
306	04	13	77	72.0000	0.0000	0			UNKNOWN	NA	NA	NA	N
307	04	13	77	48.0000	0.0000	0			UNKNOWN	NA	NA	NA	N
308	04	13	77	24.0000	0.0000	0			DRUMS	NA	NA	NA	N
309	04	13	77	3.0000	0.0000	0	05		DRUMS	NA	NA	NA	Y
310	04	13	77	2.0000	0.0000	0	05		DIISOBUTYL ALUMINUM HYDRIDE	O	I/R	L	Y
311	04	13	77	1.0000	0.0000	0	05		PHOSPHORIC ACID,TOLUENE & MISC CHEMICALS	I/O	I	L	Y
312	04	13	77	1.0000	0.0000	0	06		SODIUM-POTASSIUM ALLOY	I	TBD	S	Y
313	04	18	77	32.0000	0.0000	0			DRUMS	NA	NA	NA	N
314	04	19	77	67.0000	0.0000	0			NEUTRALIZED SALTS SOLUTION	I	TBD	L	N
315	04	19	77	25.0000	0.0000	0	02		DIL. ACETIC ACID & STRONG ALK. SOLU	O	C	L	Y
316	04	20	77	38.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
317	04	20	77	1.0000	0.0000	0	06		1 CAN CALCIUM CARBIDE	I	R*	S	Y
318	04	28	77	7.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
319	05	04	77	15.0000	0.0000	0	06		CHEMICALS, SODIUM-POTASSIUM VALVE	I/O	NA	NA	Y
320	05	06	77	10.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
321	05	09	77	8.0000	0.0000	0			SOLVENTS	O*	I*	L	N
322	05	12	77	3.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
323	05	17	77	5.5000	0.0000	0			SODIUM, CALCIUM, ORGANIC CHEMICALS	I/O	NA	NA	N
324	02	04	77	61.0000	0.0000	0			USED REFRIG. OIL AND FREON	O	TBD	L	N
325	02	07	77	0.0000	0.0000	0	05		DRUMS	NA	NA	NA	Y
326	02	09	77	36.0000	0.0000	0			CHEMICAL WASTE	NA	NA	NA	N
327	02	10	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
328	02	22	77	56.0000	0.0000	0				NA	TBD		N
329	02	24	77	5.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
330	02	24	77	0.0000	0.0000	2	09		SMALL CYLINDERS W/NICKEL CARBONYL	NA	TBD	NA	Y
331	03	02	77	5.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
332	03	02	77	0.0000	0.0000	0	06		CANS LITHIUM & SODIUM	N	R	S	Y
333	03	02	77	23.0000	0.0000	0	06		LITHIUM HYDRIDE	I	R	S	Y
334	03	02	77	23.0000	0.0000	0	05		OIL	O	TBD	L	Y
335	03	16	77	12.0000	0.0000	0	05		ACETONE	O	I	L	Y
336	03	16	77	16.0000	0.0000	0	09		OXYGEN & NITROGEN DIOXIDE CYLINDERS	I	TBD	V	Y
337	03	16	77	20.1000	0.0000	0	02		HYDROCHLORIC ACID W/PALLADIUM CHLORIDE	I	C	L	Y
338	03	22	77	40.0000	0.0000	0	02		ALKALINE SOLUTION	I*	C*	L	Y
339	03	23	77	1.0000	0.0000	0	04		SMALL CAPACITOR	O	TBD	L/S	Y
340	03	25	77	72.0000	0.0000	0			MINERAL OIL	O	TBD	L	N
341	03	31	77	8.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
342	04	06	77	18.0000	0.0000	0			CHEMICALS	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

'age No. 10
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
343	04	07	77	13.0000	0.0000	0	02		NITRIC ACID	I	C	L	Y
344	11	23	76	36.0000	0.0000	0			GLASS CARBOYS (SOLV. & EXCESS)	O*	I*	L	N
345	12	02	76	5.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
346	12	02	76	3.0000	0.0000	0	07		SODIUM, POTASSIUM	M	R	S	Y
347	12	17	76	30.0000	0.0000	0			SOLVENT (110 GAL), ETCHING SOLN (150)	O	I*	L	N
348	12	17	76	64.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
349	12	27	76	24.0000	0.0000	0			SOLVENTS	O*	I*	L	N
350	12	29	76	12.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
351	01	13	77	5.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
352	01	19	77	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
353	01	24	77	51.5900	0.0000	0	05			NA	TBD		Y
354	01	26	77	5.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
355	01	26	77	5.0000	0.0000	0	06		2 SMALL BOTTLES SODIUM	I	R	S	Y
356	01	26	77	5.0000	0.0000	0	09		3 SMALL BOTTLES OF ???	M	R	S	Y
357	01	27	77	0.5000	0.0000	0	06		SODIUM	M	R	S	Y
358	02	01	77	216.0000	0.0000	0			OIL & SOLVENTS	O	I*	L	N
359	02	02	77	160.0000	0.0000	0			OIL	O	TBD	L	N
360	02	03	77	34.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
361	01	06	76	3.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
362	01	07	76	2.0000	0.0000	0			HYDROGEN FLUORIDE CONTAMINATED CYLINDERS	I	TBD	V	N
363	02	03	76	150.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
364	02	10	76	2.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
365	02	12	76	48.0000	0.0000	0		A	SOLVENT (SOLVENT PIT)	O	I*	L	Y
366	02	12	76	12.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
367	02	24	76	36.0000	0.0000	0	06		LITHIUM METAL	M	R	S	Y
368	03	05	76	2.0000	0.0000	0			HYDROFLUORIC ACID	I	C	L	N
369	03	09	76	64.0000	0.0000	0			MISC CHEM	NA	NA	NA	N
370	03	09	76	0.0000	0.0044	0	06		SODIUM	M	R	S	Y
371	03	12	76	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
372	03	12	76	0.5000	0.0000	0	06		LITHIUM	M	R	S	Y
373	03	16	76	80.0000	0.0000	0		A	OLD CHEMICALS (SOLVENT PIT)	NA	NA	NA	Y
374	03	23	76	1.0000	0.0000	0	06		LITHIUM	M	R	S	Y
375	03	23	76	7.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
376	03	23	76	7.5000	0.0000	0	06		CYANIDE CRYSTAL	I	R	S	Y
377	03	25	76	6.0000	0.0000	0			MISC CHEMICALS	NA	NA	NA	N
378	04	07	76	58.9600	0.0000	0	06		OIL	O	TBD	L	Y
379	04	07	76	88.4400	0.0000	0		A	OLD CHEMICALS (SOLVENT PIT)	NA	NA	NA	Y
380	04	07	76	10.0000	0.0000	0	02		BARIUM NITRATE	I	T	S	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 11
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
381	04	12	76	75.0000	0.0000	0			MISC CHEMICALS & OIL	O	NA	L	N
382	04	12	76	1.0000	0.0000	0	09		GAS SAMPLES, XENON TRIFLUORIDE	I	NA	V/S	Y
383	04	13	76	40.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
384	04	13	76	0.0000	1.0000	0	06		SODIUM	M	R	S	Y
385	04	15	76	1.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
386	04	15	76	1.0000	0.0000	0	07		SODIUM-POTASSIUM CHIPS	M	R	S	Y
387	04	27	76	12.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
388	04	27	76	40.0000	0.0000	0	07		LITHIUM HYDRIDE FILTERS	I	R	S	Y
389	05	12	76	12.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
390	05	27	76	19.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
391	05	27	76	8.1700	0.0000	0	07		MAGNESIUM CHIPS IN DRUMS	M	R	S	Y
392	06	01	76	22.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
393	06	08	76	36.0000	0.0000	0			MISC CHEMICALS	NA	NA	NA	N
394	06	08	76	14.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
395	06	15	76	16.0000	0.0000	0			KETONE SOLVENTS	O	I*	L	N
396	06	15	76	10.0000	0.0000	0			3 CAPACITORS, OIL (30 GALLONS), MISC. CHEMICALS	NA	NA	NA	N
397	06	16	76	4.0000	0.0000	0			ACETIC ACID	O	C	L	N
398	06	23	76	30.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
399	06	25	76	56.0000	0.0000	0	05		WASTE OIL	O	TBD	L	Y
400	06	28	76	1.0000	0.0000	1	09		LEAKY HYDROGEN FLUORIDE CYLINDER	I	TBD	V	Y
401	07	06	76	16.0000	0.0000	0			SOLVENT	O	I*	L	N
402	07	12	76	64.0000	0.0000	0	05		HYDRAULIC OIL	O	TBD	L	Y
403	07	16	76	9.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
404	07	16	76	1.0000	0.0000	0	06		SMALL TUBE OF CESIUM	I	R	S	Y
405	07	30	76	6.5000	0.0000	0			CHEMICALS	NA	NA	NA	N
406	08	11	76	40.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
407	08	11	76	10.0000	0.0000	0	09		2 SMALL BOTTLES (NO LABELS)	M	TBD	S	Y
408	08	17	76	24.0000	0.0000	0			SOLVENT	O	I*	L	N
409	08	19	76	0.5000	0.0000	2	09		2 BORON TRIFLUORIDE CYLINDERS	I	TBD	V	Y
410	08	19	76	36.8500	0.0000	0			OIL	O	TBD	L	N
411	08	25	76	15.0000	0.0000	0			WASTE CHEMICALS	NA	NA	NA	N
412	09	01	76	8.0000	0.0000	0	05		OIL	O	TBD	L	Y
413	09	08	76	132.6600	0.0000	0	05			NA	TBD		Y
414	09	08	76	8.0400	0.0000	0	06			NA	TBD		Y
415	09	09	76	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
416	09	10	76	1.0000	0.0000	1	09		OLD CORRODED NICKEL CARBONYL CYLINDER	O	R/I	L/S	Y
417	09	10	76	8.0000	0.0000	0	05		EMPTY PLASTIC DRUM	NA	NA	S	Y
418	09	15	76	8.0000	0.0000	0			CHEMICAL WASTE	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 12
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
419	09 22 76	102.0000	0.0000	0			SOLVENT & OIL	O	I	L	N
420	09 22 76	70.0000	0.0000	0			WASTE CHEMICALS,	NA	NA	NA	N
421	10 15 76	40.0000	0.0000	0			1-55 GAL. DRUMS FROM OMEGA, TA-55 OMEGA	NA	NA	NA	N
422	10 21 76	4.0000	0.0000	0		A	SALT SOLUTION	I	TBD	L	Y
423	10 22 76	8.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
424	10 28 76	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
425	11 08 76	200.0000	0.0000	0	05			NA	TBD		Y
426	11 11 76	1.0000	0.0000	0	02		XENON TANKS	I	TBD	V	Y
427	11 19 76	4.0000	0.0000	0	06		2 BADLY CORRODED CHLORINE CYLINDERS	I	TBD	V	Y
428	11 22 76	16.0000	0.0000	0	05		SOLVENT	O	I*	L	Y
429	12 11 80	2.6800	0.0000	0	17		CHROMIC ACID	I	C	L	Y
430	12 11 80	2.6800	0.0000	0	17		ARSENIC TRIOXIDE	I	T	S	Y
431	12 11 80	2.6800	0.0000	0	17		PHOSPHOROUS TRICHLORIDE	I	TBD	L	Y
432	12 11 80	0.2700	0.0000	0	17		BENZENE	O	T/I	L	Y
433	12 11 80	0.2700	0.0000	0	17		CARBON TETRACHLORIDE	O	T	L	Y
434	12 11 80	0.2700	0.0000	0	17		HEPTANE	O	I	L	Y
435	12 11 80	0.1340	0.0000	0	17		MERCURY	M	T	S*	Y
436	12 11 80	0.2700	0.0000	0	17		PHOSPOROUS OXYCHLORIDE	I	TBD	L	Y
437	12 11 80	0.1340	0.0000	0	17		CARBON TETRACHLORIDE	O	T	L	Y
438	12 11 80	12.0600	0.0000	0	17		ORGANIC WASTE	O	NA	L	Y
439	12 03 80	0.1400	0.0000	0	17		NINHYDRIN	O	TBD		Y
440	12 23 80	0.6700	0.0000	0	17		HEXANE/ACETONE MIXTURE	O	I	L	Y
441	12 12 80	0.1400	0.0000	0		B	PERCHLORIC ACID	I	R	L	Y
442	12 04 80	0.0170	0.0000	0	17		P-CHLOROPHENOL	O	C	S	Y
443	12 04 80	0.0170	0.0000	0	17		BROMINE & CARBON TETRACHLORIDE	O	T	L	Y
444	11 21 80	0.0500	0.0000	0	17		BENZENE	O	T/I	L	Y
445	12 11 80	4.0200	0.0000	0	17		1,1,1 - TRICHLOROETHANE	O	TBD	L	Y
446	12 03 80	0.1500	0.0000	0	17		PYRIDINE	O	T/I	L	Y
447	12 03 80	0.1000	0.0000	0	17		POLYOXYETHYLENE LAURAL ALCOHOL	O	TBD	L	Y
448	11 04 80	0.1000	0.0000	0			MERCAPTANS	O	I*	L	N
449	11 04 80	3.0000	0.0000	0	13		NITRIC ACID	I	C	L	Y
450	11 05 80	0.6700	0.0000	0	13		WATCH SOLUTION	NA	NA	L	Y
451	11 05 80	77.0000	0.0000	0	19		UNKNOWN OIL	O	TBD	L	Y
452	11 03 80	2.0000	0.0000	0			RENZENETHIOL, P-DIOXANE, TETRAHYDROFURAN	O	I	L	N
453	11 07 80	0.0000	0.0000	2			BORON TRIFLUORIDE, NITROGEN DIOXIDE	I	TBD	V	N
454	11 18 80	0.0000	0.0000	0			AMMONIUM HYDROXIDE	I	C	L	N
455	11 18 80	2.0000	0.0000	0			ORGANIC & INORGANIC	O/I	NA	L	N
456	11 18 80	0.0900	0.0000	0			AMMONIUM HYDROXIDE	I	C	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 13
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
457	11	18	80	0.0350	0.0000	0			MERCURIC CHLORIDE	I	T	S	N
458	11	18	80	0.0350	0.0000	0			1% ACETIC ACID SOLN	O	TBD	L	N
459	11	18	80	0.0350	0.0000	0			HYDROCHLORIC ACID	I	C	L	N
460	11	18	80	0.0350	0.0000	0			MAYERS HEMAXYLIN (HEMATOYLIN)	O	TBD	S	N
461	11	18	80	0.0350	0.0000	0			GLACIAL ACETIC ACID	O	C/I	L	N
462	11	18	80	0.0350	0.0000	0			PICRIC ACID	O	R	S*	N
463	11	18	80	0.0350	0.0000	0			ZENKER SOLN	NA	TBD	L	N
464	11	18	80	0.0350	0.0000	0			POTASSIUM HYDROXIDE	I	TBD	S	N
465	11	18	80	0.0350	0.0000	0			IODINE SOLN	I	TBD	L	N
466	11	18	80	0.0700	0.0000	0	17		POTASSIUM DICHROMATE & PHOSPHATE BUFFER	I	T	L	Y
467	11	18	80	0.5400	0.0000	0	17		TRICHLOROETHYLENE	O	T	L	Y
468	11	19	80	0.0000	0.0000	0			MERCURY VAPORS	M/I	T	V	N
469	11	19	80	0.5000	0.0000	0			VACUUM TUBES OF MERCURY	M	T	S	N
470	11	21	80	0.0018	0.0000	1	16		FLUORINE GAS	I	TBD	V	Y
471	11	20	80	0.0012	0.0000	1	16		BROMINE	I	TBD	L	Y
472	11	20	80	0.0010	0.0000	1	16		BROMINE TRIFLUORIDE	I	R	L	Y
473	11	20	80	0.0700	0.0000	1	16		BROMINE PENTAFLUORIDE	I	R	L	Y
474	11	21	80	0.0035	0.0000	1	16		BORON TRICHLORIDE	I	TBD	L	Y
475	11	21	80	0.0180	0.0000	1	16		PHOSPHOROUS PENTOXIDE	I	R	S	Y
476	11	21	80	0.0035	0.0000	1	16		SILANE	I	I	V	Y
477	11	21	80	0.0018	0.0000	0	13		HYDROGEN FLUORIDE	I	TBD	V	Y
478	10	01	80	1.0000	0.0000	0	17		ORGANIC	O	NA	L*	Y
479	10	08	80	1.0000	0.0000	0	13		INORGANIC	I	NA	NA	Y
480	10	01	80	0.4700	0.0000	0	17		LASER DYE	O*	TBD	L	Y
481	10	03	80	0.4600	0.0000	0	13		AMMONIUM HYDROXIDE	I	C	L	Y
482	10	03	80	0.0000	5.2800	0	13		ABSORBER	NA	TBD	S	Y
483	10	03	80	14.7400	0.0000	0	19		CHEMICALS	NA	NA	NA	Y
484	10	03	80	3.0000	0.0000	0	17		CHEMICALS/STRONG ACIDS	I/O	C	L	Y
485	10	08	80	50.0000	0.0000	0	19		OIL	O	TBD	L	Y
486	10	08	80	7.0000	0.0000	0			STRONG ACIDS	I/O	C	L	N
487	00	00	00	0.0000	0.0000	0			FLUORINE GAS CYLINDERS	I	TBD	V	N
488	09	25	80	1.0000	0.0000	0			MISC. ORGANIC LIQUIDS	O	NA	L	N
489	10	09	80	14.0000	0.0000	0			MAGNESIUM CHIPPING METAL	M	R	S	N
490	10	14	80	8.0000	0.0000	0	13		CHROMIC ACID	I	C	L	Y
491	10	16	80	3.0000	0.0000	0			ORGANIC & SULFURIC ACID	O	C	L	N
492	10	03	80	13.4000	0.0000	0	13		CYANIDE COPPER STRIKE BATH	I*	TBD	L	Y
493	10	20	80	0.0170	0.0000	0			DIPHENYLSULFIDE	O	TBD	L	N
494	10	30	80	2.0000	0.0000	0			ACIDS & BASES	I/O	C*	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 14
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
495	00 00 00	1.0000	0.0000	0	13		MERCURIC CYANIDE (10/80)	I	T/R	L	Y
496	09 15 80	1.0000	0.0000	0			PROPANEDIOL, W/CHROMIUM (V)	O	T	L	N
497	09 27 80	1.0000	0.0000	0			ETHER	O	I	L	N
498	09 26 80	1.0000	0.0000	0	13		NITRIC ACID	I	C	L	Y
499	09 26 80	7.3700	0.0000	0	13		ACIDS	I/O	C	L	Y
500	09 19 80	2.8100	0.0000	0			ORGANIC	O	NA	L*	N
501	09 19 80	0.6700	0.0000	0	13		SULFURIC ACID	I	C	L	Y
502	09 19 80	2.0000	0.0000	0			CHEM WASTE CLEANUP	NA	NA	NA	N
503	09 16 80	5.0000	0.0000	0			TRICHLOROETHENE, HARDENER, ORGANIC SOLVENT (UNKNOWN)	O	TBD	L	N
504	09 15 80	0.0700	0.0000	0			NITRIC ACID	I	C	L	N
505	09 15 80	0.0700	0.0000	0			ACETIC ACID	O	C	L	N
506	09 15 80	0.0700	0.0000	0			BUTYL ACETATE	O	TBD		N
507	09 15 80	0.0000	0.0700	0			AMMONIUM HYDROXIDE	I	C	L	N
508	09 15 80	0.0000	2.0000	0			SODIUM HYDROXIDE	I	C	L	N
509	09 15 80	0.0100	0.0000	0			ACETONE	O	I	L	N
510	09 10 80	73.3000	0.0000	0	19		WASTE OIL	O	TBD	L	Y
511	09 08 80	0.0000	0.0000	0			SODIUM VALVES	I	TBD		N
512	09 05 80	1.3400	0.0000	0	13		WATER W/ASBESTOS	I	TBD	L	Y
513	08 19 80	0.0350	0.0000	0			COBALT CHLORIDE	I	TBD	S	N
514	08 19 80	0.0350	0.0000	0			ORTHO CRESOLSULFONPHTHALEIN	O	TBD	S	N
515	08 19 80	0.0350	0.0000	0			DINITROPHENOL-A	O	R	S	N
516	08 19 80	0.0350	0.0000	0			1,5-DIPHENYLCARBAZIDE	O	TBD	S	N
517	08 19 80	22.1100	0.0000	0			SODIUM CHLOROPENTAPHENATE, SODIUM-2,4,5-TRICHLOROPHENATE, SODIUM SALTS,	O	TBD		N
518	08 19 80	0.0700	0.0000	0			HYDROXYLAMMONIUM CHLORIDE	I	TBD	L	N
519	08 19 80	0.0350	0.0000	0			IODINE CRYSTALS	I	TBD	S	N
520	08 19 80	0.0350	0.0000	0			MOLYBDATE REAGANT	I	TBD	L*	N
521	08 19 80	0.0350	0.0000	0			MERCURIC IODIDE IN POTASSIUM IODIDE	I	T	L*	N
522	08 19 80	0.0350	0.0000	0			4-METHYL-2-NITROPHENOL	O	TBD	S	N
523	08 19 80	0.0350	0.0000	0			ORANGE SHELLAC	O	TBD		N
524	08 19 80	0.1100	0.0000	0			PHENOLPHTHALEIN	O	TBD	S	N
525	08 19 80	0.0700	0.0000	0			POTASSIUM CHROMATE	I	T	S	N
526	08 19 80	0.1100	0.0000	0			POTASSIUM CHROMATE	I	T	S	N
527	08 19 80	0.0350	0.0000	0			POTASSIUM HYDROXIDE OIL	O	TBD	L	N
528	08 19 80	0.0350	0.0000	0			POTASSIUM IODIDE	I	TBD		N
529	08 19 80	0.0350	0.0000	0			POTASSIUM PERMANGANATE	I	TBD		N
530	08 19 80	0.0350	0.0000	0			POTASSIUM RHODANIDE	I	TBD		N
531	08 19 80	0.0350	0.0000	0			POTASSIUM SULFOCYANIDE	I	TBD		N
532	08 19 80	0.0350	0.0000	0			SILVER NITRATE	I	TBD		N

BENCHMARK ENVIRONMENTAL CORPORATION

age No. 15
0/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
533	08 19 80	0.1100	0.0000	0			SODIUM CARBONATE	I	TBD		N
534	08 19 80	0.1100	0.0000	0			SODIUM HYDROXIDE	I	TBD		N
535	08 19 80	0.1100	0.0000	0			SODIUM HYPOSULFATE	I	TBD		N
536	08 19 80	0.0350	0.0000	0			TRANS -1,2-DIAMINOCYCLOHEXANE TETRAACETIC ACID	O	TBD		N
537	08 19 80	0.0350	0.0000	0			ETHYLENEDIAMINE-TETRAACETIC ACID	O	TBD		N
538	08 19 80	0.0350	0.0000	0			TIN DICHLORIDE	I	TBD		N
539	08 19 80	0.0350	0.0000	0			SULFAMIC ACID	I	TBD		N
540	08 19 80	0.0700	0.0000	0			HYDROGEN SULFATE	I	TBD		N
541	08 19 80	0.0350	0.0000	0			ISOPROPYL-META-CRESOL	O	TBD		N
542	08 19 80	0.1100	0.0000	0			3-3' DYMETHYLBENZIDINE	O	TBD		N
543	08 19 80	0.0700	0.0000	0			PARA-(PARA-DIMETHYLAMINO PHENYL-AZOBENZENE SULFONATE)	O	TBD		N
544	08 19 80	0.0350	0.0000	0			UNKNOWN	NA	NA	NA	N
545	08 19 80	0.0350	0.0000	0			CARBAMIDE (UREA)	O	TBD	S	N
546	08 19 80	0.0350	0.0000	0			VERSENE IRON (III)	O	TBD	S	N
547	08 19 80	0.0350	0.0000	0			ALIZARIN REDS	O	TBD	S	N
548	08 19 80	0.0700	0.0000	0			1,2 HYDROXYANTHROQUINONE	O	TBD	NA	N
549	08 19 80	0.0350	0.0000	0			XYLENE CYANOLE DIFLUORIDE	O	TBD	NA	N
550	08 19 80	0.0350	0.0000	0			XYLENE CYANOLE	O	TBD	NA	N
551	08 19 80	0.0350	0.0000	0			UNKNOWN	NA	NA	NA	N
552	08 19 80	0.0350	0.0000	0			TOTAL CHROMINE BUFFER	NA	T	L*	N
553	08 19 80	0.0700	0.0000	0			TELLURIUM VERSENE IN POWDER PILLOWS	O	TBD	S	N
554	08 19 80	0.0350	0.0000	0			SODIUM DICHROMATE	I	T	S	N
555	08 19 80	0.0350	0.0000	0			SODIUM CHLORIDE SOLUTION	I	TBD	L	N
556	08 19 80	0.0000	1.0000	0			POTATO POWDER	O*	TBD	S	N
557	08 19 80	0.0350	0.0000	0			STABLE STARCH SOLUTION	O	TBD	L	N
558	08 19 80	0.0350	0.0000	0			SODIUM NITRATE	I	I	S	N
559	08 19 80	0.0700	0.0000	0			SODIUM AZIDETE	I	TBD	S	N
560	08 19 80	0.0350	0.0000	0			SILVER NITRATE	I	I	S	N
561	08 19 80	0.1400	0.0000	0			CHLOROHYDROXYBENZENE	O	TBD	S*	N
562	08 19 80	0.0350	0.0000	0			TRI CHLOROMETHANE (CHLOROFORM)	O	T	L	N
563	08 19 80	0.0350	0.0000	0			BROMINE	I	I*	L	N
564	08 19 80	0.0700	0.0000	0			3,3',5,5'-TETRABROMO-META-CRESOLSULFON-PHTHALEIN	O	TBD	S	N
565	08 19 80	0.0350	0.0000	0			BENZIDINE DIHYDROCHLORIDE	O	TBD	NA	N
566	08 19 80	0.0350	0.0000	0			POTASSIUM CHLORIDE & SILVER CHLORIDE	I	T	S	N
567	08 19 80	0.0700	0.0000	0			AMMONIUM OXALATE	I	TBD	S	N
568	08 19 80	0.0700	0.0000	0			NITRIC REAGENT	I	NA	L	N
569	08 19 80	0.0700	0.0000	0			NITRIC REAGENT	I	NA	L	N
570	08 19 80	0.1100	0.0000	0			CADMIUM (IV) NITRATE	I	T	S	N

BENCHMARK ENVIRONMENTAL CORPORATION

ge No. 16
/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
571	08 19 80	0.0700	0.0000	0			MERCURY NITRATE	I	T/I	S	N
572	08 19 80	0.0350	0.0000	0			MANGANESE SULFATE	I	TBD	S	N
573	08 19 80	0.0350	0.0000	0			HYDROXYLAMINE REAGENT	I	TBD	L	N
574	08 19 80	0.0350	0.0000	0			3,4,5-TRIHYDROZYBENZOIC ACID (GALLIC ACID)	O	TBD	S	N
575	08 19 80	0.0350	0.0000	0			FREE CHLORINE BUFFER	I	TBD	L	N
576	08 19 80	0.0350	0.0000	0			FLUORESCEIN	O	TBD	S	N
577	08 19 80	0.0700	0.0000	0			FERROUS IRON TEST POWDER PILLOWS	I*	TBD	S	N
578	08 19 80	0.0350	6.0000	0			DIPHENYLCARBAZIDE & TETRABROMOPHENOSULFONPHTHALAIN	O	TBD	S	N
579	08 19 80	0.0350	0.0000	0			DIPHENYL CARBAZIDE	O	TBD	S	N
580	08 19 80	0.0350	0.0000	0			P-DIMETHYLAMINOBENZALDEHYDE	O	TBD	S	N
581	08 19 80	0.0000	1.0000	0			CADMIUM	M	T	S	N
582	08 19 80	0.0700	0.0000	0			DIMETHOXYSTRYCHNINE (BRUCINE)	O	TBD	S	N
583	08 19 80	0.0350	0.0000	0			TETRABROMOPHENOLSULFONPHTHALEIN	O	TBD	S	N
584	08 19 80	0.0350	0.0000	0			1-AMINO-2-NAPHTHOL-4-SULFONIC ACID	O	TBD	S	N
585	08 19 80	0.0000	1.2500	0			MOLYBDIC ACID & AMMONIUM MOLYBDATE	I	TBD	S	N
586	08 19 80	0.0000	1.0000	0			AMMONIUM OXALATE	I	TBD	S	N
587	08 19 80	0.0350	0.0000	0			PHENAZINE	O	TBD	S	N
588	08 19 80	0.0350	0.0000	0			POTASSIUM PERMANGANATE	I	I	S	N
589	08 19 80	0.0350	0.0000	0			POTASSIUM HYDRATE	I	TBD	S	N
590	08 19 80	0.0350	0.0000	0			POTASSIUM DICHROMATE	I	T/I	S	N
591	08 19 80	0.0700	0.0000	0			POTASSIUM DICHROMATE	I	T/I	S	N
592	08 19 80	0.0700	0.0000	0			POTASSIUM CHROMATE INDICATOR	I	T	S	N
593	08 19 80	0.0350	0.0000	0			POTASSIUM CHLORIDE	I	TBD	S	N
594	08 19 80	0.0000	0.1250	0			4,5-PHENANTHROLINE	O	TBD	S	N
595	08 19 80	0.0350	0.0000	0			PH-7 BUFFER	I*	TBD	L	N
596	08 19 80	0.1400	0.0000	0			NITRIVER POWDER PILLOWS	NA	TBD	S	N
597	08 19 80	7.3700	0.0000	0			DIMETHYL ARSINIC ACID,SODIUM CACODYLATE & CACODYLIC ACID	O	T	S	N
598	08 19 80	14.7400	0.0000	0			2,4-DICHLOROPHENOXYBUTHRIC ACID	O	TBD	S	N
599	08 19 80	1.0000	0.0000	0			ECCO PRIME PP (ORGANIC ACID)	O	TBD	L	N
600	09 04 80	12.0600	0.0000	0			METHYL CHLOROFORM,UNKNOWN ACID	O	T	L	N
601	07 30 80	0.0000	6.0000	0			COPPER CHLORIDE	I	TBD	S	N
602	07 30 80	0.0000	22.0000	0			ALUMINUM CHLORIDE,ANHYDROUS	I	R	S	N
603	07 30 80	0.0000	5.0000	0			FUROXYL CHLORIDE	O	TBD		N
604	07 30 80	0.0000	1.0000	0			PHOSPHORIC ANHYDRIDE	I	R	S	N
605	07 30 80	0.0000	1.0000	0			SODIUM METAL	M	R	S	N
606	07 30 80	0.0000	0.0700	0			ALKYL HALIDES	I	TBD	NA	N
607	07 30 80	0.0700	0.0000	0			BROMINATED HYDROCARBONS	O	TBD	NA	N
608	07 30 80	0.0700	0.0000	0			UNKNOWN	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 17
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
609	08 05 80	22.1100	0.0000	0	13		SULFURIC ACID	I	C	L	Y
610	08 05 80	22.1100	0.0000	0			NITRIC ACID	I	C	L	N
611	08 05 80	0.8000	0.0000	0		B	COPPER STICK SOLUTION	I	NA	L	Y
612	08 05 80	1.0700	0.0000	0		B	NITRIC ACID OF LEAD	I	T/C	L	Y
613	08 05 80	29.4800	0.0000	0		B	SODIUM HYDROGEN SULFATE & CHROMIL ACID	I	I	S	Y
614	08 05 80	6.7000	0.0000	0		B	NICKEL CHLORIDE SOLUTION	I	TBD	L	Y
615	08 05 80	0.6700	0.0000	0			SULFURIC ACID	I	C	L	N
616	08 05 80	0.0170	0.0000	0			FORMIC ACID	I	TBD	L	N
617	08 05 80	0.0000	2.2000	0			DICHLOROMETHANE	O	TBD		N
618	08 05 80	2.6800	0.0000	0			PAINT	O	I		N
619	08 04 80	14.7400	0.0000	0	19		OIL	O	TBD		Y
620	08 12 80	0.2500	0.0000	0			EPOXIDES & HARDENERS	O	I*		N
621	08 12 80	0.3400	0.0000	0	13		COPPER SULFATE SOLVENT	I	TBD		Y
622	08 15 80	0.0600	0.0000	0			LIQUID CHEMICALS	NA	NA		N
623	08 15 80	0.0100	0.0000	0			ORGANIC	O	NA		N
624	08 15 80	0.0100	0.0000	0			INORGANIC	I	NA		N
625	08 15 80	7.3000	0.0000	0	19		OIL	O	TBD		Y
626	08 15 80	0.2700	0.0000	0	19		OIL	O	TBD		Y
627	08 14 80	1.0700	0.0000	0			ACID SOLUTION OF BERYLLIUM	NA	C*		N
628	08 14 80	6.9700	0.0000	0			POTASSIUM CYANIDE GOLD RECOVERY SOLUTION	I	R		N
629	08 22 80	1.5000	0.0000	0			3-PENTANONE,CHLOROFORM,OCTYL ALCOHOL,4-HYDROXY-4-METHYL-2-PENTANONE,BRO	O	T/I*		N
630	08 22 80	0.0000	0.0000	2	16		2 BROMIDE CYLINDERS	I	I*		Y
631	07 01 80	4.0000	0.0000	0	19		OIL	O	TBD		Y
632	07 07 80	0.6800	0.0000	0		B	POWDER (TALCUM)	I	TBD		Y
633	07 07 80	0.0200	0.0000	0		B	NITRIC ACID	I	C		Y
634	07 07 80	0.7000	0.0000	0		B	PHOTOCHEMICALS	NA	NA		Y
635	07 07 80	0.0200	0.0000	0		B	HYDROCHLORIC ACID	I	C		Y
636	07 07 80	0.1340	0.0000	0		B	CITRIC ACID	O	TBD		Y
637	07 10 80	20.0000	0.0000	0		B	CHROMIC SULFURIC AICD,METHYL CHLOROFORM,TIN-LEAD SOLUTION	O	T/C		Y
638	07 10 80	7.3700	0.0000	0			NITRIC ACID	I	C		N
639	07 14 80	0.1340	0.0000	0			TOLUENE	O	I		N
640	07 14 80	0.6800	0.0000	0	13		INORGANIC	I	NA		Y
641	07 14 80	0.6800	0.0000	0			ORGANIC	O	NA	L*	N
642	07 14 80	0.3400	0.0000	0	13		INORGANIC	I	NA	NA	Y
643	07 14 80	0.5100	0.0000	0			ORGANIC	O	NA	L*	N
644	07 15 80	0.1000	0.0000	0			ORGANIC	O	NA	L*	N
645	07 15 80	0.1000	0.0000	0			LITHIUM & BERYLLIUM	M	R	S	N
646	07 15 80	0.5400	0.0000	0			SULFURIC ACID	I	TBD		N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 18
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
647	07 16 80	2.0000	0.0000	0			COAL TAR CONTAINING BENZ-A-PYRENE & CYCLOHEXANE	O	TBD	L	N
648	07 18 80	1.3400	0.0000	0			WEAK ACID	NA	NA	L*	N
649	07 21 80	3.0000	0.0000	0			1,1,1-TRICHLOROETHANE	O	TBD		N
650	07 21 80	2.0000	0.0000	0	13		FILTERS	NA	NA	S	Y
651	07 23 80	0.1700	0.0000	0			EPOXY & RESIN	O	I	L	N
652	07 31 80	0.3300	0.0000	0			STRONG ACIDS	NA	C	L	N
653	07 25 80	2.0000	0.0000	0			ORGANIC SOLVENTS	O	I*	L	N
654	07 28 80	58.9600	0.0000	0			OIL	O	TBD	L	N
655	06 20 80	2.0000	0.0000	0			GALLIUM ARSINIDE,HYDROCHLORIC ACID	I	T/C	L	N
656	06 24 80	7.3700	0.0000	0	19		OIL	O	TBD	L	Y
657	06 27 80	30.0000	0.0000	0	13		POTASSIUM SUPER OXIDE	I	TBD	S	Y
658	06 26 80	1.0000	0.0000	0	13		ASBESTOS	I	TBD	S	Y
659	06 12 80	0.2700	0.0000	0			WASTE ORGANIC	O	NA	NA	N
660	06 12 80	2.0000	0.0000	0			POLYLITE RESIN	O	TBD	NA	N
661	00 00 00	2.0100	0.0000	0			ORGANIC (6/80)	O	NA	L*	N
662	00 00 00	0.1340	0.0000	0			OTHER (6/80)	NA	NA	NA	N
663	06 13 80	0.0000	0.0000	0			ASBESTOS	I	TBD	S	N
664	06 18 80	0.0000	0.0000	0			ASBESTOS	I	TBD	S	N
665	06 19 80	0.0100	0.0000	0			SULFURIC ACID SOLUTION	I	C	L	N
666	00 00 00	0.0000	0.0000	0			MERCURY CONTAMINATED OIL (6/80)	M	T	S	N
667	06 24 80	14.7400	0.0000	0			PLATING ACID	NA	NA	L	N
668	06 24 80	0.0500	0.0000	0			MERCURY	M	T	S*	N
669	06 24 80	0.1000	0.0000	0			ORGANIC	O	NA	L*	N
670	00 00 00	0.0700	0.0000	0			ORGANIC (6/80)	O	NA	L*	N
671	06 05 80	0.2700	0.0000	0			CHEMICALS	NA	NA	NA	N
672	06 05 80	0.0000	0.0000	0			PHOTOCHEMICALS	NA	NA	NA	N
673	06 04 80	7.3700	0.0000	0			ORGANIC	O	NA	L*	N
674	06 04 80	0.0000	10.0000	0			INORGANIC	I	NA	NA	N
675	06 04 80	3.0000	0.0000	0			ASBESTOS	I	TBD		N
676	06 04 80	29.4800	0.0000	0			OIL	O	TBD		N
677	06 04 80	6.7000	0.0000	0			INORGANIC	I	TBD		N
678	06 64 80	0.5400	0.0000	0			ORGANIC	O	NA	L*	N
679	06 04 80	2.6800	0.0000	0			OIL W/ SAND & RESIN	O	TBD	L	N
680	06 10 80	0.5400	0.0000	0			AMMONIUM HYDROXIDE	I	TBD	L	N
681	06 10 80	7.3700	0.0000	0			BERYLLIUM WASTE	M	TBD	S	N
682	06 09 80	0.9400	0.0000	0			HYDROCHLORIC ACID	I	C	L	N
683	06 09 80	32.1600	0.0000	0			OIL	O	TBD	L	N
684	06 09 80	36.8500	0.0000	0			OIL	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 19
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
685	05 08 80	0.0350	0.0000	0			BUTYRIC (?) ACID	O	C	L	N
686	05 07 80	34.8400	0.0000	0			OIL	O	TBD	L	N
687	05 07 80	51.5900	0.0000	0			OIL W/WATER	O	TBD	L	N
688	05 07 80	0.0000	20.0000	0			CALCIUM CHLORIDE	I	TBD	S	N
689	05 06 80	1.3400	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
690	05 06 80	3.0000	0.0000	0			WASTE GLASSWARE & OTHERS	NA	NA	S	N
691	00 00 00	0.0000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
692	05 02 80	3.0800	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
693	05 02 80	0.1700	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
694	05 01 80	2.0100	0.0000	0			SOLVENT	O*	NA	NA	N
695	05 01 80	3.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
696	05 01 80	0.0350	0.0000	0			OIL	O	TBD	L	N
697	05 01 80	1.3400	0.0000	0			ACID	NA	C*	L	N
698	05 01 80	0.0000	0.0000	5			EMPTY GAS CYLINDERS	NA	NA	V	N
699	00 00 00	0.1500	0.0000	0			SULFURIC ACID (5/80)	I	C	L	N
700	00 00 00	0.4100	0.0000	0			PERCHLORIC ACID (5/80)	I	I/C	L	N
701	00 00 00	0.1200	0.0000	0			NITRIC ACID (5/80)	I	C	L	N
702	00 00 00	0.0500	0.0000	0			METHANOL (5/80)	O	I	L	N
703	00 00 00	0.0500	0.0000	0			ACETONE (5/80)	O	I	L	N
704	00 00 00	0.1000	0.0000	0			ACETONE (5/80)	O	I	L	N
705	00 00 00	0.1000	0.0000	0			METHANOL (5/80)	O	I	L	N
706	00 00 00	0.6800	0.0000	0			PERCHLORIC ACID (5/80)	I	I/C	L	N
707	00 00 00	1.1900	0.0000	0			NITRIC ACID (5/80)	I	C	L	N
708	00 00 00	0.3100	0.0000	0			SULFURIC ACID (5/80)	I	C	L	N
709	00 00 00	0.0500	0.0000	0			HYDROFLUORIC ACID (5/80)	I	C	L	N
710	00 00 00	0.1000	0.0000	0			FERROSULFATE (5/80)	I	TBD	L*	N
711	00 00 00	0.0700	0.0000	0			AMMONIUM MOLYBDATE (5/80)	I	TBD	S	N
712	05 21 80	0.2700	0.0000	0			CHEMICALS	NA	NA	NA	N
713	05 19 80	0.5400	0.0000	0			CHEMICALS	NA	NA	NA	N
714	05 20 80	0.2700	0.0000	0			CHEMICALS	NA	NA	NA	N
715	05 20 80	0.0000	0.0000	0			MERCURY	M	T	S*	N
716	05 20 80	0.1100	0.0000	0			CHEMICALS	NA	NA	NA	N
717	05 20 80	0.6700	0.0000	0			SOLUTION	NA	NA	L	N
718	05 19 80	1.0700	0.0000	0			CHEMICALS	NA	NA	NA	N
719	05 14 80	0.4000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
720	05 13 80	22.1100	0.0000	0			BERYLLIUM CONTAMINATED TRASH & OIL	M/O	TBD	S/L	N
721	05 13 80	24.1200	0.0000	0			ACID	NA	C*	L	N
722	05 12 80	0.6700	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 20
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
723	05	12	80	0.0000	0.0000	2			2 GAS CYLINDERS	NA	NA	V	N
724	05	12	80	0.6700	0.0000	0			ORGANIC	O	NA	L*	N
725	05	12	80	0.6700	0.0000	0			OIL	O	TBD	L	N
726	00	00	00	10.7200	0.0000	0			SULFURIC/NITRIC ACIDS (5/80)	I	TBD	L	N
727	05	30	80	2.0100	0.0000	0			NITROBENZENE W/ VERMICULITE	O	T	S	N
728	05	30	80	0.0000	0.0000	0		B	SODIUM HYDROXIDE	I	TBD	S	Y
729	05	30	80	0.2700	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
730	05	29	80	2.4100	0.0000	0			OIL MIX	O	NA	L	N
731	05	23	80	0.0000	0.0000	0			MERCURY BATTERIES	M	T	S	N
732	05	22	80	0.0900	0.0000	0			FORMALDEHYDE	O	I*	L	N
733	05	21	80	0.1700	0.0000	0			TOLUENE/STYRENE MIXTURE W/CYANIDE & VERMICULITE	O	I/R	L	N
734	04	03	80	0.0000	0.0000	1			CERIUM METAL HYDROGEN GAS CYLINDER	M	TBD	S	N
735	04	08	80	53.6000	0.0000	0		B	PHOTOCHEMICALS	NA	NA	NA	Y
736	04	09	80	0.0000	0.0000	0			CESIUM METAL SAMPLE	M	R	S	N
737	04	07	80	147.4000	0.0000	0			OIL	O	TBD	L	N
738	04	18	80	0.0000	7000.0000	0			THERMITE	I	R	S	N
739	04	18	80	56.2800	0.0000	0			LITHIUM HYDRIDE	I	R	S	N
740	04	21	80	0.0000	0.0000	0			TRICHLOROETHYLENE	O	T	L	N
741	04	20	80	2.0000	0.0000	0			ORGANIC	O	NA	L*	N
742	04	20	80	0.1340	0.0000	0			ACID	NA	C*	L	N
743	04	23	80	26.8000	0.0000	0			OIL	O	TBD	L	N
744	04	30	80	0.0000	0.0000	0			SODIUM METAL	M	R	S	N
745	03	24	80	10.8500	0.0000	0			PHOTOCHEMICAL DEVELOPER SOLUTION	O	TBD	L	N
746	03	24	80	12.7300	0.0000	0			PHOTOCHEMICAL STOP BATH	I*	TBD	L	N
747	03	24	80	9.9200	0.0000	0			PHOTOCHEMICAL FIXER	I*	TBD	L	N
748	03	12	80	0.6700	0.0000	0			COAL TAR EPOXY	O	NA	L	N
749	03	21	80	16.0000	0.0000	0			DOWFROST	O	TBD	L	N
750	03	20	80	0.4000	0.0000	0	17		TETRAHYDROFURAN	O	I	L	Y
751	03	04	80	29.4800	0.0000	0			NITRIC ACID	I	C	L	N
752	03	03	80	3.0000	0.0000	0			ORGANIC	O	NA	L*	N
753	03	03	80	4.0000	0.0000	0			INORGANIC	I	NA	NA	N
754	03	03	80	0.1400	0.0000	0			ACID	NA	C*	L	N
755	03	03	80	0.0000	0.0000	0			MERCURY BATTERIES & TRASH	M	T	S	N
756	03	05	80	0.0000	0.0000	0			TRANSIT	O	TBD	L	N
757	03	05	80	0.6700	0.0000	0			CHEMICAL SOLVENTS	O*	I*	L	N
758	03	06	80	0.1700	0.0000	0			TRICHLOROETHYLENE	O	T	L	N
759	03	06	80	0.1700	0.0000	0			TOLUENE	O	I	L	N
760	03	06	80	0.1700	0.0000	0			CHLOROFORM	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 21
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	LTN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
761	03 06 80	1.3400	0.0000	0			OIL	O	TBD	L	N
762	03 07 80	0.0000	0.0000	0			MERCURY IN OIL	M/O	T	L	N
763	03 07 80	1.0000	0.0000	0			SOLIDS	NA	NA	S	N
764	03 10 80	33.5000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
765	03 10 80	0.0000	0.0000	0			SULFURIC ACID	I	C	L	N
766	03 10 80	0.0000	300.0000	0			BARIUM NITRATE	I	I/T	S	N
767	03 11 80	3.0000	0.0000	0			INORGANIC	I	NA	NA	N
768	03 11 80	1.0000	0.0000	0			ORGANIC	O	NA	L*	N
769	03 11 80	4.0000	0.0000	0			ORGANIC	O	NA	L*	N
770	03 11 80	4.0000	0.0000	0			INORGANIC	I	NA	NA	N
771	03 11 80	1.3400	0.0000	0			OIL	O	TBD	L	N
772	03 11 80	0.1700	0.0000	0			SODIUM,MAGNESIUM,COPPER	M	R	S	N
773	03 11 80	0.4000	0.0000	0			ORGANIC	O	NA	L*	N
774	03 11 80	1.3400	0.0000	0			OIL	O	TBD	L	N
775	03 11 80	0.0000	0.0000	0			IGNITOR METAL	M	NA	S	N
776	03 11 80	2.0000	0.0000	0			WATER	I	TBD	L	N
777	03 11 80	0.0170	0.0000	0			SODIUM HYDRIDE	I	R	S	N
778	03 11 80	0.0170	0.0000	0			ACETONE	O	I	L	N
779	03 12 80	4.0200	0.0000	0			SOLVENT	O*	I*	L	N
780	03 13 80	0.0000	40.0000	0			SODIUM	M	R	S	N
781	03 12 80	12.0600	0.0000	0			OIL	O	TBD	L	N
782	00 00 00	0.0000	0.0000	80			BORON TRIFLUORIDE CYLINDERS(3/80)	I	TBD	V	N
783	03 17 80	134.0000	0.0000	0			AMMONIUM BIFLUORIDE	I	TBD	S	N
784	03 14 80	3.0000	0.0000	0			INORGANIC	I	NA	NA	N
785	03 14 80	1.0000	0.0000	0			ORGANIC	O	NA	L*	N
786	03 17 80	0.0000	0.0000	0			ASBESTOS	I	TBD	S	N
787	03 17 80	1.0700	0.0000	0			PAINT SOLVENTS	O	I	L	N
788	03 18 80	2.6800	0.0000	0			CHEMICALS	NA	NA	NA	N
789	03 19 80	0.5400	0.0000	0		B	ARSENIC	I	T	S	Y
790	03 19 80	0.0000	0.0000	0			EMPTY CYLINDERS	NA	NA	V	N
791	03 20 80	0.6700	0.0000	0			ORGANICS	O	NA	L*	N
792	03 20 80	1.0000	0.0000	0			INORGANICS	I	NA	NA	N
793	03 20 80	0.0350	0.0000	0			ACID	NA	C*	L*	N
794	03 20 80	0.0000	0.0000	0			CONTAMINATED CYLINDER VALVES	NA	NA	NA	N
795	03 20 80	0.4000	0.0000	0			PHOTOCHEMICAL	NA	NA	NA	N
796	03 20 80	0.2700	0.0000	0			ORGANIC	O	NA	L*	N
797	03 25 80	0.5400	0.0000	0			LIQUID	NA	NA	L	N
798	03 25 80	2.0000	0.0000	0			INORGANIC	I	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 22
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
799	03 25 80	14.7400	0.0000	0			ACID	NA	C*	L*	N
800	00 00 00	0.0000	0.0000	0		B	LITHIUM AND SILVER (3/80)	M	T/R	S	Y
801	03 26 80	0.0000	0.0000	100	16		CYLINDERS BORON TRIFLUORIDE	I	TBD	V	Y
802	03 26 80	3.0000	0.0000	0			ORGANIC	O	NA	L*	N
803	03 26 80	14.7400	0.0000	0			OIL	O	TBD	L	N
804	03 26 80	6.7000	0.0000	0			VAC. PUMP OIL	O	TBD	L	N
805	03 28 80	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
806	03 31 80	6.0000	0.0000	0			ORGANICS	O	NA	L*	N
807	03 31 80	0.8000	0.0000	0			ACIDS	NA	C*	L*	N
808	03 31 80	3.0000	0.0000	0			ORGANICS	O	NA	L*	N
809	03 31 80	0.8000	0.0000	0			OIL	O	TBD	L	N
810	03 31 80	0.0000	3.0000	0			CADMIUM	M	T	S	N
811	02 01 80	1.3400	0.0000	0			SOLVENT	O*	NA	L	N
812	02 01 80	0.0700	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
813	02 01 80	0.0340	0.0000	0			RESIN	O	NA	L	N
814	02 01 80	0.2000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
815	02 01 80	0.0340	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
816	02 01 80	0.0340	0.0000	0			ACID	NA	C*	L*	N
817	02 04 80	1.3400	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
818	02 04 80	0.4000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
819	02 12 80	0.0000	300.0000	0			BARIUM NITRATE	I	T/I	S	N
820	02 06 80	14.7400	0.0000	0			OIL	O	TBD	L	N
821	02 06 80	3.0000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
822	02 06 80	1.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
823	02 06 80	0.2000	0.0000	0			MERCURY	M	T	S*	N
824	02 13 80	0.4000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
825	02 12 80	0.1700	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
826	02 06 80	0.0000	0.0000	0			OIL, CHEMICALS & METALS	O/M	NA	L/S	N
827	02 13 80	0.5400	0.0000	0			ORGANICS	O	NA	L*	N
828	02 13 80	4.0000	0.0000	0			ORGANICS	O	NA	L*	N
829	02 13 80	3.0000	0.0000	0			INORGANICS	I	NA	NA	N
830	02 13 80	1.0000	0.0000	0			REACTIVE METAL	M	R	S	N
831	02 13 80	0.0000	0.0000	1			CYLINDER W/BAD VALVE	NA	NA	V	N
832	02 12 80	0.4000	0.0000	1			SOLVENT	O	NA	L	N
833	02 12 80	0.4000	0.0000	1			ORGANIC CHEMICALS	O	NA	L*	N
834	02 12 80	2.0000	0.0000	1			INORGANIC CHEMICALS	I	NA	NA	N
835	02 14 80	0.0000	0.0000	0			BERYLLIUM	M	TBD	S	N
836	02 21 80	1.0000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 23
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
837	02	21	80	2.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
838	02	21	80	7.3700	0.0000	0			DILUTE NITRIC ACID	I	TBD	L	N
839	02	21	80	4.0000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
840	02	21	80	4.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	NA	N
841	02	21	80	2.0000	0.0000	0			METAL	M	NA	S	N
842	02	21	80	0.0900	0.0000	0			MERCURY	M	T	S*	N
843	02	22	80	2.6800	0.0000	0			TOLUENE	O	I	L	N
844	02	22	80	0.0000	0.0000	0	16		CYLINDERS	NA	NA	V	Y
845	02	25	80	0.9400	0.0000	0			OIL, CHEMICALS	O	TBD	L	N
846	02	25	80	10.7200	0.0000	0			SULFURIC ACID	I	C	L	N
847	02	25	80	6.7000	0.0000	0			ORGANICS	O	NA	L*	N
848	02	26	80	14.7400	0.0000	0			TOLUENE	O	I	L	N
849	02	26	80	10.7200	0.0000	0			PHOTOCHEMICALS	NA	NA	NA	N
850	02	28	80	7.3700	0.0000	0			NITRIC ACID	I	C	L	N
851	02	28	80	1.0000	0.0000	0			INORGANIC	I	NA	NA	N
852	02	28	80	0.2700	0.0000	0			ACID	NA	C*	L*	N
853	02	28	80	0.4000	0.0000	0			ORGANIC	O	NA	L*	N
854	01	29	80	0.4000	0.0000	0			ORGANIC	O	NA	L*	N
855	01	29	80	0.1340	0.0000	0			NITRIC ACID	I	C	L	N
856	01	29	80	0.0000	0.0000	1			CYLINDER	NA	NA	V	N
857	01	31	80	4.0000	0.0000	0			DRY CHEMICALS	NA	NA	S*	N
858	01	31	80	0.9400	0.0000	0			INORGANIC LIQUID	I	NA	L	N
859	01	31	80	0.2700	0.0000	0			INORGANIC SOLIDS	I	NA	S	N
860	01	14	80	48.2400	0.0000	0			DILUTE ACID	NA	TBD	L	N
861	01	14	80	8.0400	0.0000	0			CAUSTIC	I*	TBD	NA	N
862	01	14	80	8.0400	0.0000	0			METAL	M	NA	S	N
863	01	14	80	0.6700	0.0000	0			SULFURIC ACID	I	C	L	N
864	01	14	80	0.2700	0.0000	0			ORGANIC	O	NA	L*	N
865	01	14	80	0.5400	0.0000	0			INORGANIC	I	NA	NA	N
866	01	10	80	0.6700	0.0000	0			ORGANIC	O	NA	L*	N
867	01	10	80	0.0340	0.0000	0			CAUSTIC	I	TBD	NA	N
868	01	10	80	0.0170	0.0000	0			INORGANIC	I	NA	NA	N
869	01	10	80	0.3400	0.0000	0			METAL POWDER	M	R	S	N
870	01	11	80	14.7400	0.0000	0			COPPER SULFATE	I	TBD	S	N
871	01	11	80	4.2900	0.0000	0			SULFURIC ACID	I	C	L	N
872	01	11	80	3.3500	0.0000	0			ORGANIC	O	NA	L*	N
873	01	11	80	1.3400	0.0000	0			ORGANIC	O	NA	L*	N
874	01	09	80	2.6800	0.0000	0			ORGANIC	O	NA	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 24
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
875	01	09	80	0.2600	0.0000	0			INORGANIC	I	NA	NA	N
876	01	09	80	0.0700	0.0000	0			NITRIC ACID	I	C	L	N
877	01	09	80	7.3700	0.0000	0			NICKEL-CONTAMINATED ACID	I*	NA	L	N
878	01	07	80	0.6700	0.0000	0			ALUMINUM SOLVENTS	I*	NA	L	N
879	01	07	80	3.0000	0.0000	0			ORGANICS	O	NA	L*	N
880	01	07	80	0.4000	0.0000	0			ACID	NA	C*	L*	N
881	01	07	80	0.0900	0.0000	0			INORGANICS	I	NA	NA	N
882	01	07	80	0.0170	0.0000	0			ORGANICS	O	NA	L*	N
883	01	03	80	0.0000	0.0000	0			CATHODE RAY TUBE	I	TBD	S	N
884	01	17	80	0.9400	0.0000	0			ETHANOL	O	I	L	N
885	01	17	80	0.0000	0.0000	5			SMALL CYLINDERS	NA	NA	V	N
886	01	23	80	0.0000	0.0000	1			CYLINDER OF SILANE	I	I*	V	N
887	01	23	80	0.2700	0.0000	0			ALCOHOL	O	I*	L	N
888	01	23	80	0.1700	0.0000	0			ORGANICS	O	NA	L*	N
889	01	23	80	0.1400	0.0000	0			INORGANICS	I	NA	NA	N
890	01	23	80	0.0340	0.0000	0			METHYLENE CHLORIDE	O	TBD	L	N
891	01	29	80	2.0100	0.0000	0			OIL W/MAGNESIUM CHIPS	O/M	TBD	L/S	N
892	01	14	80	2.0000	0.0000	0			ASBESTOS	I	TBD	S	N
893	01	14	80	0.1700	0.0000	0			ORGANICS	O	NA	L*	N
894	01	14	80	0.0170	0.0000	0			ETHER	O	I	L	N
895	00	00	00	2.1400	0.0000	0			ACID (1/80)	NA	C*	L*	N
896	01	02	80	0.6700	0.0000	0			ORGANICS	O	NA	L*	N
897	01	02	80	0.4000	0.0000	0			INORGANICS	I	NA	NA	N
898	01	02	80	0.1340	0.0000	0			NITRIC ACID	I	C	L	N
899	01	10	80	0.0340	0.0000	0			LITHIUM METAL IN BTS OIL	O/M	TBD	L/S	N
900	01	10	80	0.0170	0.0000	0			SODIUM METAL IN OIL	O/M	TBD	L/S	N
901	01	24	80	0.0170	0.0000	0			PICRIC ACID	O	R	S	N
902	01	24	80	0.2700	0.0000	0			RESIN CONTAMINATED W/PICRIC ACID	O	R	L	N
903	01	24	80	0.4000	0.0000	0			ORGANIC	O	NA	L*	N
904	01	14	80	0.0000	5.0000	0			COPPER SULFATE	I	TBD	S	N
905	01	09	80	0.6700	0.0000	0			ACID	NA	C*	L*	N
906	01	19	80	0.0000	25.0000	0			INORGANIC SALTS	I	TBD	S	N
907	01	19	80	0.0700	0.0000	0			INORGANIC SALTS	I	TBD	S	N
908	01	09	80	58.9600	0.0000	0			BERYLLIUM CONTAMINATED H2O	I	TBD	L	N
909	01	17	80	4.6900	0.0000	0			OIL	O	TBD	L	N
910	01	17	80	1.3400	0.0000	0			ORGANIC	O	NA	L*	N
911	01	17	80	0.2700	0.0000	0			INORGANIC	I	NA	NA	N
912	01	02	80	3.3500	0.0000	0			ACIDS	NA	C*	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 25
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
913	01 08 80	2.6800	0.0000	0			ETHER	O	I	L	N
914	01 03 80	0.6700	0.0000	0			SOLVENTS	O*	NA	L	N
915	01 07 80	0.4000	0.0000	0			VACUUM OIL W/DIRT & H2O	O	TBD	L	N
916	01 09 80	0.4000	0.0000	0			SULFURIC ACID	I	C	L	N
917	01 09 80	0.1800	0.0000	0			RESIN	O	I	L	N
918	01 23 80	0.1400	0.0000	0			BENZENE	O	T/I	L	N
919	01 23 80	0.3400	0.0000	0			ETHANOL DYE	O	I	L	N
920	01 28 80	0.4000	0.0000	0			ORGANICS	O	NA	L*	N
921	01 28 80	0.1340	0.0000	0			INORGANICS	I	NA	NA	N
922	03 25 83	4.0100	0.0000	0	23		TRANSFORMER OIL ON ZORBAL & VERMICULITE	O	TBD	S*	Y
923	02 23 83	2.0000	0.0000	0	20		CHROMIC ACID BURIED IN 15 GAL DRUM	I	ITC	L*	Y
924	02 23 83	4.0100	0.0000	0	20		ALUMINUM CHLORIDE IN DRUM #17 PLUS BE	I	R	S	Y
925	02 23 83	4.0100	0.0000	0	20		INORGANICS IN DRUM #18	I	NA	NA	Y
926	02 23 83	4.0100	0.0000	0	20		INORGANICS IN DRUM #17	I	NA	NA	Y
927	02 23 83	0.1300	0.0000	0	20		PERCHLORIC ACID	I	I/C*	L	Y
928	03 24 83	16.0400	0.0000	0	20		INORGANICS DISPOSED OF IN OWN DRUM	I	NA	NA	Y
929	03 24 83	1.3400	0.0000	0	20		10 GAL OF FUME LITHARGE (PRO) (LEAD OXIDE)	I	T	S*	Y
930	09 29 83	14.8300	0.0000	0	20		OIL ON VERMICULITE	O	TBD	S	Y
931	09 29 83	15.8900	0.0000	0	20		CUTTING OIL ON VERMICULITE	O	TBD	S	Y
932	09 29 83	21.8900	0.0000	0	20		OIL ABSORBED ON VERMICULITE	O	TBD	S	Y
933	05 23 83	2.6800	0.0000	0	21		CORRODED CHLORINE AND HYDROGEN FLUORIDE CYLINDERS	I	TBD	V	Y
934	09 29 83	0.4900	0.0000	0	21		FLUORINE CYLINDER VENTED PUT IN SHAFT	I	TBD	V	Y
935	12 15 83	7.0600	0.0000	6	21		CYLINDERS FROM C AREA TO CYL. SHAFT	NA	NA	V	Y
936	04 24 84	0.4900	0.0000	0	21		EMPTY CYLINDERS TO SHAFT	NA	NA	V	Y
937	07 03 84	0.3500	0.0000	0	21		EMPTY GAS MIXING CYLINDER	NA	NA	V	Y
938	08 06 84	2.0100	0.0000	0	21		EMPTY GAS CYLINDERS	NA	NA	V	Y
939	09 24 84	4.9400	0.0000	0	21		EMPTY CYLINDERS	NA	NA	V	Y
940	07 26 84	1.6900	0.0000	0	21		EMPTY CYLINDERS	NA	NA	V	Y
941	11 20 84	3.0000	0.0000	0	21		EMPTY GAS CYLINDERS	NA	NA	V	Y
942	11 20 84	25.0700	0.0000	0	21		EMPTY GAS CYLINDERS	NA	NA	V	Y
943	03 19 85	3.8800	0.0000	0	21		GAS CYLINDERS THAT HAVE BEEN VENTED	NA	NA	V	Y
944	07 15 85	0.1800	0.0000	0	21		EMPTY HELIUM CYLINDERS	I	TBD	V	Y
945	07 25 85	0.7100	0.0000	0	21		EMPTY KRYPTON CYLINDERS	I	TBD	V	Y
946	08 13 85	3.0000	0.0000	0	21		EMPTY FLUORINE CYLINDERS	I	TBD	V	Y
947	08 05 85	14.8300	0.0000	0	21		BATTERIES	I	NA	S	Y
948	02 23 83	3.8800	0.0000	0	22		ORGANICS IN DRUM #40	O	NA	L*	Y
949	02 23 83	3.8800	0.0000	0	22		ORGANIC SOLVENT WITH KEROSENE BASE	O	I*	L	Y
950	02 23 83	3.8800	0.0000	0	22		ORGANIC CHEMICALS	O	NA	L*	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 26
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALSTS.DBF)

ID	MO DY YR	VOLCUFT	WGT	LTN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
951	02 23 83	3.8800	0.0000	0	22		ORGANICS	O	NA	L*	
952	02 23 83	3.8800	0.0000	0	22		ORGANICS DRUM #44	O	NA	L*	
953	02 23 83	3.8800	0.0000	0	22		ORGANICS IN DRUM #45	O	NA	L*	
954	02 23 83	3.8800	0.0000	0	22		ORGANICS IN DRUM #46	O	NA	L*	
955	02 23 83	3.8800	0.0000	0	22		ORGANICS IN DRUM #47	O	NA	L*	
956	02 23 83	3.8800	0.0000	0	22		ORGANICS IN DRUM #39	O	NA	L*	
957	02 23 83	10.9500	0.0000	0	22		CUTTING OIL ON VERMICULITE	O	TBD	S	
958	03 23 83	21.8900	0.0000	0	22		PAINT THINNER IN VERMICULITE	O	TBD	S	
959	03 25 83	7.4200	0.0000	0	22		ORGANICS DRUM #48	O	NA	L*	
960	03 25 83	7.4200	0.0000	0	22		ORGANICS DRUM #49	O	NA	L*	
961	03 15 83	8.1200	0.0000	0	22		CHEMICALS DISPOSED OF IN OWN CONTAINER	NA	NA	NA	
962	03 24 83	109.4600	0.0000	0	22		UNREACT ORGANICS BURIED IN OWN CONTAINER	O	NA	NA	
963	05 25 83	29.3000	0.0000	0	23		OIL ON VERMICULITE	O	TBD	S	
964	05 25 83	29.3000	0.0000	0	23		OIL ON VERMICULITE	O	TBD	S	
965	05 25 83	7.4200	0.0000	0	23		VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	
966	05 25 83	3.8800	0.0000	0	23		OIL ABSORBED ON VERMICULITE	O	TBD	S	
967	05 25 83	1.3400	0.0000	0	23		25 GAL OIL CHROMIUM AND OXYGEN	O	T	L	
968	05 26 83	15.8900	0.0000	0	23		CUTTING OIL ON VERMICULITE	O	TBD	S	
969	12 16 83	78.0400	0.0000	0	23		LOW PCB OIL FOR AREA L	O	TBD	L	
970	12 16 83	15.8900	0.0000	0	23		CUTTING OIL ON VERMICULITE	O	TBD	S	
971	12 16 83	66.0100	0.0000	0	23		LOW PCB OIL ON VERMICULITE	O	TBD	S	
972	12 16 83	21.0900	0.0000	0	23		OIL AND WATER ABSORBED ON VERMICULITE	O	TBD	S	
973	12 16 83	0.6400	0.0000	0	23		DIRTY OIL TO OIL SHAFT	O	TBD	L	
974	12 16 83	197.7400	0.0000	0	23		DIESEL FUEL OIL ON VERMICULITE	O	TBD	S	
975	12 16 83	0.0400	0.0000	0	23		LIGHT WEIGHT OIL TO OIL SHAFT	O	TBD	L	
976	02 23 84	7.4200	0.0000	0	23		OIL ON VERMICULITE	O	TBD	S	
977	02 23 84	29.3100	0.0000	0	23		PCB FREE OIL ON VERMICULITE	O	TBD	S	
978	02 23 84	15.8800	0.0000	0	23		USED CUTTING OIL ON VERMICULITE	O	TBD	S	
979	12 16 83	7.3400	0.0000	0	24		ORGANICS IN DRUM 21	O	TBD	L*	
980	12 16 83	29.4100	0.0000	0	24		OIL AND KEROSENE ON VERMICULITE	O	TBD	S	
981	12 16 83	7.3400	0.0000	0	24		TRICHLOROETHANE ON VERMICULITE	O	TBD	S	
982	12 16 83	22.0700	0.0000	0	24		RESIN	O	TBD	S	
983	12 16 83	7.3400	0.0000	0	24		ETHYLENE GLYCOL ON VERMICULITE	O	TBD	L	
984	12 16 83	29.4100	0.0000	0	24		STODDARD SOLVENT ON VERMICULITE	O	TBD	S	
985	12 16 83	7.3400	0.0000	0	24		ORGANICS IN DRUM 88	O	TBD	S	
986	12 16 83	7.0600	0.0000	0	24		ORGANICS IN DRUM 89	O	NA	L*	
987	12 16 83	7.3400	0.0000	0	24		ORGANICS IN DRUM 99	O	NA	L*	
988	02 29 83	10.6900	0.0000	0	24		2-ETHYL-1HEXANOL	O	NA	L*	
								O	TBD	L	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 27
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
989	02 23 84	14.6900	0.0000	0	24		PAINT THINNER ABSORBED ON VERMICULITE	O	TBD	S	
990	02 23 84	14.6900	0.0000	0	24		2-PROPANOL ABSORBED ON VERMICULITE	O	TBD	S	
991	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 92	O	NA	L*	
992	02 23 84	11.3700	0.0000	0	24		SURFACTANT OVERPACKED IN VERMICULITE	O	TBD	S	
993	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 93	O	NA	L*	
994	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 94	O	NA	L*	
995	02 23 84	14.6900	0.0000	0	24		PAINT THINNER ON VERMICULITE	O	TBD	S	
996	02 23 84	4.6600	0.0000	0	24		GLYCOL ETHER ON VERMICULITE	O	TBD	S	
997	02 23 84	80.8600	0.0000	0	24		OILS WITH SOLVENT ON VERMICULITE	O	TBD	S	
998	02 23 84	36.7600	0.0000	0	24		1,1,1-TRICHLOROETHANE ON VERMICULITE	O	TBD	S	
999	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 95	O	NA	L*	
1000	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 96	O	NA	L*	
1001	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 97	O	NA	L*	
1002	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 98	O	NA	L*	
1003	02 23 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 99	O	NA	L*	
1004	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 111	O	NA	L*	
1005	04 05 84	4.0100	0.0000	0	24		ORGANICS IN DRUM 110	O	NA	L*	
1006	04 05 84	4.0100	0.0000	0	24		ORGANICS IN DRUM 109 (BENZENE)	O	NA	L*	
1007	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 108	O	NA	L*	
1008	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 107	O	NA	L*	
1009	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 106	O	NA	L*	
1010	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 105	O	NA	L*	
1011	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 104	O	NA	L*	
1012	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 103	O	NA	L*	
1013	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 102	O	NA	L*	
1014	04 05 84	7.3400	0.0000	0	24		ORGANICS IN DRUM 101	O	NA	L*	
1015	04 05 84	4.0100	0.0000	0	24		ORGANICS IN DRUM 100	O	NA	L*	
1016	04 05 84	102.9300	0.0000	0	24		LOW LEVEL PCB OIL ON VERMICULITE	O	TBD	S	
1017	04 05 84	12.0300	0.0000	0	24		VACUUM PUMP OIL ON VERMICULITETE	O	TBD	S	
1018	04 05 84	36.7600	0.0000	0	24		TEXACO REGAL OIL ON VERMICULITE	O	TBD	S	
1019	04 05 84	129.6200	0.0000	0	24		ORGANIC AND OIL ON VERMICULITE	O	TBD	S	
1020	03 25 83	7.3400	0.0000	0	25		INORGANIC IN DRUM #20	I	NA	NA	
1021	03 25 83	4.0100	0.0000	0	25		INORGANIC IN DRUM #21	I	NA	NA	
1022	03 25 83	4.0100	0.0000	0	25		INORGANIC IN DRUM #22	I	NA	NA	
1023	03 25 83	4.0100	0.0000	0	25		GALLIUM ARSENIDE ON PAPER TOWELS DRUM #23	I	T/I/C*	S	
1024	04 05 83	0.6700	0.0000	0	25		PERCHLORIC ACID	I	T/I/C*	L	
1025	05 25 83	7.3400	0.0000	0	25		PHOTOCHEMICAL WASTES IN DRUM 23	NA	NA	L*	
1026	05 25 83	7.3400	0.0000	0	25		INORGANICS IN DRUM #24	I	NA	NA	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 28
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1027	05	25	83	4.0300	0.0000	0	25		PHOTOCHEMICALS INORGANIC DRUM # 25	I*	NA	L*	
1028	05	25	83	4.0300	0.0000	0	25		PHOTOCHEMICALS IN DRUM INORGANIC # 26	I*	NA	L*	
1029	05	25	83	7.3400	0.0000	0	25		UNKNOWN WHITE POWDER IN INORGANIC DRUM #27		NA	S	
1030	07	25	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #22		NA	NA	
1031	07	25	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #28		NA	NA	
1032	07	25	83	4.0300	0.0000	0	25		INORGANICS IN DRUM #29		NA	NA	
1033	07	25	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #30		NA	NA	
1034	07	25	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #31		NA	NA	
1035	08	29	83	48.0900	0.0000	0	25		INORGANICS IN OWN CARTONS		NA	NA	
1036	12	16	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #34		NA	NA	
1037	12	16	83	4.0300	0.0000	0	25		SODA LIME IN OWN DRUM		TBD	S	
1038	12	16	83	7.3400	0.0000	0	25		INORGANICS IN DRUM #33		NA	NA	
1039	01	27	84	8.0200	0.0000	0	25		INORGANICS BURIED IN OWN CONTAINERS		NA	NA	
1040	02	23	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #35		NA	NA	
1041	02	23	84	2.0100	0.0000	0	25		OAKITE STRONG DETERGENT (SODIUM PHOSPHATE TRIBASIC)		TBD	S	
1042	02	23	84	4.0300	0.0000	0	25		CHEESECLOTH WITH DIL. ACIDS ON PLASTIC		TBD	S	
1043	04	05	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 41		NA	NA	
1044	04	05	84	4.0300	0.0000	0	25		INORGANICS IN DRUM 40		NA	NA	
1045	04	05	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 39		NA	NA	
1046	04	05	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 38		NA	NA	
1047	04	05	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 37 (NC)		NA	NA	
1048	04	05	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 36		NA	NA	
1049	04	05	84	0.2340	0.0000	0	25		GLASSWARE - MERCURY CONTAM. WITH ARSENIC		T	S	
1050	04	05	84	4.0300	0.0000	0	25		VARIOUS ARTICLES CONTAM. WITH ARSENIC	I	T	S	
1051	04	26	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #46	I	NA	NA	
1052	04	26	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #45	I	NA	NA	
1053	04	26	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #44	I	NA	NA	
1054	04	26	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #42	I	NA	NA	
1055	06	18	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #51	I	NA	NA	
1056	06	18	84	4.0300	0.0000	0	25		GALLIUM ARSENIDE IN DRUM #54	I	T	S	
1057	06	18	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #49	I	NA	NA	
1058	06	18	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #48	I	NA	NA	
1059	06	18	84	7.3400	0.0000	0	25		SIGMA CHEMICALS DISPOSED OF IN OWN DRUMS	NA	NA	NA	
1060	06	18	84	7.3400	0.0000	0	25		BROKEN BATTERY PLUS CLEANUP ON VERMICULITE	I*	NA	S	
1061	06	18	84	7.3400	0.0000	0	25		ENBOND	I*	NA	L	
1062	07	23	84	4.0300	0.0000	0	25		LEAD CHIPS	M	T	S	
1063	07	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 57 COPIER FLUID	I	NA	L	
1064	07	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 56 COPIER FLUID	I	NA	L	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 29
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1065	07	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 55 COPIER FLUID	I	NA	L	
1066	07	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 54	I	NA	L	
1067	07	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 53	I	NA	L	
1068	10	29	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 60	I	NA	L	
1069	09	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 59	I	NA	L	
1070	09	24	84	7.3400	0.0000	0	25		INORGANICS IN DRUM 58	I	NA	L	
1071	09	24	84	7.3400	0.0000	0	25		SODIUM SILICATE	I	TBD	S	
1072	10	29	84	4.0300	0.0000	0	25		BERYLLIUM WASTES PACKED IN VERMICULITE	M	TBD	S	
1073	12	19	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #64 (SALTS)	I	NA	NA	
1074	12	19	84	10.7000	0.0000	0	25		EBONAL-C	NA	TBD	NA	
1075	12	19	84	14.6900	0.0000	0	25		PHOTO RESIST STRIPPER	I*	TBD	L	
1076	12	19	84	22.0500	0.0000	0	25		AMMONIA ETCHANT	I	C*	L	
1077	12	19	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #62	I	NA	NA	
1078	12	19	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #61	I	NA	NA	
1079	12	19	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #63	I	NA	NA	
1080	12	19	84	7.3400	0.0000	0	25		INORGANICS IN DRUM #65	I	NA	NA	
1081	12	19	84	4.0300	0.0000	0	25		HYDROGEN CHLORIDE ON SODIUM CARBONATE	I	TBD	S	
1082	02	21	85	7.3400	0.0000	0	25		INORGANICS IN DRUM #66	I	NA	NA	
1083	02	21	85	7.3400	0.0000	0	25		INORGANICS IN DRUM #67	I	NA	NA	
1084	02	21	85	7.3400	0.0000	0	25		INORGANICS IN DRUM #68	I	NA	NA	
1085	04	26	85	7.3400	0.0000	0	25		INORGANICS IN DRUM #69	I	NA	NA	
1086	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #50	O	NA	L*	
1087	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #51	O	NA	L*	
1088	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #52	O	NA	L*	
1089	03	25	83	7.3400	0.0000	0	26		ORGANICS DRUM #56	O	NA	L*	
1090	03	25	83	7.3400	0.0000	0	26		ORGANICS DRUM #57	O	NA	L*	
1091	03	25	83	7.3400	0.0000	0	26		FLAMMABLE ORGANICS IN DRUM #58	O	I*	L*	
1092	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #59	O	NA	L*	
1093	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #60	O	NA	L*	
1094	03	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #60	O	NA	L*	
1095	03	25	83	14.7000	0.0000	0	26		BIPHENYL PHTHALATE CONTAMINATED EQUIPMENT	O	TBD	S	
1096	03	25	83	4.0300	0.0000	0	26		1 PT. TRIFLUOROMETHANE & SULFAMIC ACID	O	TBD	L*	
1097	05	25	83	7.3400	0.0000	0	26		ETHANOL & FREON ON VERMICULITE	O	TBD	S	
1098	05	25	83	22.0500	0.0000	0	26		SOLVENT PACKED ON VERMICULITE	O	TBD	S	
1099	05	25	83	14.7000	0.0000	0	26		CHLOROPHENE ON VERMICULITE	O	TBD	S	
1100	05	25	83	7.3400	0.0000	0	26		PHOTOCHEMICAL WASTES IN DRUM #61	I*	NA	L*	
1101	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #62	O	NA	L*	
1102	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #63	O	NA	L*	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 30
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1103	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #64	O	NA	L*	
1104	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #65	O	NA	L*	
1105	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #66	O	NA	L*	
1106	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #67	O	NA	L*	
1107	05	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #68	O	NA	L*	
1108	05	25	83	4.0300	0.0000	0	26		ORGANICS IN DRUM #69	O	NA	L*	
1109	05	25	83	4.0300	0.0000	0	26		COPPER SULFATE AND OIL ON VERMICULITE	O	TBD	S	
1110	05	25	83	4.0300	0.0000	0	26		ORGANICS IN DRUM #71	O	NA	L*	
1111	05	25	83	4.0300	0.0000	0	26		ETHYLENE DIAMINE LEAKING DRUM #72	O	I	L	
1112	06	20	83	2.6700	0.0000	0	26		4 5GAL. CANS OF OIL	O	TBD	L	
1113	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #72	O	NA	L*	
1114	07	25	83	29.4100	0.0000	0	26		CLEANING SOL. CONTAIN. BERYLLIUM ON VERMICULITE	I*	NA	S	
1115	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #73	O	NA	L*	
1116	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #74	O	NA	L*	
1117	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #75	O	NA	L*	
1118	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #76	O	NA	L*	
1119	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #77	O	NA	L*	
1120	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #78	O	NA	L*	
1121	07	25	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #79	O	NA	L*	
1122	09	29	83	94.2400	0.0000	0	26		ORGANIC CHEMICALS FROM S-SITE CLEANUP	O	NA	L*	
1123	09	29	83	22.0700	0.0000	0	26		SOLVENT WATSE ON VERMICULITE	O*	TBD	S	
1124	09	29	83	14.6900	0.0000	0	26		ORGANICS ABSORBED ON VERMICULITE	O	TBD	S	
1125	09	29	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #80	O	NA	L*	
1126	09	29	83	4.0300	0.0000	0	26		ORGANICS IN DRUM #81	O	NA	L*	
1127	09	29	83	7.3400	0.0000	0	26		DYE ON VERMICULITE DRUM #82	O	NA	S	
1128	09	29	83	7.3400	0.0000	0	26		ORGANICS IN DRUM #83	O	NA	L*	
1129	09	29	83	4.0300	0.0000	0	26		ORGANICS IN DRUM #84 ON VERMICULITE	O	NA	S	
1130	09	29	83	4.0300	0.0000	0	26		DRUM 85 DYE ON VERMICULITE	O	NA	S	
1131	09	29	83	7.3400	0.0000	0	26		ORGANICS IN DRUM 86	O	NA	L*	
1132	09	29	83	7.3400	0.0000	0	26		ORGANICS IN DRUM 87	O	NA	L*	
1133	03	07	85	16.0300	0.0000	0	26		BERYLLIUM WASTE	M	TBD	S	
1134	04	05	83	2.0000	0.0000	0	27		SULFAMIC ACID ABSORBED ON VERMICULITE	I	TBD	S	
1135	05	12	83	0.0300	0.0000	0	27		MERCURY WITH HIGH EXPLOSIVE TO SHAFT #27	M/O	T/R	S	
1136	05	25	83	11.3700	0.0000	0	27		? OR MISC. ARTICLES 1-55 GAL.,1-30 GAL.	NA	NA	NA	
1137	07	27	83	7.3400	0.0000	0	27		? CONTAMINATED OPTICLES	NA	NA	NA	
1138	07	25	83	4.0300	0.0000	0	27		SODIUM-POTASSIUM CONTAMINATED MATERIAL IN DRUM #32	I	I	S	
1139	07	28	83	0.0200	0.0000	0	27		MERCURY VAPOR LIGHT IN SHAFT 27	M	T	S	
1140	09	09	83	2.6700	0.0000	0	27		BERYLLIUM WASTE IN SPECIAL SHAFT	M	TBD	S	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 31
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1141	02	27	84	0.1100	0.0000	0	27		BERYLLIUM OXIDE	I	TBD	S	
1142	02	23	84	37.7600	0.0000	0	27		CLEANUP FROM HYDROXYLAMINE NITRATE SPILL	I	I*	S*	
1143	02	23	84	29.4100	0.0000	0	27		MAGNESIUM TURNINGS	M	R	S	
1144	02	01	84	0.1000	0.0000	0	27		LASER CELL WITH OSMIUM TETRAOXIDE	I	TBD	S	
1145	02	23	84	4.0300	0.0000	0	27		CLOTHING,GLOVES,ETC. CONTAMINTED WITH ARSENIC	I	T	S	
1146	03	09	84	0.9900	0.0000	0	27		ROLL OF ASBESTOS	I	TBD	S	
1147	03	23	84	1.3400	0.0000	0	27		MATERIALS CONTAMINATED WITH SODIUM & POTASSIUM	I	I	S	
1148	04	05	84	4.0300	0.0000	0	27		LOW LEVEL PCB CONTAM. ARTICLES IN VERM.	O	TBD	S	
1149	04	26	84	0.6700	0.0000	0	27		BERYLLIUM SCRAPS	M	TBD	S	
1150	05	14	84	2.0000	0.0000	0	27		CELLULOSE NITRATE FILM	O	I	S*	
1151	05	10	84	0.1000	0.0000	0	27		MERCURY VAPOR TUBE FROM OZALID MACHINE	I	T	V	
1152	10	29	84	32.0800	0.0000	0	27		BARIUM NITRATE	I	T	S	
1153	11	14	84	2.0000	0.0000	4	27		EMPTY KRYPTON CYLINDERS	I	TBD	V	
1154	11	28	84	0.0200	0.0000	0	27		PICRIC ACID	O	I	S	
1155	12	18	84	5.0000	0.0000	0	27		HEPA FILTERS WITH CARCINOGENS	O	NA	S	
1156	02	21	85	24.0500	0.0000	0	27		BERYLLIUM WASTE	M	TBD	S	
1157	08	06	84	0.5000	0.0000	0	28		BERYLLIUM OXIDE FROM MACHINING	I	TBD	S	
1158	04	26	85	7.3400	0.0000	0	28		ORGANICS IN DRUM #154	O	NA	L*	
1159	04	26	85	7.3400	0.0000	0	28		PHOTOCHEMICALS IN DRUM #155	NA	NA	NA	
1160	04	26	85	8.0200	0.0000	0	28		EPOXY IN DRUMS #156 & 157	O	NA	NA	
1161	04	26	85	7.3400	0.0000	0	28		ORGANICS IN DRUM #158	O	NA	L*	
1162	04	26	85	22.0700	0.0000	0	28		ORGANICS IN DRUMS 162,163,164	O	NA	L*	
1163	04	26	85	66.1700	0.0000	0	28		PAINT ON VERMICULITE	O	TBD	S	
1164	04	26	85	7.3400	0.0000	0	28		EPON RESIN	O	NA	NA	
1165	04	26	85	22.0700	0.0000	0	28		OIL ON VERMICULITE	O	TBD	S	
1166	04	26	85	14.6900	0.0000	0	28		WEED KILLER & COMPOUND SPRAY ON VERMICULITE	NA	NA	S	
1167	04	26	85	7.3400	0.0000	0	28		DIESEL FUEL ON VERMICULITE	O	TBD	S	
1168	04	26	85	8.0200	0.0000	0	28		USED CUTTING OIL ON VERMICULITE	O	TBD	S	
1169	04	26	85	14.6900	0.0000	0	28		TRANSFORMER OIL ON VERMICULITE	O	TBD	S	
1170	04	05	84	7.3400	0.0000	0	29		ORGANICS IN DRUM 113 OIL	O	NA	L*	
1171	04	05	84	7.3400	0.0000	0	29		ORGANICS IN DRUM 112	O	NA	L*	
1172	04	05	84	124.9700	0.0000	0	29		OIL ON VERMICULITE	O	TBD	S	
1173	04	05	84	7.3400	0.0000	0	29		HYDRAULIC OIL (REGAL 0) ON VERMICULITE	O	TBD	S	
1174	04	26	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #116	O	NA	L*	
1175	04	26	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #115 METHANOL	O	NA	L*	
1176	04	26	84	16.0400	0.0000	0	29		VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	
1177	04	26	84	141.2400	0.0000	0	29		OIL ON VERMICULITE	O	TBD	S	
1178	04	26	84	7.3400	0.0000	0	29		INORGANICS IN DRUM 43 (CD)	I	NA	NA	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 32
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1179	04	26	84	7.3400	0.0000	0	29		ORGANICS IN DRUM 114	O	NA	L*	
1180	04	26	84	7.3400	0.0000	0	29		MECHANICAL PUMP OIL	O	TBD	L	
1181	04	26	84	7.3400	0.0000	0	29		CHLOROETHANE,ETHANOL, AND ACETONE	O	I	L	
1182	04	26	84	7.3400	0.0000	0	29		DYE, METHANOL, AND ETHANOL ON VERMICULITE	O	TBD	S	
1183	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #127	O	NA	L*	
1184	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #126	O	NA	L*	
1185	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #125	O	NA	L*	
1186	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #123	O	NA	L*	
1187	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #122	O	NA	L*	
1188	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #121	O	NA	L*	
1189	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #120	O	NA	L*	
1190	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #119	O	NA	L*	
1191	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #118	O	NA	L*	
1192	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM #117	O	NA	L*	
1193	06	18	84	7.3400	0.0000	0	29		INORGANICS IN DRUM 47	I	NA	NA	
1194	06	18	84	29.7700	0.0000	0	29		SLUDGE WITH PCB (10PPM)	O	TBD	S	
1195	06	18	84	7.3400	0.0000	0	29		DIELECTRIC FLUID WITH TRACE OF ARSENIC	O*	T	L	
1196	06	18	84	14.6900	0.0000	0	29		MISC. ORGANIC FLUIDS ON VERMICULITE	O	NA	S	
1197	06	18	84	7.3400	0.0000	0	29		OIL WITH ACETONE ON VERMICULITE	O	TBD	S	
1198	06	18	84	7.3400	0.0000	0	29		METHYL ETHYL KETONE ON VERMICULITE	O	T	S	
1199	06	18	84	7.3400	0.0000	0	29		OIL ON VERMICULITE	O	TBD	S	
1200	06	18	84	58.8300	0.0000	0	29		? FUNGICIDE F16	NA	NA	L*	
1201	06	18	84	7.3400	0.0000	0	29		ORGANICS IN DRUM # 126	O	NA	L*	
1202	06	18	84	7.3400	0.0000	0	29		OIL ABSORBED ON VERMICULITE	O	TBD	S	
1203	06	18	84	7.3400	0.0000	0	29		DIMETHYL SULFOXIDE ON VERMICULITE	O	TBD	S	
1204	06	18	84	218.9200	0.0000	0	30		OIL ON VERMICULITE	O	TBD	S	
1205	07	23	84	22.0700	0.0000	0	30		MIXED ORGANIC WASTES ON VERMICULITE	O	NA	S	
1206	07	23	84	22.0700	0.0000	0	30		SOLVENTS AND OILS ON VERMICULITE	O*	NA	S	
1207	07	23	84	13.3700	0.0000	0	30		SOLIDIFIED PAINT	O	TBD	S	
1208	07	23	84	14.6900	0.0000	0	30		DIBUTYL PHTHALATE ON VERMICULATE	O	TBD	S	
1209	07	23	84	121.4500	0.0000	0	30		OIL ON VERMICULITE	O	TBD	S	
1210	07	23	84	7.3400	0.0000	0	30		CHLOROETHANE,ETHANOL,ACETONE,OIL ON VERMICULITE	O	TBD	S	
1211	07	23	84	14.6900	0.0000	0	30		DIBUTYL CARBITOL ON VERMICULATE	O	TBD	S	
1212	07	23	84	14.6900	0.0000	0	30		STODDARD SOLVENT ON VERMICULATE	O	TBD	S	
1213	07	23	84	14.6900	0.0000	0	30		TRICHLOROETHYLENE ON VERMICULATE	O	T	S	
1214	07	23	84	14.6900	0.0000	0	30		ISOBUTYL ACETATE ON VERMICULITE	O	TBD	S	
1215	07	23	84	14.6900	0.0000	0	30		METHYL ISOBUTYLKETONE ON VERMICULITE	O	TBD	S	
1216	07	23	84	14.6900	0.0000	0	30		DOWCLENE ON VERMICULITE	O	TBD	L	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 33
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1217	07 23 84	14.6900	0.0000	0	30		?? CONCENTRATE ON VERMICULITE	NA	NA	S	
1218	07 23 84	14.6900	0.0000	0	30		TRIBUTYL PHOSPHATE ON VERMICULITE	O	TBD	S	
1219	07 23 84	7.3400	0.0000	0	30		DIESEL OIL ON VERMICULITE	O	TBD	S	
1220	07 23 84	14.6900	0.0000	0	30		ACETONE ON VERMICULITE	O	TBD	S	
1221	07 23 84	14.6900	0.0000	0	30		METHYLENE CHLORIDE ON VERMICULITE	O	TBD	S	
1222	07 23 84	22.0700	0.0000	0	30		FREON ON VERMICULITE	O	TBD	S	
1223	07 23 84	14.6900	0.0000	0	30		WASTE OIL ON VERMICULITE	O	TBD	S	
1224	07 23 84	14.6900	0.0000	0	30		ORGANICS IN DRUM 132	O	NA	L*	
1225	07 23 84	14.6900	0.0000	0	30		ORGANICS IN DRUM 131	O	NA	L*	
1226	07 23 84	14.6900	0.0000	0	30		ORGANICS IN DRUM 130	O	NA	L*	
1227	07 23 84	14.6900	0.0000	0	30		ORGANICS IN DRUM 129	O	NA	L	
1228	07 24 84	7.3400	0.0000	0	31		ORGANIC DYE ON VERMICULITE	O	TBD	S	
1229	07 24 84	22.0700	0.0000	0	31		PAINT THINNER ON VERMICULITE	O	TBD	S	
1230	07 24 84	7.3400	0.0000	0	31		VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	
1231	07 24 84	29.4100	0.0000	0	31		DIRT WITH ORGANICS	O	NA	S	
1232	09 24 84	7.3400	0.0000	0	31		ORGAINCS IN DRUM 139	O	NA	L*	
1233	09 24 84	7.3400	0.0000	0	31		ORGANICS IN DRUM 137	O	NA	L*	
1234	09 24 84	7.3400	0.0000	0	31		ORGANICS IN DRUM 136	O	NA	L*	
1235	09 24 84	7.3400	0.0000	0	31		ORGANICS IN DRUM 135	O	NA	L*	
1236	09 24 84	12.0400	0.0000	0	31		OIL ON VERMICULITE	O	TBD	S	
1237	09 24 84	14.6900	0.0000	0	31		TRICHLOROETHYLENE ON VERMICULITE	O	T	S	
1238	10 29 84	7.3400	0.0000	0	31		ORGANICS IN DRUM 143	O	NA	L*	
1239	10 29 84	7.3400	0.0000	0	31		ORGANICS IN DRUM 144	O	NA	L*	
1240	09 24 84	132.3400	0.0000	0	31		OIL ON VERMICULITE	O	TBD	S	
1241	09 24 84	22.0700	0.0000	0	32		OIL ON VERMICULITE	O	TBD	S	
1242	09 24 84	36.7600	0.0000	0	32		SHEATH (STODDARD SOLVENT) ON VERMICULITE	O	TBD	S	
1243	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 142	O	NA	L*	
1244	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 141	O	NA	L*	
1245	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 140	O	NA	L*	
1246	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 138	O	NA	L*	
1247	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 134	O	NA	L*	
1248	10 29 84	7.3400	0.0000	0	33		ORGANICS IN DRUM 133	O	NA	L*	
1249	10 29 84	7.3400	0.0000	0	33		ORGANICS SOLVENTS ON VERMICULITE	O	NA	S	
1250	10 29 84	95.5700	0.0000	0	33		LOW LEVEL PCB OIL ON VERMICULITE	O	TBD	S	
1251	10 29 84	7.3400	0.0000	0	33		NON-PCB TRANS. OIL AND WATER ON VERMICULITE	O	TBD	S	
1252	12 19 84	7.3400	0.0000	0	33		ORGANICS IN DRUM #148	O	NA	L*	
1253	12 19 84	7.3400	0.0000	0	33		ORGANICS IN DRUM #149	O	NA	L*	
1254	12 19 84	58.8100	0.0000	0	33		OIL ON VERMICULITE	O	TBD	S	

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 34
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1255	12 19 84	7.3400	0.0000	0	33		ORGANICS IN DRUM #146	O	NA	L*	Y
1256	12 19 84	7.3400	0.0000	0	33		ORGANICS IN DRUM #145	O	NA	L*	Y
1257	12 19 84	7.3400	0.0000	0	33		ORGANICS IN DRUM #147	O	NA	L*	Y
1258	12 19 84	7.3400	0.0000	0	33		MACHINE OIL ON VERMICULITE	O	TBD	S	Y
1259	12 19 84	58.8100	0.0000	0	33		TRICHLOROETHANE,1-1-1 ON VERMICULITE	O	TBD	S	Y
1260	12 19 84	7.3400	0.0000	0	33		ORGANICS ON VERMICULITE	O	NA	S	Y
1261	12 19 84	2.2700	0.0000	0	33		USED PUMP OIL ON VERMICULITE	O	TBD	S	Y
1262	12 19 84	8.0200	0.0000	0	33		USED VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	Y
1263	02 21 85	7.3400	0.0000	0	33		CHLOROETHANE ON VERMICULITE	O	TBD	S	Y
1264	02 21 85	12.0400	0.0000	0	33		ORGANICS	O	NA	L*	Y
1265	02 21 85	7.3400	0.0000	0	33		ORGANICS IN DRUM #152	O	NA	L*	Y
1266	02 21 85	4.0300	0.0000	0	33		METHANOL & LASER DYE ON VERMICULITE	O	TBD	S	Y
1267	02 21 85	4.0300	0.0000	0	33		MOTOR OIL ABSORBED ON VERMICULITE	O	TBD	S	Y
1268	02 21 85	7.3400	0.0000	0	33		ORGANICS IN DRUM #150	O	NA	L*	Y
1269	02 21 85	7.3400	0.0000	0	33		ORGANICS IN DRUM #151	O	NA	L*	Y
1270	02 21 85	7.3400	0.0000	0	33		ORGANICS IN DRUM #153	O	NA	L*	Y
1271	02 21 85	36.7600	0.0000	0	33		USED TRASH FLUIDS IN VERMICULITE	NA	NA	S*	Y
1272	02 21 85	0.0000	0.0000	0	33		CHLORETHANE,ETHANOL,WATER,ACETONE,OIL	O	I	L	Y
1273	02 21 85	29.4100	0.0000	0	33		ACETONE ON VERMICULITE	O	TBD	S*	Y
1274	02 21 85	4.0300	0.0000	0	33		VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	Y
1275	02 21 85	14.6900	0.0000	0	33		VACUUM PUMP OIL ON VERMICULITE	O	TBD	S	Y
1276	04 26 85	7.3400	0.0000	0	34		ORGANICS IN DRUM #159	O	NA	L*	Y
1277	04 26 85	14.6900	0.0000	0	34		ORGANICS IN DRUM #160	O	NA	L*	Y
1278	04 26 85	66.1700	0.0000	0	34		PSEUDO (TRI-METHYL-BENZENE)	O	I	L	Y
1279	04 26 85	0.0000	0.0000	0	34		LOW PCB OIL ON VERMICULITE	O	TBD	S	Y
1280	04 26 85	11.3700	0.0000	0	34		NEUTRALIZED ACIDS,HYDRIDES & SULFATES	I	C*/R*	S/L	Y
1281	05 07 85	7.3400	0.0000	0	34		ORGANICS IN DRUM #161	O	NA	L*	Y
1282	05 07 85	7.3400	0.0000	0	34		ORGANICS IN DRUM #165	O	NA	L*	Y
1283	05 07 85	0.0000	0.0000	0	34		TRICHLOROETHANE ON VERMICULITE	O	TBD	S*	Y
1284	05 07 85	26.0600	0.0000	0	34		PHOTO STRIPPING ON VERMICULITE	I	TBD	S*	Y
1285	05 07 85	22.0300	0.0000	0	34		WASTE FLUID MIXED WITH VERMICULITE	NA	NA	S*	Y
1286	05 07 85	7.3400	0.0000	0	34		ORGANICS OF VARIOUS TYPES	O	NA	L*	Y
1287	05 25 83	0.5330	0.0000	0		B	DEVELOPER TO ORGANIC PIT	O	TBD	L	Y
1288	10 24 83	0.1300	0.0000	0		B	CORROSIVE LIQUID TO PIT B	I*	C*	L	Y
1289	11 01 83	0.3530	0.0000	0		B	AQUEOUS SOLUTION TO INORGANIC PIT	NA	NA	L	Y
1290	01 26 84	22.0700	0.0000	0		B	BORIC ACID SOL. TO PIT	I	NA	L	Y
1291	07 13 84	80.1900	0.0000	0			AMMONIUM BIFLUORIDE	I	TBD	S	N
1292	07 16 84	1.0030	0.0000	0			P.T. ACTIVATOR DEVELOPER	O*	NA	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 35
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1293	07 25 84	66.8400	0.0000	0			AMMONIUM BIFLUORIDE	I	TBD	S	N
1294	08 01 84	80.1900	0.0000	0			AMMONIUM BIFLUORIDE	I	TBD	S	N
1295	08 07 84	0.0000	0.3600	0			ZINC, NICKEL, ARSENIC	I	T	S	N
1296	09 02 83	0.2680	0.0000	0		B	AMMONIA FROM OZALID MACHINE TO PIT	I	C	L	Y
1297	11 14 83	0.1340	0.0000	0		B	AMMONIA FROM OZALID MACHINE TO PIT	I	C	L	Y
1298	11 29 83	0.0670	0.0000	0		B	AMMONIA FROM OZALID MACHINE TO PIT	I	C	L	Y
1299	12 20 83	0.1590	0.0000	0		B	PHOTOCHEMICALS TO PIT	O*	NA	L*	Y
1300	01 19 84	24.0500	0.0000	0		B	BASIC PHOTOCHEMICALS IN INORGANIC PIT	NA	NA	L*	Y
1301	11 17 83	0.0700	0.0000	0		B	LITHIUM HYDRIDE REACTED IN PIT	I	R	S	Y
1302	08 05 77	4.0000	0.0000	0			SOLVENTS	O	NA	L	N
1303	07 28 77	4.0000	0.0000	0			LITHIUM CHIPS	M	R	S	N
1304	07 28 77	21.4000	0.0000	0			SULFURIC & CHROMIC ACID	I	C	L	N
1305	06 20 77	4.0000	0.0000	0			ACIDS, BASES, ORGANICS	O/I	NA	L	N
1306	07 14 77	0.1000	0.0000	0			EPOXY MATERIAL	O	NA	L*	N
1307	07 22 77	1.0000	0.0000	0			OLD OZALID SOLUTION	NA	NA	NA	N
1308	07 27 77	0.5000	0.0000	0			ETHER	O	I	L	N
1309	07 28 77	1.5000	0.0000	0			SODIUM-POTASSIUM ALLOY	M	I	S*	N
1310	07 12 77	8.0000	0.0000	0	02		SODIUM CHLORIDE ALLOY	I	TBD	S	Y
1311	07 13 77	16.0000	0.0000	0			BORIC ACID	I	TBD	S	N
1312	06 21 77	3.0000	0.0000	0			MISC CHEMICALS	NA	NA	NA	N
1313	07 12 77	1.0000	0.0000	0			NITRIC ACID	I	C	L	N
1314	07 13 77	2.0000	0.0000	0			PHOSPHORIC ACID	I	C	L	N
1315	07 14 77	2.0000	0.0000	0			PLATING SOLUTION	NA	NA	L	N
1316	07 18 77	32.0000	0.0000	0			SOLVENTS	O	NA	L	N
1317	07 20 77	6.0000	0.0000	0			MISC. ORGANICS	O	NA	L*	N
1318	07 20 77	2.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1319	07 20 77	1.0000	0.0000	0			BENZENE, EPOXY MATERIAL	O	T	L	N
1320	07 20 77	0.5000	0.0000	0			BENZENE	O	T	L	N
1321	07 20 77	4.0000	0.0000	0			SOLVENTS	O	NA	L	N
1322	07 21 77	2.0000	0.0000	0			CALCIUM CARBIDE	O	R	S	N
1323	07 25 77	2.0000	0.0000	0			SODIUM-POTASSIUM ALLOY VALVES	M	I	S	N
1324	07 25 77	1.0000	0.0000	0			SODIUM-POTASSIUM ALLOY VALVES	M	I	S	N
1325	07 27 77	0.5000	0.0000	0			SODIUM-POTASSIUM ALLOY VALVES	M	I	S	N
1326	00 00 00	1.0000	0.0000	0			MISC CHEMICALS (7/77)	NA	NA	NA	N
1327	00 00 00	16.5000	0.0000	0			FERRIC CHLORIDE (7/77)	I	TBD	S	N
1328	00 00 00	1.0000	0.0000	0			LITHIUM & BERYLLIUM OXIDE (7/77)	M/I	R	S	N
1329	08 12 77	8.0000	0.0000	0			USED OIL	O	TBD	L	N
1330	08 12 77	16.0000	0.0000	0			SOLVENT-TRICHLORETHYLENE	O	T	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 36
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1331	06 06 77	0.0000	0.0000	0			MAGNESIUM METAL	M	I	S	N
1332	06 06 77	54.0000	0.0000	0			SOLVENTS & OIL	O	NA	L	N
1333	08 03 77	16.0000	0.0000	0			SOLVENTS	O	NA	L	N
1334	08 15 77	1.0000	0.0000	0			SODIUM-POTASSIUM ALLOY VALVES	M	I	S	N
1335	07 22 77	2.0000	0.0000	0			ETHYLENE OXIDE, HYDROCHLORIC ACID	O/I	I*/C	L	N
1336	08 10 77	2.0000	0.0000	0			SOLVENTS, ALCOHOL, DYE	O	I*	L	N
1337	07 14 77	16.0000	0.0000	0	10		TISSUE EQUIVALENT FLUID	NA	NA	L	Y
1338	08 10 77	8.0000	0.0000	0	10		SOLVENTS	O	NA	L	Y
1339	08 10 77	80.4000	0.0000	0		A	AMMONIUM BIFLUORIDE SOLUTION	I	TBD	S	Y
1340	00 00 00	1.0000	0.0000	0			SODIUM-POTASSIUM ALLOY (8/77)	M	I	S	N
1341	08 03 77	1.0000	0.0000	0			SODIUM-POTASSIUM ALLOY	M	I	S	N
1342	07 20 77	0.5000	0.0000	0			ARSENIC	I	T	S	N
1343	04 19 77	0.5000	0.0000	0			CALCIUM CARBIDE	O	R	S	N
1344	03 02 77	0.5000	0.0000	0			RUST INHIBITOR	NA	NA	NA	N
1345	04 06 77	4.0000	0.0000	0			SOLVENTS	O	NA	L	N
1346	03 23 77	1.0000	0.0000	0			EPOXY WASTE	O	TBD	L*	N
1347	04 20 77	18.7600	0.0000	0			ACETIC ACID	O	C*	L	N
1348	03 15 77	20.0000	0.0000	0			DIMETHYLSULFOXIDE, DIETHYL ETHER	O	TBD	L	N
1349	00 00 00	1.0000	0.0000	0			PCB (3/77)	O	TBD	L	N
1350	04 04 77	16.0000	0.0000	0			NITRITES	I	NA	S	N
1351	03 16 77	8.0000	0.0000	0			ACETONE	O	I	L	N
1352	03 16 77	20.0000	0.0000	0			OXYGEN (NITROGEN DIOXIDE) GAS CYLINDERS	I	TBD	V	N
1353	00 00 00	20.0000	0.0000	0			PALLADIUM CHLORIDE (3/77)	I	TBD	S	N
1354	02 24 77	46.0000	0.0000	0			LITHIUM HYDRIDE RESIDUES	I	I	S	N
1355	02 17 77	56.0000	0.0000	0			DIRTY OIL	O	TBD	L	N
1356	03 23 77	1.0000	0.0000	0			CAPACITOR	O	TBD	L	N
1357	03 31 77	9.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1358	03 31 77	1.0000	0.0000	0			TRIFLUOROMETHANE SULFONIC ANHYDRIDE	O	TBD	L*	N
1359	04 05 77	3.0000	0.0000	0			MAGNESIUM TURNINGS	M	I	S	N
1360	03 17 77	5.0000	0.0000	0			DARK ROOM CHEMICALS (PHOTOCHEMICALS)	I*	NA	L*	N
1361	00 00 00	13.0000	0.0000	0	02		NITRIC ACID (3/77)	I	C	L	Y
1362	03 09 77	18.0000	0.0000	0			CAPACITOR OIL & MISC. CHEMICALS	O	NA	L	N
1363	04 11 77	48.0000	0.0000	0			USED OIL	O	TBD	L	N
1364	04 12 77	24.0000	0.0000	0			USED SOLVENTS	O	NA	L	N
1365	02 28 77	0.2680	0.0000	0			TOLUENE	O	I	L	N
1366	00 00 00	0.6700	0.0000	0			CUTTING OIL CONTAINING NITRATES (2/77)	O	NA	L	N
1367	00 00 00	2.0000	0.0000	0			BARIUM PEROXIDE & NITROBASE (2/77)	NA	I/T	S*	N
1368	02 10 77	2.0000	0.0000	0			AMMONIUM PERSULFATE & MISC. PHOTOCHEMICALS	I*	N/I*	L*	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 37
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1369	00	00	00	5.0000	0.0000	0			NICKEL CARBONYL & OIL (2/77)	O	I*	L	N
1370	01	31	77	2.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1371	00	00	00	1.0000	0.0000	0			MISC. ORGANIC SOLVENTS (2/77)	O	NA	L	N
1372	02	09	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1373	02	03	77	3.5000	0.0000	0			FERRIC CHLORIDE ETCHANT	I	TBD	L*	N
1374	02	03	77	11.2000	0.0000	0			NICKEL STRIKE (NICKEL CHLORIDE & HYDROCHLORIC ACID)	I	C*	L	N
1375	02	04	77	60.0000	0.0000	0			USED OIL & PHOSPHORIC ACID	O	C*	L	N
1376	01	26	77	1.3000	0.0000	0			PHOTOCHEMICALS	I	NA	L	N
1377	02	02	77	32.1600	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1378	02	04	77	2.0100	0.0000	0			SOLVENT & DYE	O	NA	L	N
1379	02	04	77	1.0000	0.0000	0			DEUTERIUM & THALLIUM METAL	M	R	S	N
1380	02	07	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1381	02	02	77	376.0000	0.0000	0			USED OIL, MISC. CHEMICALS, SOLVENTS	O	NA	L	N
1382	02	02	77	5.0000	0.0000	0			TOLUENE	O	I	L	N
1383	01	27	77	6.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1384	01	11	77	24.0000	0.0000	0			NICKEL ELECTROPLATING BATH	I*	TBD	L	N
1385	01	26	77	10.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1386	01	19	77	0.5400	0.0000	0			ALCOHOL & DYE	O	I*	L	N
1387	01	14	77	0.1300	0.0000	0			METHYLENE CHLORIDE	O	TBD	L	N
1388	01	13	77	1.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1389	01	13	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1390	01	13	77	0.6700	0.0000	0			WASTE SOLVENT (ALCOHOL)	O	I	L	N
1391	01	27	77	0.0000	3.0000	0	06		SODIUM	M	R	S	Y
1392	12	28	77	1.0000	0.0000	0			OSMIUM TETROXIDE	I	TBD	S	N
1393	12	21	77	0.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1394	12	21	77	3.0000	0.0000	0			AMMONIUM NITRATE	I	I	S	N
1395	12	15	77	6.0000	0.0000	0			ACID, DOWANOL & MINERAL OIL	O	I*	L	N
1396	12	15	77	6.0000	0.0000	0			PHOSPHORIC ACID & MISC. CHEMICALS	NA	C*	L	N
1397	12	15	77	4.0000	0.0000	0			TRANSFORMER OIL, FORMALDEHYDE	O	TBD	L	N
1398	12	13	77	32.0000	0.0000	0			CHROMIC SULFURIC ACID ETCHING SOL'N	I	C	L	N
1399	12	08	77	2.0000	0.0000	0	09		LEAKING FLUORINE GAS CYLINDER	I	TBD	V	Y
1400	12	02	77	1.0000	0.0000	0			SOLVENTS	O	NA	L	N
1401	12	01	77	0.5000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1402	12	01	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1403	12	01	77	5.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1404	12	01	77	10.0000	0.0000	0			ASBESTOS CONTAMINATED CEMENT, OIL, ORGANIC CHEMICALS	O	NA	S/L	N
1405	12	15	77	30.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1406	11	23	77	1.0000	0.0000	0			SOLVENTS	O	NA	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 38
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALSTS.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1407	11	23	77	10.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1408	11	21	77	18.7600	0.0000	0			INDENE	O	TBD	L	N
1409	11	21	77	20.6400	0.0000	0			CHEMICALS	NA	NA	NA	N
1410	11	21	77	27.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1411	00	00	00	0.5000	0.0000	0			LITHIUM METAL IN HEAT PIPE (11/77)	N	I	S	N
1412	11	18	77	22.0000	0.0000	0	07		UNKNOWN	NA	NA	NA	Y
1413	11	18	77	20.1000	0.0000	0			LITHIUM HYDRIDE	I	I	S	N
1414	11	15	77	1.0000	0.0000	0			ACETONE, XYLENE, ALCOHOL	O	I	L	N
1415	01	14	77	5.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1416	11	14	77	5.0000	0.0000	0			MISC. OLD CHEMICALS	NA	NA	NA	N
1417	11	02	77	2.0000	0.0000	0			USED OIL	O	TBD	L	N
1418	11	03	77	14.0000	0.0000	0			KEROSENE & SOLVENTS	O	I	L	N
1419	11	03	77	40.0000	0.0000	0			USED OIL	O	TBD	L	N
1420	11	03	77	1.0000	0.0000	0			INORGANIC CHEMICALS	I	NA	S	N
1421	11	03	77	0.0000	0.0000	6			RESPIRATOR CARTRIDGES	I	NA	S	N
1422	11	09	77	2.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1423	11	10	77	15.0000	0.0000	0			SODIUM FLUORIDE, MISC. CHEMICALS & SOLVENTS	O	NA	L	N
1424	11	11	77	1.0000	0.0000	0			FREON 13	O	TBD	L	N
1425	11	14	77	32.0000	0.0000	0			SOLVENTS	O	NA	L	N
1426	11	17	77	12.0000	0.0000	0			OLD GAS CYLINDERS	NA	NA	V	N
1427	11	17	77	2.0000	0.0000	0			SOLVENTS	O	NA	L	N
1428	00	00	00	0.1000	0.0000	0			HELIUM CONTAMINATED MERCURY	M	T	S	N
1429	11	09	77	1.3400	0.0000	0			USED OIL & SOLVENTS	O	TBD		N
1430	11	08	77	0.2700	0.0000	0			OIL	O	TBD	L	N
1431	11	09	77	2.6800	0.0000	0			MISC. CHEMICALS & WASTE OIL	O	NA	L	N
1432	11	09	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1433	11	02	77	4.1000	0.0000	0			SULFURIC ACID	I	C	L	N
1434	11	02	77	2.0000	0.0000	0			LEAKY CAPACITORS	O	TBD	L	N
1435	10	14	77	48.0000	0.0000	0			EPOXY RESIN, CURING AGENTS	O	I*	L	N
1436	10	14	77	200.0000	0.0000	0			OIL	O	TBD	L	N
1437	10	14	77	1.0000	0.0000	0			LITHIUM HYDRIDE	I	I	S	N
1438	10	04	77	72.0000	0.0000	0	10		OIL	O	TBD	L	Y
1439	10	03	77	4.0000	0.0000	0			ORGANIC CHEMICALS	O	NA	L*	N
1440	09	26	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1441	09	21	77	4.0200	0.0000	0			TRANSFORMER OIL	O	TBD	L	N
1442	09	20	77	2.0000	0.0000	0			SOLVENTS, ETC.	O	NA	L	N
1443	09	16	77	17.4200	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1444	09	15	77	16.0000	0.0000	0	10		PCB CONTAMINATED RAGS	O	TBD	S	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 39
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1445	09	15	77	32.0000	0.0000	0	10		SOLVENTS	O	NA	L	Y
1446	09	08	77	0.1000	0.0000	0			MAGNESIUM	M	I	S	N
1447	09	07	77	9.0000	0.0000	0			BATTERY ACID	I	C	L	N
1448	09	06	77	10.0000	0.0000	0			OLD CHEMICALS	NA	NA	NA	N
1449	08	31	77	64.0000	0.0000	0	02		WHITE PHOSPHOROUS PACKAGED UNDER WATER	I	I	L	Y
1450	00	00	00	0.5000	0.0000	0			IRON PENTACARBONYL	O	I	L	N
1451	08	31	77	1.0000	0.0000	0			BROMINE	I	TBD	L	N
1452	08	30	77	8.0000	0.0000	0			SOLVENTS	O	NA	L	N
1453	08	30	77	1.3400	0.0000	0			OIL	O	TBD	L	N
1454	08	30	77	6.0000	0.0000	0			BERYLLIUM WIRE	M	TBD	S	N
1455	08	29	77	2.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1456	08	29	77	10.0000	0.0000	0			WHITE PHOSPHOROUS, FIRE EXTINGUISHER POWDER, MISC. CHEMICALS	NA	I	S*	N
1457	08	29	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1458	08	29	77	5.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1459	08	29	77	8.0000	0.0000	0			MISC. INORGANIC & ORGANIC CHEMICALS	I/O	NA	NA	N
1460	08	26	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1461	07	13	77	9.0000	0.0000	0			SULFURIC ACID	I	C	L	N
1462	00	00	00	0.0000	400.0000	0			POLYETHYLENE POWDER (8/77)	O	TBD	S	N
1463	00	00	00	0.0000	150.0000	0			NEOPRENE (8/77)	O	TBD	S	N
1464	07	01	77	3.3500	0.0000	0			TRICHLOROETHANE	O	TBD	L	N
1465	08	23	77	25.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1466	03	15	77	1.0000	0.0000	0			PHOSPHOROUS PENTOXIDE	I	R	S	N
1467	03	15	77	2.0000	0.0000	0			URANIUM HYDRIDE CAPSULES	I	I	S	N
1468	03	08	77	8.0000	0.0000	0			METHANE GAS CYLINDERS	O	I	V	N
1469	03	08	77	6.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1470	03	08	77	6.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1471	00	00	00	20.0000	0.0000	0			SOLVENT, USED OIL (3/77)	O	NA	L	N
1472	01	19	77	1.0000	0.0000	0			MISC. CHEMICALS	NA	NA	NA	N
1473	00	00	00	1.0000	0.0000	0			MISC. CHEMICALS (1/77)	NA	NA	NA	N
1474	01	04	77	1.0000	0.0000	0			MISC. INORGANIC CHEMICALS	I	NA	NA	N
1475	00	00	00	6.0000	0.0000	0			CHEMICALS (1/77)	NA	NA	NA	N
1476	00	00	00	0.0000	0.0000	0			CHEMICALS (1/77)	NA	NA	NA	N
1477	11	06	80	0.0170	0.0000	0			CARBON TETRACHLORIDE	O	T	L	N
1478	11	06	80	0.0340	0.0000	0			CHLOROFORM	O	T	L	N
1479	11	06	80	0.0510	0.0000	0			BROMOTRICHLOROMETHANE	O	TBD	L	N
1480	11	06	80	0.0340	0.0000	0			ACETIC ANHYDRIDE	O	I	L	N
1481	11	06	80	0.0000	44.0000	0			1,2,DICHLOROETHANE	O	T/I	L	N
1482	11	06	80	0.0340	0.0000	0			CHLOROBENZENE	O	T/I	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 40
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1483	11 06 80	0.0170	0.0000	0			N,N,DIMETHYLFORMIDE	O	I	L	N
1484	11 06 80	0.0000	2.2000	0			FLUOROBENZENE	O	I*	L	N
1485	11 06 80	0.0000	33.0000	0			BUTYROLACTONE	O	TBD	L	N
1486	11 06 80	0.0170	0.0000	0			MONOCHLORONAPHTHALENE	O	TBD	L	N
1487	11 06 80	0.0000	2.2000	0			DICHLOROBENZENE	O	T*	S*	N
1488	11 06 80	0.2000	0.0000	0			KODAK RESIST THINNER TYPE 3	O	TBD	L	N
1489	11 06 80	0.0000	28.0000	0			PHOTO RESIST CHEMICALS	I*	NA	L	N
1490	11 06 80	0.1340	0.0000	0			TRITON W30	NA	TBD	NA	N
1491	11 06 80	0.1340	0.0000	0			TRITON X15	NA	TBD	NA	N
1492	11 06 80	0.1340	0.0000	0			STAFOAM BASE & CATALYST	NA	NA	NA	N
1493	11 06 80	0.0000	1.0000	0			LEAD DIOXIDE	I	T/I	S	N
1494	11 06 80	0.0000	1.0000	0			SODIUM AZIDE	I	TBD	S	N
1495	11 06 80	0.0000	1.0000	0			POTASSIUM HYDROXIDE	I	TBD	S	N
1496	11 06 80	0.1340	0.0000	0			LEAD PERCHLORATE	I	T/I	S	N
1497	11 06 80	0.0000	220.0000	0			ZINC CHLORIDE	I	TBD	S	N
1498	11 06 80	0.1340	0.0000	0			EPON RESIN 828	O	I	L	N
1499	11 06 80	0.0170	0.0000	0			VERSAMIDE 125	O	TBD	S*	N
1500	11 06 80	0.0000	1.0000	0			SODIUM BORATE	I	TBD	S	N
1501	11 06 80	0.0000	1.0000	0			AMMONIUM CHLORIDE	I	TBD	S	N
1502	11 06 80	0.0000	1.0000	0			CALCIUM OXIDE	I	R	S	N
1503	11 06 80	0.0000	1.0000	0			POTASSIUM CHLORATE	I	I	S	N
1504	11 06 80	0.0000	1.0000	0			POTASSIUM NITRATE	I	I/R	S	N
1505	11 06 80	0.0000	1.0000	0			SULFUR	I	R	S	N
1506	11 06 80	0.0000	8.0000	0			PERCHLORIC ACID	I	I/R	L	N
1507	11 06 80	0.0000	0.5000	0			COPPER SULFATE	I	I	S	N
1508	11 06 80	0.0000	1.2500	0			POTASSIUM PERMANGANATE	I	I	S	N
1509	11 06 80	0.0000	0.2500	0			CUPRIC NITRATE	I	I	S	N
1510	11 06 80	0.0000	1.0000	0			AMMONIUM SULFIDE	I	TBD	S	N
1511	11 06 80	0.0700	0.0000	0			PHOTO RESIST STRIPPER	NA	NA	L	N
1512	11 06 80	0.0170	0.0000	0			DISPERSION COATING 92-009	NA	NA	L	N
1513	11 06 80	0.2200	0.0000	0			KEL-F OIL	O	TBD	L	N
1514	11 06 80	0.0000	25.0000	0			POTASSIUM CARBONATE	I	TBD	S	N
1515	11 06 80	0.0700	0.0000	0			OAKITE #33 (SODIUM PHOSPHATE, TRIBASIC)	I	TBD	S	N
1516	11 06 80	0.0170	0.0000	0			SILICONE PUMP OIL 704	O	TBD	L	N
1517	11 06 80	0.0170	0.0000	0			FLUOROSILICONE FLUIDS	I	TBD	L	N
1518	11 06 80	0.0000	1.0000	0			IODINE	I	TBD	S	N
1519	11 06 80	0.0000	1.0000	0			SODIUM HYDROXIDE	I	TBD	S	N
1520	11 06 80	0.0000	1.0000	0			NICKEL SULFATE	I	TBD	S	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 41
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1521	11	06	80	0.0040	0.0000	0			POTASSIUM PERMANGANATE SOL.	I	I	S	N
1522	12	04	79	0.2010	0.0000	0			CHEMICALS ORGANICS	O	NA	L*	N
1523	12	03	79	2.6800	0.0000	0			OIL	O	TBD	L	N
1524	12	14	79	0.0000	0.0000	0			CHEMICALS, 2 BOTTLES HYDROCHLORIC ACID	I	C	L	N
1525	12	04	79	0.5100	0.0000	0			ORGANIC SOLVENT, DRY INORGANIC	I/O	C	L/S	N
1526	12	07	79	0.8040	0.0000	0			SULFURIC ACID	I	C	L	N
1527	12	06	79	0.5360	0.0000	0			CHEMICALS ORGANIC	O	NA	L*	N
1528	00	00	00	0.0000	0.0000	0			BERYLLIUM WASTE, 6 BOXES & 1 VACUUM CLEANER	M	TBD	S	N
1529	12	10	79	0.4020	0.0000	0			CHEMICALS ORGANIC & BASE	O/I	NA	L*	N
1530	12	13	79	2.0000	0.0000	0			1 IGNITRON, ORGANICS, ASBESTOS	O/I	T/NA	NA/S	N
1531	12	13	79	2.2780	0.0000	0			10 GALLON ORGANIC, 2 GALLON INORGANIC, 5 GALLON NITRIC ACID	M/O/I	C/NA	L/NA	N
1532	12	13	79	22.1100	0.0000	0			OIL NON PCB	O	TBD	L	N
1533	12	13	79	0.0000	0.0000	0			ZIRCONIUM CHIPS,1 GALLON VAC. OIL,3 QT. INORGANIC	M/O/I	I/NA	S/L	N
1534	12	14	79	2.0000	0.0000	0			1 IGNITRON,ORGANICS	O/M	T/NA	S/NA	N
1535	12	14	79	5.0000	0.0000	0			2 CU.FT. INORGANIC,3 CU.FT. ORGANIC	O/I	NA	NA	N
1536	12	13	79	1.6080	0.0000	0			10 GAL. ORGANIC,2 GALLON INORGANIC	O/I	NA	NA	N
1537	12	18	79	2.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1538	12	18	79	3.4690	0.0000	0			2 1/2 GALLONS ORGANIC, 1 GALLON ACID, 3 CU.FT. INORGANICS	I/O	NA	L/S	N
1539	12	18	79	4.4220	0.0000	0			VACUUM PUMP OIL	O	TBD	L	N
1540	12	18	79	29.4800	0.0000	0			3-55 GAL. DRUMS MAGNESIUM METAL, 1-55 GAL. DRUM HAFNIUM, 1 CAN BERYLLIU	M	I*	S	N
1541	12	19	79	0.0000	25.0000	0			BORIC ACID	I	TBD	S	N
1542	11	01	79	7.3700	0.0000	0			ORGANIC	O	NA	L*	N
1543	11	02	79	0.1340	0.0000	0			1 GAL CHLOROFORM	O	T	L	N
1544	11	02	79	0.1675	0.0000	0			COMBUSTIBLE TOXIC METAL	NA	I*	NA	N
1545	11	05	79	0.6750	0.0000	0			NICKEL METAL;ARSENIC	I	T	S	N
1546	11	06	79	0.1340	0.0000	0			ORGANIC CHEM.	O	NA	L*	N
1547	11	06	79	0.0000	0.0000	0			OIL	O	TBD	L	N
1548	11	05	79	0.9380	0.0000	0			5 GAL VACUUM PUMP OIL, 2 GAL. ORGANIC WASTE, 1 PINT INORGANIC WASTE	I/O	NA	L*	N
1549	11	09	79	0.0000	0.0000	0			ASBESTOS GLOVE,PIECE OF ASBESTOS	I	TBD	S	N
1550	11	09	79	0.0000	0.0000	0			SOLVENT & OIL	O	NA	L	N
1551	11	14	79	3.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1552	11	14	79	2.0000	0.0000	0			3 QTS. ORGANIC,3 QTS. INORGANIC,1 CU.FT. UNKNOWN	I/O	NA	NA	N
1553	11	14	79	5.6280	0.0000	0			27 GAL. CHROMIC SULFATE,15 GAL. ORGANIC	I	T	S	N
1554	11	15	79	0.2680	0.0000	0			ORGANIC & INORGANIC CHEMICALS	I/O	NA	NA	N
1555	11	15	79	0.8040	0.0000	0			ORGANIC & INORGANIC CHEMICALS	I/O	NA	NA	N
1556	11	28	79	0.5360	0.0000	0			MINERAL OIL	O	TBD	L	N
1557	10	01	79	0.0670	0.0000	0			1,2-DICHLOROETHANE	O	I/T	L	N
1558	10	02	79	0.0000	0.0000	0			IGNITRONS	M	T	S	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 42
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1559	10 02 79	0.0350	0.0000	0			AMMONIA	I	C	L	N
1560	00 00 00	0.0510	0.0000	0			BENZENE (10/79)	O	I/T	L	N
1561	10 05 79	4.5500	0.0000	0			SULFURIC ACID	I	C	L	N
1562	10 17 79	0.0000	50.0000	0			ASBESTOS	I	TBD	S	N
1563	10 11 79	7.3700	0.0000	0			PLATING SOLUTION	I*	NA	L	N
1564	10 12 79	5.3600	0.0000	0			CHROMATE SOLUTION	I	T	S*	N
1565	10 12 79	1.3400	0.0000	0			ACID	NA	C*	L*	N
1566	10 12 79	0.0000	0.0000	0			IGNITRON	M	T	S	N
1567	10 12 79	0.0000	50.0000	0			HOSES, CYC. SOLVENT (3 GAL), 50 LB. FLUORINE	I/O	NA	S/L/V	N
1568	10 15 79	0.0000	500.0000	0			BARIUM NITRATE	I	I/T	S	N
~~1569~~	~~10 16 79~~	~~8.0400~~	~~0.0000~~	~~0~~			~~CHROMIC ACID,~~ STRIPPING SOLUTION, ORGANIC & INORGANIC CHEMICALS	~~I/O~~	~~C/T~~	~~L~~	~~N~~
1570	10 17 79	0.3400	0.0000	0			LASER DYE	O*	NA	L	N
1571	00 00 00	0.0000	0.0000	0			SOLUTION ARSENIC & CHLOROFORM (10/79)	O	T	L	N
1572	10 23 79	4.0200	0.0000	0			ACID	NA	C*	L*	N
1573	00 00 00	0.6700	0.0000	0			AMMONIA (10/79)	I	C*	L	N
1574	10 25 79	0.2010	0.0000	0			CHLOROFORM	O	T	L	N
1575	10 26 79	7.3700	0.0000	0			ETHANOL	O	I	L	N
1576	10 30 79	0.5360	0.0000	0			ACID	NA	C*	L*	N
1577	10 30 79	0.0000	0.0000	0			LYE	I	TBD	S	N
1578	09 06 79	0.0000	100.0000	0			ACID,SODIUM,TITANIUM,INORGANIC,ORGANIC	I/O/M	I/R/C	S/L	N
1579	00 00 00	14.3380	0.0000	0			ACID, SOLVENTS (9/79)	NA	NA	L	N
1580	09 10 79	4.0200	0.0000	0			SOLVENT	O	NA	L	N
1581	08 07 79	3.0000	0.0000	0			BERYLLIUM CONTAMINATED PLASTIC	M	TBD	S	N
1582	09 08 79	2.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1583	09 18 79	147.4000	0.0000	0			OIL	O	TBD	L	N
1584	09 17 79	29.4800	0.0000	0			OIL	O	TBD	L	N
1585	09 18 79	0.1340	0.0000	0			TOLUENE	O	I	L	N
1586	09 18 79	36.8500	0.0000	0			OIL	O	TBD	L	N
1587	09 17 79	0.0000	3.0000	0			CHROMIC ACID	I	C/T	L	N
1588	09 21 79	2.1440	0.0000	0			PHOTOCHEMICALS	I*	NA	L	N
1589	09 25 79	2.0000	0.0000	0			ASBESTOS COATS	I	TBD	S	N
1590	09 25 79	0.0000	0.2500	0			LITHIUM 4" X 8" X 1/16" SHEET	M	I	S	N
1591	08 01 79	1.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1592	08 01 79	1.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1593	08 01 79	10.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1594	08 07 79	14.7400	0.0000	0			MINERAL OIL	O	TBD	L	N
1595	08 07 79	44.2200	0.0000	0			OIL	O	TBD	L	N
1596	00 00 00	0.0000	0.0000	0			ACID (8/79)	NA	C*	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 43
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1597	00	00	00	6.0000	0.0000	0			INORGANIC CHEMICAL (8/79)	I	NA	NA	N
1598	08	14	79	6.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS	I/O	TBD	NA	N
1599	08	20	79	21.0000	0.0000	0			LIQUID CHEMICAL	NA	NA	L	N
1600	08	21	79	2.5000	0.0000	0			ORGANIC & INORGANIC CHEMICALS	O/I	NA	NA	N
1601	08	21	79	0.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1602	08	20	79	7.3700	0.0000	0			NITRIC ACID	I	C	L	N
1603	08	20	79	6.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS,OIL	O/I	NA	L	N
1604	08	21	79	0.5360	0.0000	0			CHEMICALS	NA	NA	NA	N
1605	08	23	79	0.0000	0.0000	0			MERCURY CONTAINERS	M	T	S	N
1606	08	23	79	4.0200	0.0000	0			TRICHLOROETHANE	O	TBD	L	N
1607	08	23	79	4.0000	0.0000	0			INORGANIC & ORGANIC CHEMICALS	I/O	NA	NA	N
1608	08	24	79	1.0000	0.0000	0			DYES	NA	NA	L*	N
1609	07	02	79	6.0000	0.0000	0			INORGANIC & ORGANIC CHEMICALS	I/O	NA	NA	N
1610	07	05	79	2.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1611	07	05	79	3.0000	0.0000	0			CHEMICALS INORGANIC & ORGANIC	I/O	NA	NA	N
1612	07	05	79	2.0000	0.0000	0			CHEMICALS ORGANIC	O	NA	L*	N
1613	07	09	79	5.0000	0.0000	0			CHEMICALS INORGANIC	I	NA	NA	N
1614	00	00	00	0.0000	0.0000	0			ACID (7/79)	NA	C*	L*	N
1615	07	10	79	21.0000	0.0000	0			BARIUM NITRATE	I	I/T	S	N
1616	00	00	00	0.0000	0.0000	0			GLASS WITH MERCURY	M	T	S	N
1617	07	13	79	0.0000	0.0000	0			TUBES (?)	NA	NA	NA	N
1618	07	13	79	11.3900	0.0000	0			GAS & OIL	O	NA	L	N
1619	07	16	79	3.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS	I/O	NA	NA	N
1620	07	17	79	0.6700	0.0000	0			LEAD NITRATE SOLUTION	I	T/I	L	N
1621	07	18	79	1.0000	0.0000	0			CHEMICALS ORGANIC	O	NA	L*	N
1622	07	18	79	3.0000	0.0000	0			TOXIC CHEMICALS (ORGANIC & INORGANIC)	I/O	NA	NA	N
1623	07	19	79	10.0000	0.0000	0			CHEMICALS INORGANIC & ORGANIC	I/O	NA	NA	N
1624	07	23	79	0.0000	0.0000	0			SULFURIC ACID,HYDROCHLORIC ACID	I	C	L	N
1625	07	23	79	1.3400	0.0000	0			ACID	NA	C*	L*	N
1626	07	25	79	23.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS	O/I	NA	NA	N
1627	07	19	79	2.0000	0.0000	0			LASER DYE	NA	NA	L*	N
1628	07	30	79	0.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1629	07	30	79	2.0000	0.0000	0			AMMONIUM HYDROXIDE	I	C*	L	N
1630	07	30	79	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1631	06	04	79	8.0000	0.0000	0			OIL	O	TBD	L	N
1632	06	04	79	15.0000	0.0000	0			OIL	O	TBD	L	N
1633	06	05	79	28.0000	0.0000	0			OIL	O	TBD	L	N
1634	06	05	79	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 44
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1635	06 11 79	8.0000	0.0000	0			INORGANIC & ORGANIC ACIDS & BASES	I/O	C*	L*	N
1636	06 11 79	16.7500	0.0000	0			SOLVENTS	O	NA	L	N
1637	06 15 79	70.0000	0.0000	0			NITRIC ACID; SOLVENTS	I/O	C/NA	L	N
1638	06 12 79	22.1100	0.0000	0			ACID & BASE	NA	C*	L*	N
1639	06 12 79	0.6700	0.0000	0			OIL	O	TBD	L	N
1640	06 13 79	0.0000	0.0000	0			BERYLLIUM OXIDE IN A TUBE	I	TBD	S	N
1641	06 19 79	0.0000	0.0000	0			OIL	O	TBD	L	N
1642	00 00 00	0.0000	0.0000	0			BERYLLIUM CONTAMINATED BAG	M	TBD	S	N
1643	06 12 79	0.0700	0.0000	0			ACID	NA	C*	L*	N
1644	06 19 79	0.0000	0.0000	0			LAB CHEMICALS	NA	NA	NA	N
1645	06 19 79	0.0000	0.0000	0			POTASSIUM NITRITE	I	I/R	S	N
1646	06 20 79	176.8800	0.0000	0			OIL,KEROSENE,METHANOL	O	I*	L	N
1647	06 20 79	9.3800	0.0000	0			CHEMICAL	NA	NA	NA	N
1648	06 20 79	0.0000	0.0000	0			BERYLLIUM CONTAMINATED OIL	O	TBD	L	N
1649	06 21 79	0.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1650	06 25 79	0.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1651	06 26 79	3.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1652	06 26 79	4.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1653	06 27 79	198.9900	0.0000	0			CALCIUM NITRATE	I	I	S	N
1654	06 28 79	1.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1655	06 28 79	2.0000	0.0000	0			ASBESTOS GLOVES	I	TBD	S	N
1656	06 04 79	7.3700	0.0000	0			OIL	O	TBD	L	N
1657	06 04 79	14.7400	0.0000	0			OIL	O	TBD	L	N
1658	05 31 79	20.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1659	05 31 79	33.5000	0.0000	0			NITRIC ACID CONTAMINATED WITH NICKEL	I/M	C*	L	N
1660	05 30 79	3.0000	0.0000	0			CHEMICAL	NA	NA	NA	N
1661	05 30 79	3.0000	0.0000	0			CHEMICAL	NA	NA	NA	N
1662	05 30 79	51.5900	0.0000	0			OIL NO PCB	O	TBD	L	N
1663	05 30 79	7.3700	0.0000	0			OIL	O	TBD	L	N
1664	05 30 79	29.4800	0.0000	0			OIL NO PCB	O	TBD	L	N
1665	05 29 79	8.7100	0.0000	0			40 GAL SOLVENT, 25 GAL SULFURIC ACID	O/I	C/NA	L	N
1666	05 25 79	4.0000	0.0000	0			BERYLLIUM CONTAMINATED WOOD, 2 GAL SOLVENT	M	NA	S	N
1667	05 25 79	0.2680	0.0000	0			2 GAL. SOLVENT	O	NA	L	N
1668	05 24 79	0.0000	0.0000	0			SCRAP METAL	M	NA	S	N
1669	05 24 79	0.1340	0.0000	0			CESIUM 2 GRAMS IN VERMICULITE	M	I	S	N
1670	05 23 79	0.0000	0.0000	0			NITRIC ACID,MERCURY,INORGANIC	I/M	C/T	L/S	N
1671	05 23 79	0.0000	0.0000	0			CYLINDER WITH NITROGEN AND WATER	I	TBD	V/L	N
1672	00 00 00	3.0000	0.0000	0			CHEMICALS (5/79) BENCHMARK ENVIRONMENTAL CORPORATION	NA	NA	NA	N

Page No. 45
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITN	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1673	05 14 79	2.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1674	05 14 79	8.0000	0.0000	0			ORGANICS & INORGANICS,BASES & ACIDS	I/O	NA	L*	N
1675	05 14 79	33.5000	0.0000	0			NITRIC ACID	I	C	L	N
1676	05 09 79	2.0000	0.0000	0			CHEMICALS ORGANIC & INORGANIC	O/I	NA	NA	N
1677	05 08 79	1.0000	0.0000	0			PICRIC ACID	O	I	S	N
1678	05 03 79	2.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1679	05 04 79	6.0000	0.0000	0			ORGANIC & INORGANIC CHEMICALS, ACIDS, BASES & METALS	I/O/M	NA	NA	N
1680	05 01 79	2.0000	0.0000	0			NITRIC ACID	I	C	S	N
1681	05 01 79	1.0000	0.0000	0			CHEMICAL	NA	NA	NA	N
1682	04 30 79	20.0000	0.0000	0			BERYLLIUM TRASH	M	TBD	S	N
~~1683~~	~~04 30 79~~	~~53.6000~~	~~0.0000~~	~~0~~			~~OIL CONTAMINATED WITH SOLVENT~~	~~O~~	~~NA~~	~~L~~	~~N~~
1684	04 26 79	4.0000	0.0000	0			METAL OIL SALT	M/O/I	NA	S/L	N
1685	04 26 79	2.0000	0.0000	0			ORGANIC CHEMICAL	O	TBD	L	N
1686	04 27 79	0.0000	0.0000	0			LITHIUM METAL	M	I	S	N
1687	04 24 79	2.0000	0.0000	0			CHEMICALS ORGANIC & INORGANIC	I/O	NA	NA	N
1688	04 24 79	1.0000	0.0000	0			INORGANICS & ORGANICS	I/O	NA	NA	N
1689	04 24 79	13.0000	0.0000	0			12 CU. FT. INORGANIC,1 CU. FT. ACID	I	NA	NA	N
1690	04 23 79	0.0000	0.0000	0			CHEMICALS INORGANIC & ORGANIC	I/O	NA	NA	N
1691	04 20 79	4.0000	0.0000	0			OIL (NITRATE SOLUTION)	O	TBD	L	N
1692	04 20 79	1.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1693	04 19 79	0.0000	0.0000	0			SODIUM-POTASSIUM ALLOY	M	I	S	N
1694	04 19 79	0.0000	0.0000	1			CHLORINE TRIFLUORIDE	I	I/R	V	N
1695	04 18 79	2.0000	0.0000	0			MAGNESIUM CHIPS	M	I	S	N
1696	04 18 79	0.2680	0.0000	0			NITRIC ACID	I	C*	L	N
1697	04 17 79	1.0000	0.0000	0			CHEMICALS ORGANIC	O	NA	L*	N
1698	04 17 79	3.0000	0.0000	0			PHOTOCHEMICALS	I*	NA	L*	N
1699	04 17 79	3.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1700	03 30 81	0.0000	0.0000	0			USED VACUUM PUMP OIL-1 PLASTIC JAR	O	NA	L	N
1701	03 30 81	2.0000	0.0000	0		B	1-15 GAL. CONTAINER-NITRIC ACID	I	C	L	Y
1702	03 30 81	0.1200	0.0000	0		B	5 PT.-GLACIAL ACETIC ACID,2 PTS.-HYDROCHLORIC ACID	O/I	C	L	Y
1703	03 30 81	0.3400	0.0000	0		B	2-20 FL. OZ. AMMONIA,2-9 1/2" X 9 1/2" AMMONIA ABSORBER CANISTER	I	C*	L	Y
1704	04 28 81	52.0000	0.0000	0	17		1-15 GAL. DRUM PHYTAR 560,60 GAL 2-4D BUTYL ESTER IN 1 GAL PLASTIC BOTT	O	TBD	NA	Y
1705	04 23 81	14.7400	0.0000	0		B	HYDROCHLORIC ACID AND WATER	I	C*	L	Y
1706	04 20 80	1.0000	0.0000	0	13		16 GLASS JARS, INORGANICS	I	NA	NA	Y
1707	04 21 81	3.0000	0.0000	0		B	2-15 GAL. LITHIUM HYDROXIDE WITH DEPLETED URANIUM,10 GM PER DRUM	I	I	S	Y
1708	04 20 81	1.0000	0.0000	0	17		4 GLASS BOTTLES WITH ORGANICS, 1 PLASTCIC BOTTLE WITH LITHIUM ACETYLIDE	O	NA	L*	Y
1709	04 16 81	1.0000	0.0000	0	17		SOLVENT	O	NA	L	Y
1710	04 16 81	1.0000	0.0000	0		B	AMMONIA 5 BOTTLES	I	C	L	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 46
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1711	00 00 00	6.0000	0.0000	0			BERYLLIUM WASTE (4/81)	M	TBD	S	N
1712	04 23 81	0.6700	0.0000	0		B	2-3.25 L AMMONIUM HYDROXIDE,12.5 L OF KODAK RAPID FILTER	I	C*	L	Y
1713	04 08 81	0.0000	0.0000	0			MOSTLY ORGANIC SOLVENTS AND SOLID ORGANICS, SOME INORGANICS	I/O	NA	L/S	N
1714	04 08 81	2.0000	0.0000	0		B	7 BOTTLES (SAVIN) ?, 7 BOTTLES OF LIQUID (COPY MACHINE) ?, QT BOTTLES	NA	NA	NA	Y
1715	03 09 81	1.0700	0.0000	0			4-2 GALLON CANS-MACHINE OIL, CUTTING OIL, ETC.	O	TBD	L	N
1716	03 10 81	0.0000	0.0000	0	15		LITHIUM METAL, 2 1/2 FT. LENGTH DRUMS,UNOPENED	M	I	S	Y
1717	03 09 81	0.0000	0.0000	0	17		1.0 ML LIQUID (DICHLOROETHYLENE W/ BORON)	O	NA	L	Y
1718	03 09 81	0.0000	0.0000	0	17		ORGANICS W/ CANCER SUSPECT AGENTS	O	NA	NA	Y
1719	03 00 81	0.0000	0.0000	0			KEMWIPES & GLOVES CONTAMINATED WITH PYRENE AND OTHER SUSPECT CANCER AGE	O	NA	S	N
1720	03 09 81	0.0070	0.0000	0	17		METHANOL, TRICHLOROETHYLENE & UNIDENTIFIED CANCER SUSPECT AGENTS	O	I/T	L	Y
~~1721~~	~~03 05 81~~	~~0.0000~~	~~0.0000~~	0			~~WASTE MATERIAL CONTAMINATED WITH CANCER SUSPECT AGENTS~~	~~NA~~	~~NA~~	~~NA~~	~~N~~
1722	03 03 81	0.0510	0.0000	0	17		SOLVENT	O	NA	L	Y
1723	03 02 81	3.0000	0.0000	0		B	75# ACID CARBOY FULL, 75#ACID CARBOY PARTIAL FULL-NITRIC ACID	I	C	L	Y
1724	03 17 81	0.0340	0.0000	0	17		LIQUID "A" QUINIENE 13 SOLVENT BASE	O*	TBD	L*	Y
1725	03 17 81	8.0000	0.0000	0		B	NITRIC ACID	I	C	L	Y
1726	03 17 81	1.0500	0.0000	0		B	BRIGHT DIP ACID BATH:MIXTURE 14.7L WATER,2.2L NITRIC ACID,13.1L SULFURI	I	C	L	Y
1727	03 16 81	0.0000	0.0000	0	17		LIQUID ORGANICS/INORGANICS	O/I	NA	NA	Y
1728	03 16 81	2.0000	0.0000	0		B	INORGANICS,SOME SOLVENTS 19 CONTAINERS	O/I	NA	NA	Y
1729	03 09 81	1.0000	0.0000	0			CARBON TETRACHLORIDE	O	T	L	N
1730	03 09 81	8.0400	0.0000	0			DIRTY TRICHLORETHYLENE	O	T	L	N
1731	03 09 81	0.1250	0.0000	0			ALUMINUM PHOSPHIDE,ALUMINUM NITRIDE,TITANIUM	I/M	TBD	S	N
1732	03 31 81	7.3700	0.0000	0			OIL,ONE BATTERY;APPEARS TO HAVE NOT BEEN DISPOSED OF	O	TBD	L	N
1733	04 01 81	6.0000	0.0000	0			30-1 GAL CONTAINERS CHROMIC ACID,3 QT. OF SOLVENT:BENZENE,CARBON TETRAC	O	I/R	L	N
1734	03 31 81	0.0000	0.0000	0			ACIDS & BASES:PHOSPHORIC,NITRIC,ACETIC,HYDROCHLORIC ACIDS;AMMONIUM HYDR	I/O	C	L	Y
1735	03 31 81	14.7400	0.0000	0			1 BBL TRANSMISSION OIL,1BBL GEAR OIL	O	TBD	L	N
1736	03 30 81	0.0000	0.0000	0		B	2 BARRELS-COPPER AMMONIUM HYDROXIDE	I	TBD	NA	Y
1737	00 00 00	0.0000	0.0000	0			CERIUM METAL (3/81)	M	TBD	S	N
1738	00 00 00	0.0090	0.0000	0		B	UNKNOWN (ACID) (3/26/81)	NA	NA	NA	Y
1739	03 20 81	1.0000	0.0000	0	17		3 CANS & 2 BOTTLES EPOXY	O	I*	L*	Y
1740	03 16 81	16.0000	0.0000	0	17		12 GAL. CANS,9 GAL BTLS,2 QT. BTTLS,2-5 GAL CANS,1-1 GAL PLASTIOC,1 BOX	O	I	L	Y
1741	03 23 81	0.0000	0.0000	0			80 SMALL GLASS CONTAINERS (LIST MISSING)	NA	NA	NA	N
1742	02 19 81	3.5000	0.0000	0	17		30 GALLON DRUM-METHYLETHYL KETONE MIX ON VERMICULITE	O	T/I	L/S	Y
1743	02 12 81	5.0000	0.0000	0			30-9LB. CONTAINERS (SULFURIC ACID),7 GAL. CONTAINERS,25-QT CONTAINERS	O/I	C	L	N
1744	02 11 81	0.0000	0.0000	0	17		1 PT. PAINT THINNER,1 PT. CITRIC AICD,5 GAL. OIL	O	I	L	Y
1745	02 11 81	0.2500	0.0000	0	16		CADMIUM ANALGUM,CADMIUM-MERCURY	M	T	S	Y
1746	02 11 81	0.2500	0.0000	0	16		TRIMETHYLALUMINUM	O	I	S	Y
1747	02 11 81	1.0000	0.0000	0	16		TANTALUM PENTACHLORIDE	I	TBD	S	Y
1748	02 09 81	0.0000	0.0000	1			90 WT. GEAR BOX OIL	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

age No. 47
0/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1749	02 09 81	16.0000	0.0000	0			2-55 GAL. DRUMS-VACUUM OIL	O	TBD	L	N
1750	02 05 81	0.3500	0.0000	0		B	ARSENIC/NICKEL-LIQUID	I	T	L	Y
1751	02 05 81	0.0000	0.0000	0	17		3-PINTS,2 QUARTS,2 1/2 PINTS - ORGANICS	O	NA	NA	Y
1752	01 08 81	0.5000	0.0000	0		B	FERRIC CHLORIDE-3 GAL.	I	TBD	S	Y
1753	01 11 81	0.5360	0.0000	0		B	3 GAL. OF AZ303 DEVELOPER,1 GAL. OF THINNER	O	I	L	Y
1754	01 27 81	2.0000	0.0000	0	17		VERSATEC TONER & DISPERSANT (KEROSENE BASE)	O	I	L	Y
1755	01 27 81	7.3700	0.0000	0	17		1,1,1 TRICHLOROETHANE W/ OIL FORM PART CLEANING	O	TBD	L	Y
1756	01 21 81	0.2500	0.0000	0	17		3 BOTTLES ORGANIC WASTE-TRICHLOROETHANE,BENZENE	O	I	L	Y
1757	01 19 81	22.1100	0.0000	0		B	TREATED COPPER CYANIDE SOLUTION FROM TA-50	I	TBD	L	Y
1758	01 19 81	0.2680	0.0000	0		B	AMMONIUM HYDROXIDE;ABSORBER	I	TBD	S	Y
~~1759~~	~~01 19 81~~	~~20.1000~~	~~0.0000~~	0		~~B~~	~~RAPID CIRCUIT ETCHANT,FERRIC CHLORID~~	~~I~~	~~TBD~~	~~S~~	Y
1760	01 19 81	1.0000	0.0000	0	17		12 CONTAINERS,ASBESTOS,MERCURY VAPORLITE,2 PTS. THINNER,5 PTS. SOLVENTS	I/O/M	I/T	S/L	Y
1761	01 16 81	12.0600	0.0000	0			3-5 GAL. PHOTO RESISTOR,11-5 GAL. METHYLCHLOROFORM,4-5 GAL. ISOPROPANOL	O	I	L	N
1762	01 10 81	2.0000	0.0000	0	13		1 PLASTIC BAG WASTE CONTAMINATED W/ ARSENIC,HYDROCHLORIC ACID	I	T/C	S/L	Y
1763	01 10 81	0.8710	0.0000	0	17		4-1 GAL. & 1-10L CAN; N-METHYLPYRROLIDONE AND CYCLOHEXANE	O	I	L	Y
1764	01 11 81	0.2000	0.0000	0	17		MERCURY SWITCH	M	T	S	Y
1765	01 07 81	0.1340	0.0000	0	17		TRICHLOROETHANE	O	TBD	L	Y
1766	01 07 81	1.5000	0.0000	0	17		VARIOUS ORGANICS,ASBESTOS(40) MERCURY (2CC)	O/I/M	T	S/L	Y
1767	01 07 81	29.4800	0.0000	0		B	4-55 GAL. DRUMS-ETHANOL CONTAMINATED W/ BERYLLIUM	O	I	L	Y
1768	04 10 79	0.0000	0.0000	0			LITHIUM METAL	M	I	S	N
1769	04 06 79	0.0000	0.0000	0			ORGANIC	O	NA	L*	N
1770	04 06 79	0.0000	0.0000	0			SOLVENTS	O	NA	L	N
1771	04 05 79	0.0000	0.0000	0			SULFURIC ACID	I	C	L	N
1772	04 04 79	0.0000	0.0000	0			SULFURIC ACID	I	C	L	N
1773	04 04 79	0.0000	0.0000	0			OIL	O	TBD	L	N
1774	04 02 79	7.0000	0.0000	0			ORGANIC & INORGANIC CHEM.	O/I	NA	NA	N
1775	04 02 79	1.0000	0.0000	0			MERCURY	M	T	S	N
1776	02 07 79	51.5900	0.0000	0			TRANSFORMER OIL	O	TBD	L	N
1777	02 07 79	4.6900	0.0000	0			OIL	O	TBD	L	N
1778	03 27 79	81.0700	0.0000	0			MINERAL OIL	O	TBD	L	N
1779	03 26 79	0.0670	0.0000	0			SULFURIC ACID	I	C	L	N
1780	03 26 79	0.6700	0.0000	0			VAC. OIL	O	NA	L	N
1781	03 23 79	0.3500	0.0000	0			CHROMIC ACID	I	T/C	L	N
1782	03 23 79	24.0000	0.0000	0			OIL & SOLVENTS	O	NA	L	N
1783	03 21 79	0.0000	0.0000	0			SODIUM - POTASSIUM ALLOY	M	I	S	N
1784	03 21 79	0.0000	0.0000	0			BROMOBENZENE	O	I	L	N
1785	03 14 79	2.0000	0.0000	0			PAINT CANS, OIL	O	NA	L	N
1786	03 19 79	29.4800	0.0000	0			MAGNESIUM CHIPS	M	I	S	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 48
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1787	03	14	79	20.0000	0.0000	0			CHLOROETHANE, SULFURIC ACID	O/I	I/C	L	N
1788	03	14	79	18.7600	0.0000	0			SULFURIC ACID	I	C	L	N
1789	03	12	79	0.0000	0.0000	0			SULFURIC ACID, BROMINE, HYDROFLUORIC ACID	I	C	L	N
1790	03	07	79	44.2200	0.0000	0			OIL	O	TBD	L	N
1791	03	07	79	0.0000	0.0000	0			PLATING CHEMICALS	I*	NA	L*	N
1792	03	07	79	0.0000	0.0000	0			PHOTO CHEM.	I*	NA	L*	N
1793	03	06	79	0.0000	0.0000	0			EPOXY HARDNER	O	I	L	N
1794	03	07	79	2.6800	0.0000	0			TRICHLOROETHANE	O	TBD	L	N
1795	03	06	79	0.9380	0.0000	0			BATTERY ACID	I	C	L	N
1796	03	02	79	0.0000	0.0000	0			ACID BASES METAL	M/NA	NA	S/NA	N
1797	03	01	79	0.8000	0.0000	0			MINERAL OIL & ACID	I/O	NA	L	N
1798	03	01	79	20.1000	0.0000	0			KEROSENE	O	I	L	N
1799	01	23	79	22.1100	0.0000	0			OIL	O	TBD	L	N
1800	02	07	79	0.0000	0.0000	0			AMMONIUM HYDROXIDE, NITRIC ACID	I	C/R	L	N
1801	02	27	79	0.0000	0.0000	0			BERYLLIUM METAL	M	TBD	S	N
1802	02	27	79	10.7200	0.0000	0			OIL	O	TBD	L	N
1803	02	27	79	3.3500	0.0000	0			BERYLLIUM OXIDE CONTAMINATED WITH WATER	I	TBD	L	N
1804	02	07	79	12.0000	0.0000	0			PVC PIPE FILLED WITH CALCIUM CHLORIDE	I	TBD	S	N
1805	02	23	79	14.7400	0.0000	0			OIL & WATER	O	TBD	L	N
1806	02	23	79	0.0000	0.0000	0			SODIUM - POTASSIUM ALLOY	M	I	S	N
1807	02	26	79	2.0000	0.0000	0			PHOTO CHEM.	I*	NA	L*	N
1808	01	02	79	6.0000	0.0000	0			CALCIUM METAL, FERRIC CHLORIDE	M/I	R	S	N
1809	01	20	79	0.6700	0.0000	0			VAC. OIL	O	TBD	L	N
1810	01	17	79	5.0000	0.0000	0			ACIDS	NA	C*	L*	N
1811	01	12	79	1.0000	0.0000	0			PHOSPHOROUS PENTOXIDE	I	R	S	N
1812	01	22	79	0.5000	0.0000	0			ORGANICS	O	NA	L*	N
1813	02	01	79	1.0000	0.0000	0			NITROSYLSULFURIC ACID	I	C	L	N
1814	02	02	79	1.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1815	02	02	79	5.0000	0.0000	0			WASTE OIL	O	TBD	L	N
1816	02	02	79	4.0000	0.0000	0			PERCHLORIC ACID	I	I	L	N
1817	02	02	79	10.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1818	01	17	79	22.0000	0.0000	0			MERCURY, CONTAMINATED GLASSWARE	M	TBD	S	N
1819	02	02	79	2.0000	0.0000	0			CHEMICAL	NA	NA	NA	N
1820	01	19	79	2.0000	0.0000	0			PHOTO CHEM.	I*	NA	L*	N
1821	11	09	78	52.0000	0.0000	0			LITHIUM HYDRIDE	I	I	S	N
1822	01	08	79	1.0000	0.0000	0			ASBESTOS	I	TBD	S	N
1823	01	11	79	1.0000	0.0000	0			ISOPENTANE & WATER	O	I*	L	N
1824	12	27	78	10.0000	0.0000	0			CHEMICALS	NA	NA	NA	N

BENCHMARK ENVIRONMENTAL CORPORATION

age No. 49
0/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1825	01	05	79	2.0000	0.0000	0			HYDROGEN FLUORIDE	I	TBD	L	N
1826	01	05	79	2.0000	0.0000	0			CHEM. ACID & BASE	NA	C*	L*	N
1827	01	04	79	2.0000	0.0000	0			SODIUM HYDROXIDE, CARBON DISULFIDE	O	C/I	L	N
1828	01	03	79	3.0000	0.0000	0			CHEM., ACETIC ACID, NITRO METHANE	O	C/I	L	N
1829	01	04	79	4.0000	0.0000	0			CHEMICAL	NA	NA	NA	N
1830	12	22	78	1.0000	0.0000	0			DICHLOROETHYLENE	O	I/T	L	N
1831	10	04	78	6.0000	0.0000	0			CHEMICALS	NA	NA	NA	N
1832	12	27	78	3.0000	0.0000	0			CHEM.	NA	NA	NA	N
1833	12	27	78	23.0000	0.0000	0			SHELL DIALA AX	NA	TBD	NA	N
1834	12	03	75	51.5900	0.0000	0			TOLUENE, ACETIC ACID, ALCOHOL	O	I/C	L	N
~~1835~~	~~12~~	~~03~~	~~75~~	~~1.0000~~	~~0.0000~~	0			~~SODIUM & OTHER CHEMICAL~~	~~N/NA~~	~~R/NA~~	~~S/NA~~	~~N~~
1836	00	00	00	1.0000	0.0000	0			ALCOHOL (12/75)	O	I	L	N
1837	00	00	00	13.0000	0.0000	0			BARIUM CHIPS IN OIL (12/75)	N/O	I/T	S/L	N
1838	00	00	00	3.0000	0.0000	0			AMMONIUM HYDROXIDE & ABSORBER (12/75)	I	C*	L*	N
1839	00	00	00	13.0000	0.0000	0			HYDROCARBON TRANSFORMER OIL (12/75)	O	TBD	L	N
1840	11	21	75	0.5000	0.0000	0			ETHER OIL, POSSIBLE PEROXIDE MAT'L.	O	I*	L	N
1841	11	18	75	3.0000	0.0000	0			MISC. CHEM.	NA	NA	NA	N
1842	10	24	75	1.0000	0.0000	0			METAL (?) UNDER KEROSENE (?) POSSIBLE SODIUM	M/O*	R/I*	S/L	N
1843	10	20	75	3.0000	0.0000	0			WASTE CHEM. FROM PHOTO LAB	NA	NA	NA	N
1844	10	17	75	2.0000	0.0000	0			PLATING ACIDS	NA	C*	L*	N
1845	10	17	75	1.0000	0.0000	0			SEVERAL SMALL BOXES OF NON-SALVAGE CHEMICALS	NA	NA	NA	N
1846	10	04	75	0.0000	0.0000	0			LITHIUM - HYDROXIDE	I	I	S	N
1847	10	03	75	2.0000	0.0000	0			MISC. INORGANIC CHEMICAL	I	NA	NA	N
1848	10	08	75	0.0000	500.0000	0			USED STOCK OF ORGANICS NO REUSE	O	NA	NA	N
1849	10	02	75	8.0000	0.0000	0			NITRATED WET BAGS	I	TBD	S*	N
1850	09	30	75	28.0000	0.0000	0			TRICHLOROETHANE	O	TBD	L	N
1851	09	20	75	6.0000	0.0000	0			MISC. ACIDS - CAUSTICS & ELECTROPLATE CHEM.	NA	C*	L*	N
1852	09	18	75	0.0000	0.0000	0			MISC. CHEM. & ETHER	O	I	L	N
1853	09	18	75	0.0000	0.0000	0			NITROBENZENE & OTHER DERIVITIVES	O	TBD	L*	N
1854	09	17	75	3.0000	0.0000	0			BORON IN CANS, SMALL AMT.	I	I	S	N
1855	09	16	75	0.0000	500.0000	0			LITHIUM - HYDRIDE	I	I	S	N
1856	09	11	75	10.0000	0.0000	0			10GAL.DIMETHYLSULFOXIDE,5GAL.METHYL CELLOSOLVE,1GAL.BROMOBENZEN,1GAL.EP	O	I	L	N
1857	09	11	75	0.0000	65.0000	0			SMALL GAS CYLINDER HAZARDOUS MATERIAL	NA	NA	V	N
1858	09	11	75	0.0000	0.0000	0			MISC. WASTE CHEMICALS	NA	NA	NA	N
1859	09	11	75	12.0000	0.0000	0			1-1-1 TRICHLOROETHANE	O	TBD	L	N
1860	09	03	75	4.0200	0.0000	0			2 GAL. CARBON TETRACHLORIDE,1 GAL. CHLOROFORM	O	I/T	L	N
1861	08	25	75	14.0700	0.0000	0			USED OIL 2-55 GAL. DRUMS	O	TBD	L	N
1862	08	25	75	1.0000	0.0000	0			TRIFLUORO ACETIC ACID	O	TBD	L	N

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 50
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1863	08	21	75	1.0000	0.0000	0			LEAKING BOTTLE OF TRIFLUOROACETIC ACID	O	C*	L	N
1864	08	15	75	5.0000	0.0000	0			BOXED CHEMICALS CLEANED OUT OLD LAB.	NA	NA	NA	N
1865	08	14	75	2.0000	0.0000	0			3-30LBS BOXES CARBON DIOXIDE CARTRIDGES	O	TBD	V	N
1866	08	12	75	4.6900	0.0000	0			35 GAL. SOLVENTS	O	NA	L	N
1867	08	12	75	1.0000	0.0000	0			BOX MISC. ORGANICS	O	NA	L*	N
1868	08	12	75	2.0000	0.0000	0			PHOSPHOROUS TRICHLORIDE, PHOSPHOROUS PENTOXIDE	I	R	L/S	N
1869	08	11	75	0.0000	0.0000	0			SODIUM HYDROXIDE, POTASSIUM DICHROMATE	I	I/C	S*	N
1870	08	05	75	7.3700	0.0000	0			55 GAL. FLAMMABLE LIQ.	O*	I*	L	N
1871	08	04	75	4.0000	0.0000	0			ORGANIC SOLVENTS, ALCOHOL DIMETHYL FORMAMIDE	O	I*	L	N
1872	07	29	75	10.0000	0.0000	0			OLD CHEMICALS	NA	NA	NA	N
~~1873~~	~~07~~	~~28~~	~~75~~	~~10.0000~~	~~0.0000~~	~~0~~			~~MISC. CHEM. ACID, BASES, ORGANICS, INORGANICS~~	~~I/O~~	~~NA~~	~~L*~~	~~N~~
1874	07	28	75	0.0000	0.0000	0			MISC. CHEM.	NA	NA	NA	N
1875	07	25	75	1.0000	0.0000	0			FLAM. LIQ. & PUMP OIL	O	I*	L	N
1876	07	23	75	1.0000	0.0000	0			MIXED CHEM. INORGANIC	I	NA	NA	N
1877	07	23	75	5.0000	0.0000	0			100 LBS. MIXED CHEM.	NA	NA	NA	N
1878	07	21	75	2.0000	0.0000	0			MISC. WASTE CHEM.	NA	NA	NA	N
1879	07	20	75	1.0000	0.0000	0			MISC. WASTE CHEM.	NA	NA	NA	N
1880	07	17	75	3.0000	0.0000	0			2 - BOXES MIXED CHEM., MOSTLY INORGANIC	NA	NA	NA	N
1881	07	10	75	0.0000	0.0000	1			HYDROGEN FLUORIDE CYL. LEAKING HYDROGEN FLUORIDE	I	TBD	V	N
1882	06	20	75	0.0000	0.0000	0			ALCOHOL	O	I*	L	N
1883	06	05	75	1.0000	0.0000	0			MISC. CHEM.	NA	NA	NA	N
1884	06	05	75	6.0000	0.0000	0			TRIETHYL BENZENE	O	TBD	L	N
1885	06	03	75	1.0000	0.0000	0			MISC. CHEM.	NA	NA	NA	N
1886	06	03	75	20.0000	0.0000	0			500 LBS. DRY CHEM. USED IN PLATING SOLUTION DAMAGED BY WATER	NA	NA	NA	N
1887	06	02	75	40.0000	0.0000	0			2-55 GAL. DRUMS TRICHLOROETHYLENE	O	I	L	N
1888	05	31	75	0.0000	0.0000	0			SODIUM CONTAMINATED PIPING	N	R	S	N
1889	05	30	75	0.0000	0.0000	41			41 GAS CYL. FAILED HYDROSTETIC TESTS	NA	NA	V	N
1890	11	18	81	0.2300	0.0000	0			AMMONIUM HYDROXIDE (W/AMMONIUM ARRESTORS)	I	C	L	N
1891	11	30	81	12.3300	0.0000	0			ETHYLENE GLYCOL, 2 AMYLE ACETATE, ACETIC ACID,SULFURIC ACID,NITRIC ACID	I/O	C/I	L	N
1892	11	23	81	176.8800	0.0000	0	17		METRAN 425 P(10 DRUMS) CO-REZYN (13 DRUMS), CORGIL A-527 (1 DRUM)(CONTA	O	I	L	Y
1893	11	18	81	0.2700	0.0000	0			SILGARD SEALANT COMPOUND TYPE 102 IN WATER	NA	NA	L	N
1894	11	20	81	0.9400	0.0000	0	19		N-METHYLPYROLIDONE	O	TBD	L	Y
1895	11	18	81	0.0000	27.5000	0		B	AMONONIUM HYDROXIDE	I	C	L	Y
1896	11	16	81	0.2500	0.0000	0	19		48 BOTTLES OF POTENTIALLY HAZARDOUS CHEMICALS	NA	NA	NA	Y
1897	11	16	81	0.2500	0.0000	0	19		2 BOXES CONTAINING LESS THAN 35 BOTTLES OR CANS EACH	NA	NA	NA	Y
1898	11	12	81	2.0000	0.0000	0	19		1 BOX, SOLVENTS, PHOTO CHEMICALS	O*	NA	L*	Y
1899	11	13	81	1.5000	0.0000	0	15		2 EA; (ONE-1FT3) (ONE-1FT2X1") ASBESTOS	I	TBD	S	Y
1900	11	03	81	0.2000	0.0000	0	19		2-1 GAL. SAFETY CANS; 1-1QT. SAFETY CANS CHLOROTHENE (METHYL CHLOROFORM	O	TBD	L	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 51
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1901	11	02	81	1.0000	0.0000	0	15		ASBESTOS	I	TBD		Y
1902	10	30	81	0.0000	0.0000	0			2 BARRELS TRANSFORMER OIL COLD	O	TBD		N
1903	11	03	81	0.6120	0.0000	0	15		DISPERSANT	I*	C*		Y
1904	11	03	81	0.1140	0.0000	0	15		AMMONIUM HYDROXIDE	I*	C*		Y
1905	11	03	81	0.1340	0.0000	0	15		PHOSPHORIC ACID	I*	C*		Y
1906	11	03	81	0.0000	0.0000	0	15		RADIO MIXTURE #3	I*	C*		Y
1907	11	02	81	4.0200	0.0000	0			30 GAL. CUTTING OIL FROM MACHINE SHOP	O	TBD		N
1908	11	02	81	2.0100	0.0000	0			15 GAL. CHLORONATED HYDROCARBINS (TRICHLOROETHYLENE, ETC.)	O	T*		N
1909	11	02	81	8.0000	0.0000	0			ACID AND WATER	NA	NA		N
1910	10	23	81	0.0000	0.0000	0		B	1# SODIUM SULFIDE, 1 QT. VARNISH, 2 PINTS SODIUM HYDROXIDE, 24 PINTS SO	I/O	R*/C*		Y
~~1911~~	~~10~~	~~27~~	~~81~~	~~0.3500~~	~~0.0000~~	0		~~B~~	~~ARSENIC-NICKEL (ACIDS/LIQUIDS)~~	~~M/NA~~	~~T/NA~~		~~Y~~
1912	10	20	81	2.9500	0.0000	0			BELIEVED TO BE ETHEYLENE GLYCOL IN 55 GAL. DRUM	O	TBD		N
1913	08	25	81	0.1340	0.0000	0			ACRYLIC ADHESIVE RESIN RP560 (NEW) DAMAGED DURING SHIPPING	O	I*		N
1914	10	15	81	0.1700	0.0000	0	19		KEROSENE, TRI-N-BUTYL PHOSPHITE, DI-BUTYL, BUTYLPHOSPHENATE, 1M NITRIC	O	I/C		Y
1915	10	13	81	9.3800	0.0000	0			TRICHLOROETHENE, PHOTO RESIST STRIPPER (MILD ACID)	O	TBD		N
1916	09	23	81	51.5900	0.0000	0			7-DRUMS OIL & VERMICULITE/OIL	O	TBD		N
1917	09	23	81	0.3400	0.0000	0			20-1PT. BOTTLES CHLOROFORM & 1,1,2 TRICHLOROETHENE, ASBESTOS GLOVE,1 CA	O/I/M/	I/T/NA		N
1918	09	23	81	0.0000	4.4000	0	19		HYDRAZINE	I	I		Y
1919	09	23	81	5.3600	0.0000	0	19		CAPELLA OIL	NA	TBD		Y
1920	10	09	81	7.3700	0.0000	0	19		55 GAL. OF KEROSENE	O	I		Y
1921	10	05	81	3.3000	0.0000	0	16		RAGS FROM MERCURY HG SPILL CLEAN UP	M	T		Y
1922	10	05	81	20.0000	0.0000	0	19		SAND MIXED WITH OIL	O	TBD		Y
1923	10	09	81	1.0000	0.0000	0	19		METHYLETHYLKETONE, MERCURY-CONTAMINATED OXYLENE, N,N,DIMETHYLY FORMAMID	O/M	T/I		Y
1924	10	05	81	2.0100	0.0000	0	19		DOW CORNING FLUID (SILICON OIL)	O	TBD		Y
1925	10	05	81	0.2700	0.0000	0		B	HYDROCHLORIC ACID	I	C		Y
1926	10	05	81	4.0000	0.0000	0	17		TRANSENE	NA	NA		Y
1927	10	05	81	14.7400	0.0000	0	15		BARIUM NITRATE & INERT	I	I/T		Y
1928	09	14	81	0.0007	0.0000	0			CESIUM - 2 CONTAINERS	M	I		N
1929	09	14	81	3.0000	0.0000	0	17		PICHROMIC ACID,BENZENE,HEPTONE,LEXANE,ETHYL ETHER,TETRAHYDROFURAN,14-1G	I/O	I/T/C		Y
1930	09	14	81	2.0000	0.0000	0	17		6LBS. POTASSIUM HYDROXIDE, 1QT. SYLARD 134 DIELECTRIC GEL, 6PT. CAN EPO	I/O	C/I		Y
1931	07	29	81	7.3700	0.0000	0			VACUUM PUMP OIL	O	TBD		N
1932	09	09	81	10.0000	0.0000	0	17		5 CARTONS CONTAINING 165 BOTTLES (LONG LIST SAME FAMILY DANGERS)	NA	NA		Y
1933	09	09	81	7.0000	0.0000	0			2-18X18X13, 1-13X13X24, 1-12X12X12 OLD REAGENT GRIDE ORGANIC CHEMICALS	O	NA		N
1934	09	09	81	8.0000	0.0000	0		B	PLATING SOLUTION - ACID	I*	C*		Y
1935	09	01	81	29.4800	0.0000	0	19		MOTOR OIL - STODDARS SOLVENT	O	I*		Y
1936	09	03	81	30.0000	0.0000	0	17		35-1 GAL, 5-5 GAL, 1-55 GAL, MISC PAINT THINERS & DRUM OF RAGS, BRUSHES	NA	NA		Y
1937	09	03	81	4.0000	0.0000	0		B	HYDROCLORIC ACID, CLEAN UP WASTE	I	C*		Y
1938	09	03	81	8.0400	0.0000	0	17		60-1 GAL, TRINSENE 100-22GAL, XYLENE-26GAL, SESQUANOX-12GAL	O	I		Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 52
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO	DY	YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1939	09	03	81	1.0000	0.0000	0	17		ALKOLE, PAINT CANS, GLUE	O	I	L	Y
1940	09	02	81	1.0000	0.0000	0	17		XYLENE, NITRIC ACID	O/I	I/C	L	Y
1941	08	21	81	0.0000	0.0095	0			LEAD FLOURIDE	I	T	S	N
1942	08	13	81	0.0000	0.0000	0			1 BOX CONTAINING POTASSIUM HYDROXIDE OR BORON NITRIDE, 1 PIECE PIPE COV	I	TBD	S	N
1943	08	13	81	2.0100	0.0000	0			3-5GAL CAN CONTAINING VACUUM PUMP OIL, DIALEX,AND/OR TURBO-OIL (NNRL BA	O	TBD	L	N
1944	08	06	81	36.8500	0.0000	0	19		SMALL CAPACITORS CONTAINING PCBS	O	TBD	L	Y
1945	08	07	81	14.7400	0.0000	0	19		SMALL CAPACITORS CONTAINING PCBS	O	TBD	L	Y
1946	08	13	81	13.3500	0.0000	0	17		PHOTO RESIST STRIPPING SOLUTION CONTAINING METHYLENE CHLORIDE SOLVENT	O	I	L	Y
1947	08	13	81	6.0300	0.0000	0	17		TRICHLOROETHYLENE PHOTO DEVELOPER (METHYL CHLOROFORM)	O	T	L	Y
1948	08	13	81	36.8500	0.0000	0	19		SMALL CAPACITORS CONTAINING PCBS	O	TBD	L	Y
1949	08	11	81	4.0000	0.0000	0	17		ORGANICS & INORGANICS (OIL & OTHER CHEMICALS)	O/I	NA	NA	Y
1950	08	10	81	0.0340	0.0000	0	13	B	1 PT NITRIC ACID, 1 PT COPPER SULFATE	I	C	L/S	N
1951	08	10	81	1.0000	0.0000	0	17		2-1 GAL PLASTIC WASTE DCE, ONE-1/2 GALLON GLASS UNKNOWN	NA	NA	NA	Y
1952	08	05	81	7.3700	0.0000	0			1-55 GAL. DRUM TRI CHLOROTHENE	O	TBD	L	N
1953	08	05	81	0.6700	0.0000	0	17		5 GAL CANS - TETRAHYROFURAN, ETHYLENE DICHLORIDE, METHENOL	O	I/T	L	Y
1954	08	05	81	0.0000	0.0000	0	19		PYRINIDINE, PYRIDAZINE, TRIAZINE, & TWO UNKNOWN LIQUIDS	O/NA	NA	L	Y
1955	08	06	81	6.0000	0.0000	0	17		2-30 GAL DRUMS OF CUTTING OILS FROM MACHING SHOP OPS. (SOME TRICHLOROET	O	TBD	L	Y
1956	08	07	81	1.0000	0.0000	0	17		4-500 ML - THALLIUM MALONATE/FORMATE (CLERS' SOLN)	O	TBD	S	Y
1957	08	30	81	0.0000	1.0000	0	13		2 JARS - 1 POTASSIUM CHLORIDE CRYSTALS, 1 UNIDENTIFIED DRY CHEMICAL	I	TBD	S	Y
1958	07	29	81	7.3700	0.0000	0			TRANSFORMER OIL - TO BE SAMPLED FOR PCBS 8/12/81	O	TBD	L	N
1959	00	00	00	10.0500	0.0000	0		B	ALUMINUM DE-SMUTTING SOLUTION ACID (CHROMIC ACID 30E/GAL PLT 2)(7/81)	I	C	L	Y
1960	00	00	00	6.7000	0.0000	0			PHOSPHORIC ACID CONCENTRATED,NITRIC ACID 3 GAL,ALUMINUM METAL 1OZ/GAL 7	I/M	C	S	N
1961	00	00	00	6.7000	0.0000	0			COPPER STRIPPING SOLUTION PH10 8OZ. COPPER/GAL (8/81)	I	TBD	L	N
1962	07	20	81	29.4800	0.0000	0		B	15% SULFURIC ACID ANODIZING BATH, 5 GM/L ALUMINIUM SULFATE	I	C	L	Y
1963	07	17	81	0.0000	0.0000	0		B	HYDROCHLORIC ACID	I	C	L	Y
1964	07	19	81	0.0170	0.0000	0		B	SULFURIC ACID - CONCENTRATED	I	C	L	Y
1965	07	09	81	2.5000	0.0000	0			25 BOTTLES CANS - ACIDS, BASES & SALTS ONE IS RADIOACTIVE (UR???? NITRA	NA	NA	NA	N
1966	07	07	81	0.8040	0.0000	0	17		HEXANE	O	I	L	Y
1967	07	10	81	0.2500	0.0000	0	17		1-ETHYL ETHER 2-ETHYL OXALATE,24OZ PHOSPHOROUS TRICHLORIDE,1-TRICHLORO	O/I	I/R	L	Y
1968	07	08	81	3.0000	0.0000	0		B	3-ACETIC ACID, 1-SULPHURIC ACID, 2-UNKNOWNS, 2-AMMONIUM HYDROXIDE	O/I	C	L	Y
1969	07	29	81	0.0000	0.0000	0		B	1 PLASTIC BOTTLE - FIXER	I	TBD	L	Y
1970	07	29	81	0.0000	0.0000	0	13		MOSTLY 1 LB BOTTLES OF ANALYTICAL REAGENTS (LIST GONE)	NA	NA	NA	Y
1971	07	24	81	0.2680	0.0000	0		B	4-1/2 GAL NALGEN BOTTLE W/NITRIC ACID (50% SOLUTION)	I	C	L	Y
1972	07	21	81	14.5600	0.0000	0		B	COPPER PLATING BATH - 200 GAL	I*	TBD	L	Y
1973	07	21	81	36.8500	0.0000	0		B	COPPER SULFATE, 80GM/L SULFURIC ACID	I	C	L	Y
1974	07	21	81	5.3600	0.0000	0		B	ZINCATE FOR ZINC COATING ALUMINUM. 7000/GAL SODIUM HYDROXIDE, 13OZ/GAL	I	C*	L	Y
1975	07	21	81	22.1100	0.0000	0		B	ALODINE FOR CHROMATE COATING ALUMINUM 2.0 OX/GAL CHROMIC ACID, 0.4OZ/GA	I*	C*	L	Y
1976	07	21	81	5.9500	0.0000	0		B	NICKEL PLATING BATH, 80GM/L NICKEL, 46GM/L BORIC ACID	I	TBD	L	Y

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 53
10/08/91

TA-54, AREA L SOURCE TERM DATABASE
(AREALST5.DBF)

ID	MO DY YR	VOLCUFT	WGT	ITM	SHAFT	PIT	DESCRIP	CHEM TYPE	RCRA CHAR	PHYS PHAS	LOC
1977	07 17 81	1.0000	0.0000	0			5-1LB PERCHLORIC ACID 70%, 4-1LB HYDROFLORIC ACID 48%, 2-3.25L AMMONIUM	I	C/I	L	N
1978	07 17 81	0.0000	0.0000	0			1 BOX - HYDROCHLORIC ACID - 4LB JARS	I	C	L	N
1979	00 00 00	162.1400	0.0000	0			TRANSFORMER OIL (HAS RSWDS) (7/81)	O	TBD	L	N
1980	06 01 81	4.0000	0.0000	0	17		1-1LB GLASS BOTTLE LITHIUM FLUORIDE, 7-1GAL PLASTIC BOTTLES & 2QT CAN E	I/O	I*	L	Y
1981	06 02 81	37.5200	0.0000	0			2-55 GAL & 2-30GAL DRUMS OF ?????, 2-55 GAL DRUMS OF ABSORBED OIL	O	NA	L	N
1982	06 03 81	64.0000	0.0000	0		B	INORGANIC CHEMICALS	I	NA	NA	Y
1983	06 04 81	0.1500	0.0000	0			CHROMIC ACID	I	T	NA	N
1984	06 09 81	8.0000	0.0000	0	13		1 BBL OF UNKNOWN FROM BIOMED EQUIP. ROOM, 1PT PLASTIC, 1QT HG, 1 SHEET	M/NA	T	S	Y
1985	06 11 81	5.0000	0.0000	0		B	13-1GAL & 1 LOT ASSORTED SIGN - PHOTO GRAPHIC CHEMICALS	I	TBD	L	Y
1986	06 12 81	0.0000	0.0000	0	15		MERCURY	M	T	S	Y
1987	06 19 81	5.0000	0.0000	0		B	29-GLASS GAL, 9-GLASS QTS 4-1/2GAL DICHROMIC ACID, AQUA ????, PHOSPHORU	O/I	T/I	L	Y
1988	05 26 81	0.0000	0.0000	0	17		5 PT ETHERS, 2 BOXES & 5 UNKNOWN ORGANICS	O	I	L	Y
1989	05 26 81	3.0000	0.0000	0			4-1 GAL BOTTLES CASTOR OIL, 1-5 GAL SAFETY CAN ETHANOL	O	I	L	N
1990	05 25 81	0.0000	0.0000	0			12 CONTAINERS - LONG LIST - INORGANIC & ORGANICS	I/O	NA	NA	N
1991	05 18 81	4.0000	0.0000	0		B	PHOTOGRAPHIC CHEMICALS, I.E., FIXER, DEVELOPER, REPLENISHER, 20 CC MERC	M/I	T	S/L	Y
1992	04 28 81	0.0000	0.0000	0	17		2 CANS EPOXY, 2 CANS HARDNER	O	I*	L	Y
1993	08 23 81	1.3400	0.0000	0		B	NITRIC ACID/WATER 70% HNO2) & UNLABELED ACID BOTTLE 600ML	I	C	L	Y
1994	04 07 81	9.0000	0.0000	0			1-30 GAL DRUM BROMACIL (HYVAR-X6)	O	TBD	L	N
1995	05 04 81	2.0000	0.0000	0			1 PLASTIC BAG; HYDROCHLORIC ACID SATURATED WITH SOME /SS TUBING	I	C/T	L/S	N

BENCHMARK ENVIRONMENTAL CORPORATION

BATCH WASTE SOURCE TERM DATA BASE

ge No. 1
/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

MO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
12	20	74	14.7000	Aniline Dye	NONE	Y	A		O	CMB-6			
12	20	74	5.3500	HNO_3-20%	NaOH	Y	A		M	CMB-6			
01	08	75	13.3700	$NiCl_2$-NH_4Cl+	NaOH	Y	A			CMB-6			
01	03	75	0.0000	$NaC_6H_5O_7$		Y	A			CMB-6			
01	03	75	0.0000	NaH_2PO_2		Y	A			CMB-6			
01	08	75	20.0500	Ni Sulfamate	NaOH	Y	A		M	CMB-6			
01	03	75	0.0000	Boric Acid		Y	A			CMB-6			
01	03	75	0.0000	Ni Bromide		Y	A			CMB-6			
01	10	75	3.3400	Cl_3CrO_3	SO_2 + NaOH	Y	A		M	CMB-6			
01	03	75	0.0000	H_2SO_4		Y	A			CMB-6			
~~01~~	~~10~~	~~75~~	~~8.0200~~	~~H_2SO_4 20%~~	~~NaOH~~	~~Y~~	A			~~CMB-6~~			
01	10	75	8.0200	H_2SO_4 + Cr(+6)	SO_2 + NaOH	Y	A		M	E-2			
01	10	75	6.6900	Ferric Cl_3		Y	A		M	CMB-6			
01	16	75	13.3700	Ni Chloride	H_2SO_4+NaOH	Y	A		M	CMB-6			
01	16	75	8.0200	ABF	CaOH	Y	A			ENG-4			
02	10	75	0.5300	H_3PO_4 + HF + CrO_3		Y	A		M	CMB-6			
02	10	75	33.4200	CuCN + NaCN + Na_2CO_3		Y	A		O,M	CMB-6			
02	12	75	6.6900	HNO_3 + H_3PO_4		Y	A			ETL			
02	12	75	33.4200	H_2SO_4 + HNO_3 + HCl		Y	A			CMB-6			
02	12	75	2.0000	H_3PO_4		Y	A			CMB-6			
01	31	75	80.2000	NH_4F	400 # lime	Y	A			TA-48 ENG-4			
01	31	75	60.1000	NH_4F	300 # lime	Y	A			TA-48 ENG-4			
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.7061	3M	Asphalt lined drums	N			AreaG	CMC-11		yes	
02	07	75	0.2825	3M	Asphalt lined drums	N			AreaG	CMC-11		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.0706	3M	Asphalt lined drums	N			AreaG	CMB-1		yes	
02	07	75	0.4944	3M	Asphalt lined drums	N			AreaG	CMC-11		yes	
03	25	75	6.6900	HNO_3 + H_3PO_4	NaOH	Y	A			ETL			
03	25	75	0.7239	3M	Asphalt drum	N			AreaG	CMC-11			
03	26	75	33.4200	50% HNO_3, Co, Al, Fe	NaOH	Y	A		M	CMB-6			

BENCHMARK ENVIRONMENTAL CORPORATION

ge No. 2
/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

MO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
03	26	75	0.0706	3H-0.17 ug/l	Asphalt drum	N			AreaG	CMB-1			
03	26	75	0.0706	3H < 0.01 mg/l	Asphalt drum	N			AreaG	CMB-1			
09	29	75	13.3700	HNO3 - 33%	NaOH	Y	A			SH-105			
09	30	75	13.3700	NiCl + NaAc	NaOH	Y	A		M	CMB-6			
00	00	00	0.0000	NH4Cl		Y	A			CMB-6			
09	30	75	33.4200	NiCl2 + HCl	NaOH	Y	A		M	CMB-6			
09	30	75	3.3400	HNO3 + Cu	NaOH	Y	A		M	CMB-6			
09	30	75	0.4000	KCN + NaOH	Cl + NaOH	Y	A			CMB-6			
10	15	75	0.2119	3H @ 21.6 mg/l	Grit Chamber	N			TA-50	CMB-1		yes	
12	12	00	8.0200	NaOH + 2NiO		Y	A		M	CMB-6			
12	12	00	6.6900	30% HNO3 - 5% H3PO4		Y	A			ETL			
01	13	76	10.7000	Trichloroethylene		Y	A		O	CMB-6			
03	22	76	80.2000	ABF	600 lbs Ca(OH)2	Y	A			ENG-4-TA-48			
02	16	76	12.0300	90% H3PO4		Y	A			CMB-6			
02	16	76	5.3500	NaOH Zinc Bright		Y	A		M	CMB-6			
02	12	76	6.6900	20% HNO3 + H3PO4		Y	A			ETL			
02	20	76	16.0400	H2SO4 + Cr(+6)		Y	A		M	E-2			
07	02	76	33.4200	NiSO4 + NiCl3 + H3BO3		Y	A		M	CMB-6			
12	12	75	8.0200	NaOH + 2NiO		Y	A		I,M	CMB-6			
12	12	75	6.6900	30% HNO3 + 5% H3PO4		Y	A		I	MP			
12	20	75	16.0400	H2SO4 + Cr(+6)		Y	A		I,M	E-2			
01	13	76	10.7000	TriClor (TCE)		Y	A		O	CMB-6			
03	22	76	100.2800	ABF	Ca(OH)2 - 600 lb.	Y	A		I	ENG-4			
02	10	76	12.0300	90% H3PO4		Y	A		I	CMB-6			
02	10	76	5.3500	NaOH + Zinc Bright		Y	A		I,M	CMB-6			
02	-12	76	6.6900	30% HNO3 + 5% H3PO4		Y	A		I	MP			
05	27	00	4.6800	NaCN + CuCN		N			O,M	CMB-6			
05	04	76	66.8400	ABF	Ca(OH)2 - 300 lb.	Y	A		I	ENG-4			
05	27	00	0.4700	NiCO3+HF+C6H8O7+NH4F,NaHPO3		Y	A		I,O,M	CMB-6			
05	27	00	1.4700	NiSO4+Ni+(NH4)2SO4,ZnSO4,NaSCN		Y	A		I,O,M	CMB-6			
05	27	00	1.6000	H3PO4		Y	A		I	CMB-6			
05	27	00	4.0100	NH4F+Na2Cr2O7+H3PO4		Y	A		I,M	CMB-6			
05	27	00	0.4700	CoCO3+EDTA+NH4OH		Y	A		I,O	CMB-6			
07	02	76	2.0100	KCN		N			O	CMB-6	R		
07	02	76	33.4200	NiSO4+NiCl2+H3BO3		Y	A		I,M	CMB-6	C		
08	04	76	6.6900	NiClSO4, Na3PO4		Y	A		I,M	CMB-6	C		
08	10	76	66.8400	ABF	Ca(OH)2+CaCl2	Y	A		I	ENG-4			
08	10	76	66.8400	ABF	Ca(OH)2+CaCl2	Y	A		I	ENG-4			

BENCHMARK ENVIRONMENTAL CORPORATION

age No. 3
0/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

	MO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
77	04	22	77	0.0000	KCN-Granuler (1/4 lb.)	Cl2 (2 lbs)	Y	A		O	N-7			L,S
78	11	10	76	16.0400	Chromic Acid	SO2 (100 lbs)	Y	A		I	E-2			L,S
79	11	15	76	7.3500	HNO3 - 20%	NaOH (5 gal)	Y	A		I	NP-11			L
80	09	20	76	66.8400	ABF	CaOH (500 lbs)	Y	A		I	ENG-4			L,S
81	04	24	77	23.4000	NH4 + CN(*)	Cl2 (25 lbs)	Y	A		I,O	CMB-6			L
82	04	19	77	7.3500	CN-Ni, CU(*)	Cl2 (150 lbs)	Y	A		I,O	CMB-6			L,S
83	03	22	77	6.6900	Chrome +6(*)	SO2 + NaOH	Y	A		I	E-2			L,S
84	10	21	00	267.4000	ABF	NaOH	Y	A		I	ENG-4			L,S
85	10	22	00	28.0800	3H	Dumped in Grit Chamb	Y	A			CNC-11		Yes	L
86	04	22	77	0.0530	NaCN	Cl2 (5 lbs)	Y	A		O	P-4			L
~~87~~	~~11~~	~~15~~	~~76~~	~~20.0600~~	~~HNO3~~	~~NaOH (30 gal)~~	~~Y~~	~~A~~		~~I~~	~~CMB-6~~			~~L~~
88	04	19	77	0.1300	NaCN	Cl2	Y	A		O	WX-2			L
89	04	19	77	0.0100	NaCN	Cl2	Y	A		O	CMB-1			L
90	11	15	76	2.0100	HNO3 - 50%	NaOH (5 gal)	Y	A		I	R			L
91	01	04	77	40.1200	ABF	NaOH	Y	A		I	ENG-4			L,S
92	03	10	77	40.1200	ABF	NaOH	Y	A		I	ENG-4			L,S
93	03	22	77	14.0400	H2SO4 + Cr(+6)	SO2 + NaOH	Y	A		I	E-2			L,S
94	03	22	77	4.0100	HNO3+HCL+CO	NaOH	Y	A		I	Q-13			L
95	03	26	77	80.2000	ABF	NaOH	Y	A		I	ENG-4			L,S
96	04	02	77	66.8400	ABF	NaOH	Y	A		I	ENG-4			L,S
97	04	17	77	160.4400	ABF	NaOH	Y	A		I	ENG-4			L,S
98	04	20	77	13.3700	KCN+CU+K2O3	Cl2 + NaOH	Y	A		O,N	CMB-6			L,S
99	04	20	77	14.7000	DTPA+KCN+CU	Cl2 + NaOH	Y	A		O,N	CMB-6			L
100	04	20	77	4.0100	Na+Cr(+6)+H2SO4	SO2 + NaOH	Y	A		I,N	CMB-6			L,S
101	08	09	77	33.0191	70% H2SO4+Cr(+6)+U238	SO2 + NaOH (NOT DUMP)	N				CMB-6		yesU	
102	08	08	77	14.7000	Nickel/Acetate		Y	A		I,O,N	CMB-6	T		L
103	08	08	77	29.4000	H2SO4 Anodizer	NaOH	Y	A		I	CMB-6			L
104	08	09	00	80.2000	ABF	Ca(OH)2+CaCl2	Y	A		I	ENG-4			L,S
105	08	10	77	0.5300	Udylite	NaOH	Y	A			CMB-6			L
106	08	10	77	14.7000	KCN+NH3	Cl2+NaOH	Y	A		O	CMB-6			L
107	08	10	77	2.0100	H2SO4+Na2Cr(+6)2O7	SO2+NaOH	Y	A		I,N	CMB-6			L,S
108	09	22	77	5.3500	Cr(+6)+H2SO4	SO2+NaOH	Y	A		I,N	E-2			L,S
109	09	27	77	133.7000	ABF	450#Ca(OH)2+160#CaCl2	Y	A		I	ENG-4			L,S
110	09	30	77	133.7000	ABF	200#Ca(OH)2+160#CaCl2	Y	A		I	ENG-4			L,S
111	10	03	77	133.7000	ABF	300#Ca(OH)2+80#CaCl2	Y	A		I	EN-4			L,S
112	10	05	77	133.7000	ABF	300# Ca(OH)2	Y	A		I	ENG-4			L,S
113	10	20	77	29.4100	50% HNO3 + AgCl-AgClAl		Y	A		I,N	CMB-6	C		L
114	10	13	77	4.0100	Fluoroboric Acid, Pb		Y	A		I,N	CMB-6	C		L

BENCHMARK ENVIRONMENTAL CORPORATION

ge No. 4
/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

	MO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
15	11	22	77	4.0100	(Fe,Ni,CO,Hg) HNO3	NaOH	Y	A		I,M	Q-13			L,S
16	11	24	77	6.0200	NH4 Citrate+NaOH+CN	Cl2 + NaOH	Y	A		O	CMB-6			L
17	04	19	78	7.3500	NH4 Citrate+NaOH+CN	Cl2 + NaOH	Y	A		O	CMB-6			L
18	11	22	77	4.0100	H3PO4	NaOH	Y	A		I	CMB-6			L
19	04	21	78	5.3500	KCN	Cl2 + NaOH	Y	A		O	CMB-6			L
20	04	25	78	2.0100	KCN+KNi(CN)2	Cl2 + NaOH	Y	A		O,M	CMB-6			L
21	04	25	78	5.3500	KCN+NaOH	Cl2 + NaOH	Y	A		O,M	CMB-6			L
22	04	27	78	14.7000	NaCN+Na2CO3	Cl2 + NaOH	Y	A		O	CMB-6			L
23	02	07	78	6.0200	FeCl3		Y	A		I	WX-7	C		L
24	02	07	78	4.0100	Stripper		Y	A			WX-7			L
25	~~02~~	~~17~~	~~78~~	~~133.7000~~	~~ABF~~	~~Ca(OH)2 + CaCl2~~	Y	A		~~I~~	~~ENG-4~~			~~L,S~~
26	02	23	78	66.9000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
27	04	01	78	133.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
28	04	06	78	133.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
29	04	08	78	240.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
30	04	12	78	2.0100	Cr(+6) Acid	SO2 + NaOH	Y	A		I,M	H-7			L,S
31	04	12	78	0.4000	Cr(+6) Acid	SO2 + NaOH	Y	A		I,M	AP1			L,S
32	04	12	78	240.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
33	04	19	00	133.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
	04	19	78	200.0000	ABF	Ca(OH)2	Y	A		I	ENG-4			L
35	04	21	78	240.6600	ABF	CaCl2	Y	A		I	ENG-4			L
36	04	25	78	267.4000	ABF	CaCl2	Y	A		I	ENG-4			L
37	04	27	78	22.0600	Ni Acetate	NaOH	Y	A		O,M	CMB-6			L,S
38	04	27	78	7.3500	Ni Salt	NaOH	Y	A		I,M	CMB-6			L,S
39	04	27	78	7.3500	Cr(+6) + H2SO4	SO2 + NaOH	Y	A		I,M	CMB-6			L,S
40	04	27	78	267.4000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
41	05	15	78	36.7700	30% HCl, Fe, Cu	NaOH	Y	A		I,M	CMB-6			L,S
42	05	12	78	22.0600	50% HNO3, Fe, Cu	NaOH	Y	A		I,M	CMB-6			L,S
43	05	15	78	0.6700	Lead Fluorobate		Y	A		I,M	CMB-6			L,S
44	05	15	78	7.3500	Ni Strip		Y	A		u	CMB-6			L
45	05	19	78	0.6700	Ag+CN+KCN	Cl2+NaOH	Y	A			CMB-6		yes	L
46	10	19	78	13.3700	Cr(+6)+H2SO4	SO2 + NaOH	Y	A		I,M	E-2			L,S
47	07	26	78	66.9000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
48	07	27	78	0.2700	3H		Y	A			H-4		yes	L
49	10	19	78	6.6900	HNO3	NaOH	Y	A		I	MP			L
50	10	19	78	2.7600	HNO3	NaOH	Y	A		I	Q-13			L
51	10	19	00	9.3600	HNO3	NaOH	Y	A		I	CTR-11			L
52	09	21	00	14.7000	1,1,1 Methyl Chloroform		Y	A		O	E-2			L

BENCHMARK ENVIRONMENTAL CORPORATION

ᵓage No. 5
0/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

NO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
	28	78	20.0500	Cr(+6)+H2SO4	SO2 + NaOH	Y	A		I,N	E-2			L,S
	17	00	133.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
	19	00	133.7000	ABF	Ca(OH)2 + CaCl2	Y	A		I	ENG-4			L,S
	06	78	36.1000	HCl+Cu+Ni	NaOH	Y	A		I,N	CMB-6			L,S
	06	78	29.4000	Ni-Acetate	NaOH	Y	A		O,N	CMB-6			L,S
	06	78	7.3500	Gold Solute W/NaOH+SO3		Y	A		I,N	CMB-6			L
	08	79	7.3500	20% HNO3		Y	B		I	NP			L
	22	79	7.3500	SO3+H2SO4	NaOH	Y	B		I	CMB-6			L
	13	79	14.7000	DTPA+CN+NaOH+Au+Cu	Cl2+NaOH	Y	B		O,N	CMB-6			L
	13	79	4.0100	CN+NaOH	Cl2+NaOH	Y	B		O	CMB-6			L
	20	79	133.7000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	25	79	66.9000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	27	79	66.9000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	05	79	36.7621	HNO3+Cu+Ni+Te	NaOH n-1 PAD)	N				CMB-6		yes	
	18	79	7.3500	Cr(+6) Dye	SO2 + NaOH	Y	B		I,N	E-1			L,S
	24	00	401.0000	ABF	Ca(OH)2 + CaCl2	Y	B		I	ENG-4			L,S
	04	00	6.0156	HNO3+3802	(N-1 PAD)	N				CMB-6		yes	
	04	00	6.0156	CuCl2+HF+3802	(N-1 PAD)	N				CMB-6		yes	
	12	00	7.3500	CN+H2O2+C	Cl2+NaOH	Y	B		O	CMB-6			L
	12	00	11.3600	NaOH+CN+Au	Cl2+NaOH	Y	B		O,N	CMB-6			L
	09	79	133.9000	ABF	Ca(OH)2 CaCl2	N				ENG-4			L,S
	15	79	36.7700	HCl+Fe+Cu		Y		2,13	I,N	CMB-6	C		L,S
	18	00	7.3500	50% HNO3	NaOH	Y	B		I	CMB-6			L
	25	00	80.2083	ABF	Ca(OH)2+CaCl2(PLANT	N				ENG-4 OMEGA		YES	
	30	00	36.7700	Nickel Bright		Y	B		?,N	CMB-6			L
	05	79	66.8403	ABF	Ca(OH)2+CaCl2(N-1 PAD	N				ENG-4		YES	
	04	79	66.9000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	11	00	14.7000	50% HNO3		Y	B		I	CMB-6	C		L
	11	00	7.3500	NaOH+DTPA+S		Y	B		I	CMB-6			L
	11	00	7.3500	Dow Therm		Y	B		u	N-7			L
	16	00	0.8000	H2SO4+Cr(+6)	SO2 + NaOH	Y	B		I,M	N-7			L,S
	14	00	0.4000	H2SO4+Cr(+6)	SO2 + NaOH	Y	B		I,M	N-7			L,S
	03	00	133.7000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	07	00	5.3500	HNO3	NaOH	Y		13	I	CTR			L
	05	79	133.7000	ABF	Ca(OH)2+CaCl2	Y	B		I	ENG-4			L,S
	11	79	7.3500	Ni Bright		Y	B		u	CMB-6			L
	00	00	1.3400	Ni Bright		Y	B		u				L
	12	79	5.3500	Ca + Ni		Y	B		I,M	E-2			L,S

BENCHMARK ENVIRONMENTAL CORPORATION

Page No. 6
10/02/91

BATCH WASTE TREATMENT PLANT AREA L SOURCE TERM

	MO	DY	YR	VOLUME (cu. ft)	CONTENT	TREATMENT (batch analysis)	LOCATION KNOWN?	PIT	SHAFT	WASTE TYPE	SOURCE	HAZ CHAR	RADIAT. IN WASTE	PHYSICAL PHASE
191	11	02	79	133.7000	ABF	Ca(OH)2 + CaCl2	Y	B		I	ENG-4			L,S
192	01	09	80	7.3500	Ni Plating	Ni	Y	B		I,M	CMB-6			L
193	02	20	80	133.7000	ABF	Ca(OH)2 + CaCl2	Y	B		I	ENG-4			L,S
194	03	04	80	56.1500	HNO3	Ni	Y	B		I,M	CMB-6			L
195	03	11	80	133.7000	ABF	CaCO3+CaCl2	Y	B		I	ENG-4			L
196	08	12	80	56.1500	Ni Plating	Ca(OH)2 + CaCl2	Y	B		I,M	CMB-6			L
197	08	20	80	6.6900	CN + Ag	Cl2 + NaOH	Y	B		O,M	CMB-6			L
198	08	25	80	6.6900	CN+Ag+Cu	Cl2 + H2O	Y	B		O,M	CMB-6			L
199	10	00	80	6.6900	CN+Cu	Cl2 + H2O	Y	B		O,M	CMB-6			L
200	01	00	81	6.6900	CuCN	Cl2 + H2O	Y	B		O,M	CMB-6			L
201	06	16	81	133.7000	ABF	Ca(OH)2 + CaCl2	Y	B		I	ENG-4			L,S
202	07	14	82	29.4100	CN	Cl2	Y	B		O	CM6			L
203	04	19	83	1.3400	CN	Ca(OCl)2+NaOH	Y	B		O	MST6			L
204	06	09	83	6.0200	CN	Ca(OCl)2+NaOH	Y	B		O	MST6			L
205	07	21	83	3.6100	CN	Ca(OCl)2+NaOH	Y	B		O	MST6			L
206	07	13	84	80.2200	ABF	CaO+CaCl2	Y	B		I	ENG-4			L,S
207	07	25	84	66.9000	ABF	CaO+CaCl2	Y	B		I	ENG-4			L,S