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Date: November 15, 2007
Refer To: EP2007-0666

James P. Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of Investigation Report for Consolidated Units 16-007(a)-99 and 16 008(a)-99 at Technical Area 16

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the "Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16." This document is due to the New Mexico Environment Department (NMED) on November 15, 2007, as approved in the NMED letter entitled "Approval of Second Request for Extension to Submit the Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99 Technical Area-16 Ponds," dated July 18, 2007.

If you have any questions, please contact John McCann at (505) 665-1091 (jmccann@lanl.gov) or Woody Woodworth at (505) 665-5820 (lwoodworth@doeal.gov).

Sincerely,

Susan G. Stiger, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

David R. Gregory, Project Director
Environmental Operations
Los Alamos Site Office

SGS/DRG/DDH/:sm

Enclosures: 1) Two hard copies with electronic files - Investigation Report for Consolidated Solid Waste Management Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16 (EP2007-0666)

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LA-UR-07-7693
November 2007
EP2007-0666

Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

LA-UR-07-7693
EP2007-0666

Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16

November 2007

Responsible project leader:

Printed Name	Signature	Title	Organization	Date
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David R. Gregory	David R Gregory	Project Director	DOE-LASO	11/14/07

EXECUTIVE SUMMARY

The Los Alamos National Laboratory (LANL or the Laboratory) Environmental Programs Directorate–Corrective Actions Program has investigated Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16. These Laboratory sites are referred to as the 30s Line and 90s Line, respectively. Investigation activities were conducted between September 2006 and August 2007. In addition, historical data from previous investigations at the 30s Line and 90s Line completed between 1995 and 2004 are incorporated into this investigation report.

The 30s Line and 90s Line were primarily high explosives (HE) machining facilities where HE was machined to specific shapes to support the development of nuclear weapons. The former line operated from 1945 to the early 1950s, and the latter operated from 1950 to the time that TA-16-260 became fully operational. In both facilities, HE-contaminated wastewater was routed through sumps and drainlines to either settling ponds or to a drainage to Cañon de Valle. The 30s Line buildings, fixtures, and settling ponds were decommissioned during the 1960s, the 90s Line buildings and fixtures were decommissioned and cleaned up during a 1996 voluntary corrective action, and the 90s Line Pond remains at TA-16.

During this phase of field investigations, a total of 486 field screening samples and 389 laboratory samples were collected from near-surface soil and deeper rock (tuff) samples. Sampling locations were based on previous investigations, knowledge of likely contaminant-release points, field-screening results, and the conceptual site model for contaminant transport at TA-16. Field screening consisted of qualitative photoionization detector readings, HE spot testing, semiquantitative D-TECH screening for HE (primarily RDX [cyclotrimethylenetrinitramine]), and bench-top x-ray fluorescence screening for metals (particularly barium). Maximum sampling depths were 150 ft at three boreholes drilled at the 30s Line and at three boreholes drilled at the 90s Line.

One surface-water sample was collected from within the 90s Line Pond, and one groundwater sample was collected from a perched water zone located at a depth of 145 ft in a borehole southeast of the 90s Line Pond. Other 150 ft boreholes did not contain perched water.

Chemicals of potential concern (COPCs) for both 30s Line and 90s Line include 24 inorganic chemicals (particularly barium and hexavalent chromium) and 50 organic chemicals (particularly HE constituents such as RDX, volatile organic compounds such as toluene, and semivolatile organic compounds including polyaromatic hydrocarbons).

Under the industrial risk screening scenario, concentrations of carcinogenic COPCs were less than their respective soil screening levels (SSLs) at the 30s Line and 90s Line. The total excess cancer risks for the consolidated units are below the New Mexico Environment Department (NMED) target cancer risk level of 1×10^{-5}. The noncarcinogenic hazard indices (HIs) are less than NMED's target level of 1.0.

Under the construction scenario, concentrations of carcinogenic COPCs are less than their respective SSLs at the 30s Line, and the total excess cancer risk is below the NMED target cancer risk level. The total excess cancer risk at the 90s Line slightly exceeds the NMED target cancer risk level of 1×10^{-5}; the major contributor for risk is hexavalent chromium. The noncarcinogenic HIs at the 30s Line and 90s Line exceed an HI of 1.0 for the construction worker scenario. Manganese and aluminum are the major contributors to the HIs at the 30s Line and the 90s Line. However, concentrations of these COPCs are similar to background; the HIs without aluminum and manganese are equivalent to or less than an HI of 1.0.

The ecological screening evaluation for the 30s Line identified 18 chemicals of potential ecological concern (COPECs) and were eliminated in the uncertainty analysis. The ecological screening evaluation

for the 90s Line identified 26 COPECs and were also eliminated in the uncertainty analysis. The results of the ecological risk screening assessment indicate no potential risk to ecological receptors at the 30s Line and 90s Line.

Based on the sampling results, the vertical and lateral extent of contamination are not defined for all COPCs detected at Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line). Several COPCs are detected either at maximum depth of sampling or in downgradient lateral samples.

The following actions are proposed to define the nature and extent of contamination and to minimize risks at the site.

- For Consolidated Unit 16-008(a)-99, one deep borehole (300-ft depth) is proposed between the locations of several boreholes (up to 150-ft depth) in which COPCs were detected at their maximum depths. There is potentially unacceptable risk to the construction worker from hexavalent chromium at one location, and remediation is recommended at this location.
- For Consolidated Unit 16-007(a)-99, a single location with an extremely elevated RDX concentration (~1000 parts per million) is proposed for removal both to reduce the human health risk and to eliminate a potential RDX source to deeper groundwater.
- For perched groundwater, water will be sampled at a frequency of once per quarter for four quarters following the development of the borehole as a monitoring well.

CONTENTS

Figures

Tables

Appendixes

Plates

1.0 INTRODUCTION

The Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, LLC. 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 fingerlike 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 eastern portion of the plateau stands 300 to 1000 ft above the Rio Grande.

The Laboratory's Environmental Programs (EP) Directorate, which includes the former Environmental Restoration (ER) Project, is participating in a national effort by DOE to clean up sites and facilities formerly involved in weapons research and development. The goal of EP is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, EP is currently investigating sites potentially contaminated by past Laboratory operations. The latest investigations at the 30s and 90s Lines were conducted from September 2006 through August 2007 in accordance with the approved investigation work plan (LANL 2005, 089331; LANL 2005, 089653; NMED 2005, 091672) and the response to the notice of disapproval issued to LANL by the New Mexico Environment Department (NMED) in August 2005 (LANL 2005, 089653).

This investigation report details the environmental investigations conducted at Consolidated Units 16-007(a)-99 (also known as 30s Line) and 16-008(a)-99 (also known as 90s Line) located in Technical Area (TA) 16, Los Alamos, New Mexico. Consolidated Unit 16-007(a)-99 consists of Solid Waste Management Units (SWMUs) 16-007(a), 16-025(e), 16-025(f), 16-024(e), and 16-024(c) and Area of Concern (AOC) C-16-024(d). Consolidated Unit 16-008(a)-99 consists of SWMUs 16-008(a), 16-017(a)-99, 16-017(b)-99, 16-017(c)-99, 16-017(d)-99,16-017(e)-99, 16-026(m), 16-026(n), 16-026(o),16-026 (p), 16-029(k), 16-029(l), 16-029(s), 16-029(t), and 16-029(u) and AOC C-16-067.

Corrective actions at the Laboratory are subject to the March 1, 2005, Compliance Order on Consent (the Consent Order), issued pursuant to the New Mexico Hazardous Waste Act (HWA), New Mexico Statutes Annotated (NMSA) 1978,§ 74-4-10, and the New Mexico Solid Waste Act (SWA), NMSA 1978, § 74-9-36(D). Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the NMED in accordance with DOE policy.

1.1 General Site Information

TA-16 is located in the southwest corner of the Laboratory (Figure 1.1-1). TA-16 covers approximately 2410 acres (3.8 mi^2) and is on a portion of land that was acquired in 1943 by the Department of the Army for the Manhattan Project. TA-16 is bordered by Bandelier National Monument along State Highway 4 to the south and by the Santa Fe National Forest along State Highway 501 to the west. To the north and east it is bordered by TAs 8, 9, 11, 14, 15, 37, and 49 (Figure 1.1-1). Water Canyon, a 200-ft-deep ravine with steep walls, separates State Highway 4 from active sites at TA-16. Cañon de Valle forms the northern boundary of TA-16. TA-16 is surrounded by a security fence.

The 30s Line [Consolidated Unit 16-007(a)-99] and 90s Line [Consolidated Unit 16-008(a)-99] facilities are located near the western end of TA-16 (Figures 1.1-1 and 1.1-2) and were used for high explosives (HE) processing operations, including electroplating and machining. Discharge from the 30s Line and 90s

Line facilities was contained in settling ponds (referred to as the 30s Line Ponds and 90s Line Pond respectively) (Figure 1.1-2). The associated ponds were unlined and received wastes contaminated with HE, barium, and possibly uranium and organic compounds. The 30s Line and 90s Line facilities have been removed; only the 90s Line Pond remains. Buildings associated with the 30s Line and 90s Line were decommissioned and destroyed in 1960 and 1996, respectively.

1.2 Purpose of the Investigation

The purpose of the investigations at the 30s Line and 90s Line areas is to characterize the nature and extent of potential contamination present in surface and subsurface soil and tuff and to determine if additional activities are required to complete characterization and cleanup. This report presents soil, tuff, and water results from surface and subsurface sampling. Included are data on samples previously collected from Resource Conservation and Recovery Act (RCRA) facility investigations (RFIs) at the 30s and 90s Lines conducted in 1996 and 2004 as well as data from the 2006–2007 investigations.

1.3 Document Organization

This investigation report is presented in nine sections, including this introduction, with multiple supporting appendixes. Section 2 presents an overview of the site, its operational history, the results of previous investigations, and details on additional investigation data requirements, and section 3 discusses, in detail, the scope of investigatory activities. Section 4 presents field-investigation results, including physical and observational data, as well as survey results and field-screening data, and section 5 summarizes the regulatory criteria governing the interpretation of results and implementation of the investigation. Section 6 summarizes site contamination, including the analytical results, identifies chemicals of potential concern (COPCs), and defines the nature and extent of contamination. Section 7 presents conclusions based on applicable historical data as well as the 2006–2007 investigation data and summarizes the risk-screening assessments performed. Recommendations for Consolidated Units 16-007(a)-99 and 16-008(a)-99 based on applicable data and the risk-screening assessments are discussed in section 8. Section 9 lists the references cited in this report, and it provides map data sources.

The majority of appendixes present field documentation and associated information; however, two appendixes present substantial discussion and supporting information critical to the interpretation and assessment of current site conditions. Appendix I presents a detailed analysis of analytical data, discusses the COPC identification process, and presents an analysis of the nature and extent of contamination at Consolidated Units 16-007(a)-99 and 16-008(a)-99. Appendix J presents the results of the risk-screening assessments performed at Consolidated Units 16-007(a)-99 and 16-008(a)-99.

2.0 BACKGROUND

TA-16 was established to develop explosive formulations, cast and machine explosive charges, and assemble and test explosive components for the U.S. nuclear weapons program. The majority of work at TA-16 has been conducted in support of developing, testing, and producing explosive charges for the implosion method. Present-day use of TA-16 is essentially the same, although the facilities have been upgraded and expanded as explosive and manufacturing technologies have advanced. The 30s Line and 90s Line ponds received waste from former HE-processing facilities within TA-16. The 30s Line Ponds received waste discharged from former machining facilities in buildings 16-31, 16-32, and 16-33, and the 90s Line Pond received waste from HE sumps from buildings 16-89, 16-90, and 16-91 (Thrap 1970, 005784). These buildings and structures were destroyed and decommissioned in 1960 and 1996, however, the 90s Line Pond remains (LANL 1993, 020948, pp. 5-214-5-217; LANL 2005, 089331, pp. 3-4).

All the former 30s Line and 90s Line buildings (buildings 16-31, 16-32, 16-33, 16-89, 16-90, 16-91, 16-92, 16-93) had underground sump and drainline systems consisting of 8-in. vitrified clay piping that drained to the northwest (LANL 2005, 089331 pp. B-3, B-8, B-32). In addition, numerous water and steam condensate lines served these buildings (LANL 2005, 089331 p. 42) (Figure 1.1-2).

Previous investigations were conducted at the 30s Line and 90s Line areas and include

- 1986 and 1989 pre-RFI investigations at the 30s and 90s Lines (LANL 1993, 020948, pp. 5-217-5-219),
- 1996 Voluntary Corrective Action (VCA) at the 90s Line (LANL 1997, 087847),
- Phase II RFI report for potential release site 16-021(c) (LANL 1998, 059891, pp. 4-24-4-34), and
- 2004 RFI at 30s Line (LANL 2005, 089331, Appendix B).

Further details of these investigations are provided in the following subsections.

2.1 Site Description and Operational History

Site descriptions and operational history of the 30s and 90s Lines and their associated ponds are provided in detail in the historical investigation report (HIR) (LANL 2005, 089331, Appendix B). The historical information is summarized below.

2.1.1 Consolidated Unit 16-007(a)-99, 30s Line

Consolidated Unit 16-007(a)-99 (30s Line) (Figure 2.1-1) includes

- four settling ponds: SWMU 16-007(a),
- three former HE-machining buildings: 16-31 [SWMU 16-025(e)], 16-32 [SWMU 16-025(f)], and 16-33 [SWMU 16-024(e)], and their associated sumps and drainlines, and
- two former HE magazines: 16-30 [AOC 16-024(c)] and 16-34 [AOC 16-024(d)].

The HE-machining buildings were operated from 1944 to the early 1950s. All three buildings were of similar construction and each housed four separate machining chambers (LANL 1994, 039440, p. 5-306). All three buildings had HE sumps, associated drainlines, and outfalls. In the HE-machining operation, castings of HE lenses (the explosives component of a nuclear weapon) were machined under a stream of water, and lathes, drill presses, and other machine tools were used to remove imperfect surface material and to establish a final shape (LANL 1994, 039440, p. 5-311). The HE sumps received the machine-tool cooling wastewater and retained a volume of water before it was discharged to the drainline and outfall, allowing a significant amount of the entrained HE particles to settle out. After the early 1950s, building 16-31 was converted to a hot-cold chamber, building 16-32 was converted to an x-ray building, and building 16-33 was used as an additive storage building (LASL 1959, 005778, p. 1). The magazines were built in 1945 to store HE. All these structures were destroyed by intentional burning in 1960 and/or were demolished and removed shortly thereafter (LANL 1997, 056660.289, pp. 36-44). In addition, the HE sumps and drainlines were removed, and the soil was cleaned up to a residual level of less than 3% HE (LANL 1994, 039440, p. 5-305).

The 30s Line settling ponds received wastewater discharge from buildings 16-31, 16-32, and 16-33 (Figure 1.1-2). Each of the ponds was an approximately 100 ft by 100 ft flat-bottomed depression that was 8 to 10 ft deep, unlined, and aligned in a row from northwest to southeast. Aerial photographs from the 1940s and 1950s show the ponds containing liquid (Figure 2.1-2). The ponds were excavated and filled as part of the S-Site demolition in the 1960s (Thrap 1970, 005784, p. 2), and the area was leveled and seeded with grasses. The ponds are believed to have received liquids containing HE, barium, and organic chemicals from the HE-machining buildings until the mid- to late 1950s.

2.1.2 Consolidated Unit 16-008(a)-99, 90s Line Pond

Consolidated Unit 16-008(a)-99 (90s Line) (Figure 2.1-1) includes

- five sumps: SWMUs 16-029(k), 16-029(l), 16-029(s), 16-029(t), and 16-029(u),
- four drainlines and outfalls: SWMUs 16-026(m), 16-026(n), 16-026(o), and 16-026(p),
- one drum storage area: AOC C-16-067,
- one settling pond: SWMU 16-008(a), and
- buildings 16-89 [SWMU 16-017(e)-99], 16-90 [SWMU 16-017(d)-99], 16-91 [SWMU 16-017(c)-99], 16-92 [SWMU 16-017(a)-99], and 16-93 [SWMU 16-017(b)-99].

Most of the 90s Line structures were built in 1950 and operated from 1950 to 1970. All the 90s Line buildings were significantly larger than the 30s Line structures, and each building had two HE sumps. The sumps were located on opposite corners of each building, and were all identical concrete structures with a footprint of 15 by 5 ft. The sumps discharged to subsurface vitrified clay pipes, which daylighted at varying distances from the buildings, forming outfalls and associated drainage channels (LANL 1994, 039440, pp. 5-459 to 5-462). The buildings were initially used to support HE-machining operations while the 16-260 HE-machining facility was under construction. This facility went into service in 1951, and most machining operations conducted at the 90s Line migrated to the 16-260 facility at that time. In later years (1960s–1970s), some of the buildings were reallocated to support minor HE-electroplating operations and the cleaning and refurbishing of HE-contaminated equipment. After 1970, the buildings were used for storage until they were removed from service in 1991. In 1996, demolition and decommission (D&D) activities removed all the buildings and subsurface structures (sumps and drainlines). Outfalls from buildings 16-92 and 16-93 discharged into a small drainage that feeds into Cañon de Valle referred to as the 90s Line drainage (Figure 1.1-2). Outfalls from buildings 16-89, 16-90, and 16-91 discharged into drainages that feed into the 90s Line Pond (LANL 2005, 089331, p. 4) (Figure 1.1-2).

During active operations, the 90s Line Pond received liquid waste containing HE, barium, and, possibly, uranium and organic chemicals from the HE building sumps and drainlines. Although all other structures and buildings have since been removed, the 90s Line settling pond remains (Figure 2.1-3). The pond is unlined, approximately 200 ft in diameter, and was less than 10 ft deep based on the 2006–2007 drilling. The pond currently contains runoff water but has periodically dried out (LANL 2005, 089331, p. 4). This area was used as an HE burning area during WWII.

2.2 Historical Investigations

Historical investigations at the 30s Line and 90s Line areas include 1986 and 1989 pre–RFI investigations (LANL 2005, 089331, Appendix B, p. B-6); a 1996 VCA at 90s Line Pond (LANL 2005, 089331, Appendix B, pp. B-7–B-12); and a 2004 RFI at the 30s Line Ponds (LANL 2005, 089331, pp. B-14-B-17). The results of these historical investigations are discussed in detail in the HIR for the 30s Line and 90s

Line areas (LANL 2005, 089331, Appendix B). A map of sampling locations from the historical investigations is presented in Figure 2.2-1.

2.2.1 1986 and 1989 Pre–RFI

Soil, sediment, and surface water samples were collected and analyzed from the 30s Line and 90s Line in 1986 and 1989 (LANL 2005, 089331, Appendix B, p. B-6). Soil samples from the 30s Line were found to contain metals, volatile organic compounds (VOCs), and radionuclides. HE was not detected; however, the data were noted to be of poor quality (LANL 2005, 089331, p.10–11). Soil samples collected from the 90s Line were found to contain metals, VOCs, and HE. A sample collected on the shore of the 90s Line Pond was found to have a maximum of 0.02 weight percent (wt%) total HE. All other soil samples contained total HE below 0.02 wt% or HE was not detected (Baytos 1986, 005834). Three water samples collected from the 90s Line Pond contained metals and VOCs (LANL 2005, 089331, Appendix B). These early investigations were conducted before the RFI process, the data were not processed through the Laboratory’s Sample Management Office (SMO), and samples were not analyzed by off-site analytical laboratories. Therefore, the quality of the data is uncertain.

2.2.2 1996 and 2004 RFI

Two RFI activities were conducted as a result of the 1986 and 1989 pre–RFI. In 1996, a VCA was conducted at Consolidated Unit 16-008(a)-99 (the 90s Line) to remove contamination (LANL 1997, 087847). In 2004, an RFI was initiated at Consolidated Unit 16-007(a)-99 (the 30s Line) to characterize the nature and extent of contamination in the subsurface soil, sediment, and bedrock within the boundaries of the 30s Line and 90s Line areas and to determine if additional investigative or corrective actions were warranted (LANL 2005, 089331, Appendix B). These investigations are summarized below.

2.2.2.1 1996 VCA at Consolidated Unit 16-008(a)-99, 90s Line

The 1996 VCA was conducted in coordination with D&D activities at the 90s Line (LANL 1997, 087847). Above- and belowground structures and several hundred cubic yards of soil and sediment were removed. Following the removal, samples collected beneath the excavated areas and former sumps, drainlines, outfalls, drainages, and drum storage area were field screened and sent for off-site analysis. Based on the analytical results, further material was excavated both vertically and laterally until the concentrations were below one-half the industrial preliminary remediation goals, based on field screening analyses (LANL 1997, 087847, p. 4-8). Confirmation samples were collected at locations where the final excavation and cleanup occurred from depths of 2 to 3 ft beneath the excavated soil and sediment. Results of the confirmation sampling and analyses indicated metals were above background values (BVs), low-level concentrations of organic chemicals (HE, VOCs, and semivolatile organic compounds [SVOCs]) were detected, and no radionuclides were detected. The results of the sampling and analyses are presented in section B-3.0 of Appendix B of the investigation work plan for Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line) (LANL 2005, 089331, Appendix B). These results indicated further work was required to define the nature and extent of contamination at the 90s Line.

2.2.2.2 RFI at Consolidated Unit 16-007(a)-99, 30s Line

RFI fieldwork was conducted at the 30s Line in 2004, based on the U.S. Environmental Protection Agency (EPA)–approved RFI work plan (LANL 1993, 020948, pp. 5-222-5-225). The objectives of the investigation were to identify contaminants in the subsurface soil, sediment, and bedrock within the boundaries of the pond and to determine if additional investigations were warranted. The investigation indicated that inorganic chemical and organic chemical contamination was present in both soil and tuff. Inorganic chemicals above BVs were pervasive in the areas investigated. Barium was detected frequently, with a maximum detected concentration of 2270 mg/kg occurring at a depth of 7 to 8 ft in the northernmost pond (location 16-23740). Low-level concentrations of organic chemicals, including HE, VOCs, polyaromatic hydrocarbons (PAHs), and other SVOCs, were detected at all the areas investigated. Most of the detected concentrations, however, were slightly more than the laboratory estimated quantitation limit. HE was also detected frequently: the highest concentrations of RDX (cyclotrimethylenetrinitramine) above 1000 mg/kg were noted in the northernmost pond (location 16-23739). The results of the sampling and analyses are detailed in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331, Appendix B). The investigation concluded that the scope of the RFI sampling did not define the nature and extent of contamination at the 30s Line Ponds, and further investigation was required.

2.3 Relationship to Other SWMUs/AOCs

Several groups of nearby SWMUs and AOCs have a potential to impact the 30s Line and 90s Line. These sites include the T-Site Complex, the TA-16-99 area, the radiography buildings, the septic system, and the Machining Line buildings. These sites are discussed briefly below and are detailed in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331, p. 5-7). Figure 2.3-1 shows these SWMUs and AOCs in relation to the 30s Line and 90s Line areas.

T-Site, located approximately 250 ft northwest of SWMU 16-017(b)-99 and 750 ft west of SWMU 16-008(a), was used for radiography of HE and the metal parts used in the Fat Man implosion device. The structures at T-Site were destroyed by burning in 1960 and underwent further cleanup activities in 1966 (LANL 1994, 039440, p. 5-477–5-500). The HE was remediated to less than 3 wt% (Martin and Hickmott 1993, 087662, p. 1), and the radionuclides were cleaned up to background levels using hand-held screening equipment (Buckland 1966, 005060, p. 1). The primary contaminants remaining at T-Site that can potentially impact the 30s Line and 90s Line areas include inorganic chemicals, HE, VOCs, SVOCs, and radionuclides (LANL 2005, 089331, p. 5).

The building 16-99 area is located approximately 500 ft west of the 30s Line area. The site included sumps, outfalls, HE magazines, storage areas, and utility buildings used primarily for sawing risers off cast explosives. The structures were cleaned up as part of the 1996 VCA of the 90s Line (LANL 1997, 087847). The primary contaminants that may potentially impact the 30s Line and 90s Line areas include inorganic chemicals, HE, and VOCs (LANL 2005, 089331, p. 6).

The radiography buildings 16-39 [16-025(a)] and 16-40 [16-025(b)] were located approximately 300 ft west-northwest of the 30s Line area and approximately 750 ft due west of the SWMU 16-008(a) pond. Before the buildings were decommissioned, building 16-39 was found to be contaminated with cobalt-60 (Buckland 1957, 005764, p. 1). HE contamination was also discovered in buildings 19-39 and 16-40 (LASL 1959, 005778, p. 1). Additionally, both buildings were contaminated with radium-226 and uranium-238 (Blackwell 1983, 005823, p. 2). In 1966, the debris from the buildings was checked for radioactivity after cleanup, and no radioactivity was detected (Buckland 1966, 005060, p. 1). The primary contaminants that could potentially impact the 30s Line and 90s Line from these sites include radionuclides, inorganic chemicals, and HE (LANL 2005, 089331, p. 6).

The septic system structures [SWMU 16-005(n) and AOC C-16-003] were located north of the 90s Line structures and 300 ft northwest of the SWMU 16-008(a) pond. The septic system was decommissioned in the 1960s (LANL 2005, 089331, p. 6-7). TA-16 personnel indicated the system did not use hazardous material (Blackwell 1983, 005823, p. 4). A series of 1971 memoranda led to the conclusion that the system did not pose a threat to human health or the environment (DeField 1971, 055274, p. 1).

The Machining Line buildings (often referred to as the “north-south-east-west” buildings) were located approximately 550 ft south of the SWMU 16-008(a) pond and 200 ft southeast of the southernmost 30s Line Pond. The buildings and subsurface structures were destroyed and removed in the 1960s (LANL 2005, 089331, Appendix B). The buildings were designated as HE-contaminated in a 1959 HE survey (LASL 1959, 005778). The principal contaminants that could potentially impact the 30s Line and 90s Line areas are inorganic chemicals and HE (LANL 2005, 089331, p. 6-7).

2.4 Historical Nature and Extent of Contamination and Additional Data Requirements

The results of the historical investigations indicated that contamination has been released to the environment at the 30s Line and 90s Line areas. Pre–RFI sampling data collected during 1986 and 1989 confirmed the presence of HE, metals, and VOCs in soil around and within the 30s Line and 90s Line (LANL 2005, 089331, Appendix B). The presence of contamination was confirmed during the 1996 VCA for the 90s Line and the 2004 RFI for the 30s Line (LANL 2005, 089331, Appendix B). In addition, the 1996 VCA indicated the release of HE as well as organic solvents and inorganic chemicals into soil associated with the sump water from the 90s Line (LANL 1997, 087847).

Specifically, contaminants released within the 30s Line include HE (principally 2,4,6-trinitrotoluene [TNT] and RDX, and to a lesser extent HMX [octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine]); HE byproducts (e.g., 2,4- and 2,6-dinitrotoluene [DNT], 1,3-dinitrobenzene [DNB], 1,3,5-trinitrobenzene [TNB]); VOCs; SVOCs, including PAHs; and inorganic chemicals (LANL, 2005, 089331, Appendix B). The contaminants in the sumps, drainlines, and outfall discharge areas associated with the 90s Line are HE (principally TNT and RDX), HE byproducts, VOCs, SVOCs, cyanide, and inorganic chemicals (barium, chromium, copper, nickel, and uranium) (LANL 2005, 089331, Appendix B).

The relevant release and transport processes associated with these contaminants are a function of chemical-specific properties that include the relationship between the physical form of the chemicals and the nature of the transport processes in the environment. Specific properties include degree of saturation and the potential for ion exchange or sorption or the potential for natural bioremediation. The transport of VOCs occurs primarily in the vapor phase by diffusion or advection in the subsurface. Relatively water-soluble low vapor pressure chemicals are susceptible to release and transport by infiltration of water through the vadose zone or by alluvial water pathways. These mechanisms are discussed in more detail in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331, p. 7-8; NMED 2005, 091672) and in Appendix J of this document.

The previously described historical investigations did not define the vertical and lateral extent of contamination at the 30s Line and 90s Line. The 2006–2007 30s Line and 90s Line investigation was designed to address the data requirements presented in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331; NMED 2005, 091672).

3.0 SCOPE OF ACTIVITIES

This section presents the activities performed as part of the 2006–2007 investigation to define the nature and extent of contamination at the 30s Line and 90s Line. The 2006–2007 investigation included the following activities:

- pre- and postmobilization surveys
- surface and shallow subsurface sampling
- intermediate drilling and sampling

- environmental field screening
- neutron logging
- monitoring well construction
- borehole abandonment
- waste management

3.1 Field Methods

Fieldwork was carried out in accordance with the most current versions of the standard operating procedures (SOPs), manufacturers instructions (i.e., for screening analyses), and quality assurance (QA) procedures. The subsections below briefly describe the procedures and methods used to carry out the activities for the 2006–2007 investigation. Appendix C details the field methods and procedures followed during the investigation.

3.1.1 Pre- and Postmobilization Site Surveys

Several premobilization field surveys were carried out for the 30s Line and 90s Line investigations before drilling and sampling. The objectives of these site surveys were to ensure the field area was safe and proposed sampling points were placed in correct locations. Following fieldwork, final locations were surveyed as defined by the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331; NMED 2005, 091672).

Before any fieldwork at the 30s Line and 90s Line was conducted, an explosive ordinance device (EOD) walk-over survey was conducted to identify the presence of HE materials at the surface or in the near subsurface. An EOD–certified expert from the TA-16 facility, trained to identify various types of HE, conducted a broad visual sweep of the area before any field activities began. This survey was conducted to ensure the safety of the fieldworkers before the geomorphic and geodetic surveys were conducted and before the soil was disturbed.

Several samples had to be collected from geomorphically significant locations (e.g., drainage confluences, areas of deposition, and high-water marks). Qualified field geologists conducted a geomorphic survey of the site to identify the significant landforms and features as outlined in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331; NMED 2005, 091672). The field team geologists marked all the proposed sampling locations using pin flags or survey stakes. Some of the surveyed locations were changed during actual field activities because the samples were difficult to collect and the drill rig could not be moved easily to the proposed locations. Any locations that changed from the original location were resurveyed at the end of the field campaign.

A geodetic survey was conducted to properly ascertain the longitude, latitude, and elevation of the locations. The geodetic survey was carried out by Laboratory personnel with support from the field team, using methods consistent with established professional survey procedures.

After the geomorphic and geodetic surveys were completed, the EOD expert conducted a second sweep of the area, collected samples from each proposed sampling location, and spot tested each proposed location for HE. The EOD expert provided further guidance on how to proceed if chunk HE or significant concentrations of HE had been identified in the soil during any part of the investigation. The EOD expert did not identify any chunk HE during the survey, and chunk HE was not encountered during the drilling and sampling campaign.

A potholing survey was conducted at several locations within the 30s Line and 90s Line before soil at these locations was disturbed. The objective of this potholing activity was to mitigate unplanned breaches of possible unidentified underground utility systems. Designated locations were potholed by using a hand auger to the soil/tuff interface or until refusal. If a utility system was encountered, the sampling location was repositioned in 5-ft step-outs and potholed until it was confirmed that utilities were not impacted. Subsurface utilities were not identified during the potholing survey or during the drilling and sampling campaign.

3.1.2 Surface and Shallow Subsurface Sampling

Surface soil samples were collected within the 90s Line drainages and from all borehole drilling locations. The surface samples were collected from 0.0 to 0.5 ft, using spade and scoop or hand auger methods.

Shallow subsurface samples were collected at the 30s Line and 90s Line areas associated with the former structures (i.e., sumps, buildings, and drainlines) using a hollow-stem auger (HSA) drill rig. These shallow boreholes were drilled a minimum of 2 ft into unweathered tuff. Each borehole was typically advanced to 10 to 15 ft below ground surface (bgs). Surface soil was usually 3 to 7 ft thick, and the boreholes were drilled past the weathered horizon in 5-ft intervals. The approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331; NMED 2005, 091672) called for collecting some subsurface samples using a hand auger or power auger; however, a drill rig was thought to be the most efficient way to collect these samples. The rig was easy to move from one location to another, allowed sampling depths to be reached more quickly, and use of the rig minimized the risk of not reaching the prescribed total depth (TD) of the boreholes. Therefore, an HSA drill rig was used to collect all the shallow subsurface samples. Section 3.1.3.2 discusses further the characterization strategy for soil and rock sampling.

Surface and shallow subsurface samples were field screened for VOCs and spot tested for HE for health and safety purposes. VOC screening was conducted using a hand-held MiniRae 2000 photoionization detector (PID), equipped with an 11.7 electron volt (eV) lamp. Measurements of the core were recorded on the borehole logs (Appendix D). HE spot test screening was conducted using Laboratory-developed test kits. Rinsate blanks on equipment were collected at a frequency of one per every 10 analytical samples collected (10% frequency) for QA/quality control (QC) purposes. All samples were placed into preapproved sample containers in the field and stored on ice.

The samples remained in field team custody at all times until they were delivered to the SMO for shipment to off-site laboratories for analysis. All samples were field-screened onsite by the Laboratory's Health, Safety, and Radiation Protection Group 1 for alpha, beta, and gamma activity prior to transport and release to the SMO. To document sample handling, chain-of-custody (COC) forms were completed for all samples (Appendix F). Sample analyses were requested according to the Laboratory's statement of work for analytical services (LANL 2000, 071233). Sample collection logs were completed for all samples (Appendix F).

3.1.3 Borehole Drilling and Sampling

Intermediate-depth samples were also collected from boreholes at both the 30s Line and 90s Line. The boreholes were drilled using a CME-85 HSA dry coring-drill rig, with 4.25-in.-inside-diameter augers equipped with a split barrel sampler. The sample barrel was connected to a cable on a hexagonal rod that extends through the augers. The split sample barrels were 5 ft in length and provided continuous 3 in. outside diameter cores. The HSAs could not consistently drill through the consolidated tuff bedrock. When the HSA met refusal, the CME-85 was converted to a 94-mm air-rotary wire-line coring system that allowed drilling through intervals of more densely welded tuff. The air-coring system also produced continuous 5-ft core samples. The intermediate-depth boreholes were drilled to approximately 150 ft bgs.

The drilling equipment was decontaminated after use at each borehole. Rinsate blanks on drilling equipment were collected at a 10% frequency for QA/QC purposes. The drill cuttings generated during sampling activities were placed in 1 yd^3 waste containers and staged in an appropriate waste storage area. The waste was inspected and documented in accordance with the Laboratory's waste management requirements. The waste management documentation is presented in Appendix K.

3.1.3.1 Core Retrieval, Screening of Core, and Borehole Logging

Core was collected continuously on 5-ft sampling runs. After it was retrieved, the split barrel was opened and the core was screened for VOCs and HE for health and safety purposes. Screening for VOCs was conducted using a hand-held MiniRae 2000 PID, equipped with an 11.7 eV lamp. Measurements of the core were recorded on the borehole logs (Appendix D). HE screening was conducted using the HE spot test kit and D-TECH kits.

If no health and safety concerns arose, the core was visually inspected for sample-collection biasing criteria, such as the presence of fractures, staining, discoloration, saturated conditions, or unconsolidated sediments. Detailed lithologic logs of each boring were completed in the field by a qualified geologist and classified in accordance with Unified Soil Classification System, American Society for Testing and Materials (ASTM) D2487 and D2488, or American Geological Institute Methods for Soil and Rock Classification. The following information was recorded in the borehole logs for each boring: percent recovery; lithology and respective lithologic unit thickness, color (according to Munsell soil color chart), relative moisture content, grain size and distribution; and any other field observations (Appendix D). If fracturing was encountered in the recovered core, a detailed physical description of the fracture-fill material and rock matrix was also noted in the borehole logs. Some of the core was digitally photographed before sampling was performed (Appendix E).

3.1.3.2 Collection of Soil and Rock Characterization Samples

Characterization samples for the shallow subsurface were collected and submitted for off-site laboratory analyses from the surface (as discussed in section 3.1.2 above), the soil/tuff interface, and at TD of the borehole, as required by the approved investigation work plan (LANL 2005, 089331; NMED 2005, 091672). A minimum of three samples were collected from each borehole. Additional samples were collected and submitted for laboratory analyses based on field observations and field-screening results. On-site field screening is discussed in section 3.1.4. Samples with the highest RDX concentrations based on D-TECH kit field screening were submitted for laboratory analyses.

Characterization samples for the intermediate-depth subsurface boreholes were collected and submitted for off-site laboratory analyses for the surface, the soil/tuff interface, every 40 ft within the boring, and at TD, as required by the approved investigation work plan (LANL 2005, 089331; NMED 2005, 091672). A minimum of five samples were collected from each borehole. Additional samples were collected and submitted for laboratory analyses based on field observations and field-screening results. If fractures were encountered, paired fracture samples were collected: one sample was collected from the rock matrix above the fracture, and a second was collected from the fractured core. The ratio of fracture fill to rock matrix material in the second sample was estimated from field measurements and included in the sample descriptions on the borehole logs. Samples that contained the highest RDX concentrations, based on field screening using the D-TECH kit, were submitted for laboratory analyses.

Sample management protocols, described in section 3.1.2, were followed. The COC forms and sample collection logs for these samples are provided in Appendix F.

3.1.4 Environmental Field Screening

Field-screening samples were collected from boreholes at the following locations: surface interval of 0.0 to 0.5 ft, intervals where staining or other features indicated contamination were encountered, major fractures, major lithologic changes, soil/tuff interface, surge beds (for the intermediate boreholes), and TD. These samples were screened for VOCs, total HE, RDX, and metals. The shallow boreholes were screened every 5 ft, whereas the intermediate boreholes were field screened at least every 20 ft.

Field screening samples for VOCs were collected and containerized immediately in 125-mL amber glass jars. The samples were measured for volatile organic vapors (headspace) using the hand-held MiniRae 2000 PID, equipped with an 11.7 eV lamp. Total HE was measured using the HE spot test. This test has a detection limit of 100 parts per million (ppm), but does not indicate the types of HE, whereas the D-TECH kit measures RDX and TNT with a detection limit of 1 ppm. Metals were field screened using a QUANTEX energy-dispersive x-ray fluorescence (XRF) spectrometer. Samples were first prepared in the field by sieving and placing into appropriate labeled containers. Samples were analyzed for metals (barium, chromium, nickel, copper, and lead). All environmental field-screening results were recorded in the borehole logs (Appendix D) or field-screening summary table (Appendix D).

3.1.5 Installation of Temporary Surface Casing and Geophysical Neutron Logging

The six intermediate boreholes were moisture logged using a neutron probe. Logging was conducted at 1-ft intervals. The Laboratory supplied the Mount Sopris downhole geophysical logging equipment. The neutron probe was operated using a wireline winch. Data were collected and stored on a laptop computer. The raw neutron data, measured in counts per second (cps), were converted to percent volumetric water content (% vwc) using the standard correlation equation for 9-in.-diameter uncased boreholes in Bandelier Tuff.

3.1.6 Monitoring Well Construction

Perched water was encountered in one intermediate borehole at location 16-26644 near the 90s Line Pond. As a result, a monitoring well was installed in accordance with specifications established in the Consent Order, and the well design was reviewed and approved by the NMED before the well was constructed (Young 2007, 098733).

The well casing was threaded, 2-in.-inside-diameter, flush-joint polyvinyl chloride (PVC) pipe that conformed to the requirements of ASTM F 480-81 SDR 13.5 (schedule 40) and to the National Sanitation Foundation potable-water-quality-grade pipe. The casing was installed approximately 2 ft above the ground surface to allow for surface completion. The annulus between the hole and the casing is approximately 2 in. A 5-ft well screen was placed across the saturated zone in the borehole. The screen is a noncontaminating, factory-constructed, preslotted, flush-joint screen with a slot width of 0.010 in. A sand filter pack extends from the bottom of the hole to approximately 5 ft above the top of the screen, on top of which a 3- to 5-ft-thick bentonite seal was installed. For the seal, following manufacturer guidelines, bentonite pellets were slowly tremied into the hole and hydrated with potable water. The well annulus was sealed with a grout slurry, composed of Portland cement and water. A 4-ft-square concrete pad, approximately 6 in. thick, was installed at the surface. A water-tight cap was used to protect the PVC riser and to prevent unwanted material from entering the well.

Well development is not part of the 2006–2007 investigation. A groundwater sample was collected from the undeveloped well and submitted for off-site laboratory analyses. Sample management protocols described in section 3.1.2 were followed, and COC forms and sample collection logs for the groundwater sample are presented in Appendix F.

3.1.7 Borehole Abandonment

The shallow subsurface and intermediate borings were abandoned in accordance with the Consent Order, the notice of disapproval (NOD) response (LANL 2005, 089653), and the NMED response approval (NMED 2005, 091672). Borings greater than 20 ft in depth were filled with bentonite grout by filling upward from the bottom via tremie pipe to within 2 ft of the surface, the remainder was grouted to surface grade. After 24 h, the backfilled level was checked for settling, and additional grout added as necessary. Borings less than 20 ft deep were filled with bentonite pellets and then hydrated. The upper 3 ft was either filled to the top with bentonite or native soil.

3.2 Health, Safety, and Security

All 2006–2007 investigation activities were conducted in accordance with a site-specific health and safety plan and an integrated work document, which detailed work steps, potential hazards, hazard controls, and required training to conduct the work.

Both consolidated units are located in a secure area. A project specific security plan was required by the facility operations oversight organization to work in the area. All field team members were trained to and adhered to the security requirements.

3.3 Waste Management and Disposal

The investigation-derived waste (IDW) from the 30s Line and 90s Line investigations included: (1) drill cuttings; (2) contaminated personal protective equipment (PPE); (3) other wastes such as plastic, glass, disposable sampling supplies and solid decontamination wastes that came in contact with contaminants; (4) spent field-screening supplies, (5) petroleum-contaminated soil; and (6) petroleum-contaminated adsorbent materials.

All the wastes generated were characterized, stored, managed, and disposed of per the approved site-specific waste characterization strategy form (WCSF) and in accordance with all applicable SOPs.

The drill cuttings were characterized using analytical results from sampled media. One yd^3 waste containers were individually labeled with a unique identification number and with information regarding waste classification, item(s), associated samples, locations from which waste was generated, and date generated. The waste was contained in a clearly marked and appropriately constructed waste accumulation area. Waste accumulation area postings, regulated storage duration, and inspection requirements were based on the type of IDW and its classification.

The IDW generated during the investigations was characterized as hazardous, nonhazardous, or New Mexico special waste. Hazardous waste was transported and disposed of at an approved off-site hazardous waste disposal facility, and the nonhazardous waste was disposed of at an approved nonhazardous solid waste disposal facility. The WCSF, waste profile forms, chemical waste disposal request forms, and uniform hazardous waste manifests are presented in Appendix K.

4.0 FIELD INVESTIGATION RESULTS

The following section presents the results of field investigation activities performed during 2006–2007 at 30s Line and 90s Line. These activities included the following: surface sampling and surveys, exploratory drilling, subsurface sampling and surveys, exploratory geophysical logging, monitoring well installation, and groundwater and surface water sampling. Additional details regarding the procedures and methods used to carry out these activities were presented in section 3.1 and Appendix C.

4.1 Surface Conditions at 30s and 90s Line

The 30s Line and 90s Line SWMUs and AOCs are mesa top locations within TA-16 (Figure 1.1-1). The mesa is bounded on the north by Cañon de Valle (approximately 1200 ft north) and on the south by Water Canyon (approximately 5500 ft south). The elevation of the mesa ranges from 7700 ft to 7500 ft, and the elevation of the 30s Line and 90s Line area is approximately 7600 ft. The topography in the area is relatively level, with a gentle slope from west to east. Any native soil present on the TA-16 mesa is primarily derived from weathering of the Tshirege Member of the Bandelier Tuff, the El Cajete Pumice (including contributions from phenocrysts and phenocryst fragments, devitrified glasses, and minor lithic fragments) and from windblown sources (LANL 1998, 059891, Appendix B).

The surface vegetation community at TA-16 consists of species typical of the Rocky Mountain montane conifer forest, which contains several distinct habitat types (LANL 1998, 059891, pp. B-41-B-43). The most prevalent habitat type on the mesa top and in the area around the 30s Line and 90s Line is ponderosa pine/gambel oak, whereas the canyon bottoms, such as Cañon de Valle, grade into ponderosa pine/Douglas fir. The dominant trees within the mesa overstory canopy are ponderosa pine and aspen. The mesa-top shrub layer is primarily gambel oak and New Mexico locust, and the dominant forbs and grasses include bluegrass, mountain muhly, blue gramma, pine dropseed, wormwood, false tarragon, tall lupine, and cinquefoil. As the immediate areas in and around the 30s Line and 90s Line did not burn during the 2000 Cerro Grande fire, these habitats are fairly mature and well established. Additional details on the vegetation communities and habitat types at TA-16 are presented in Appendix B of the Phase II RFI report for Consolidated Unit 16-021(c)-99 (LANL 1998, 059891, pp. B-32-B-58).

TA-16 is a secure industrial area; however, neither the 30s Line nor the 90s Line is currently active. At both areas all former buildings and related near-surface structures, such as drainlines and sumps, have been removed by D&D. The debris has been removed. Native soil in the vicinity has been disturbed and much of the area has been excavated, backfilled, and recontoured.

Surface water at the 90s Line Pond is seasonal. Typically following spring snowmelt, the pond will have standing water until late May or early June. Following the summer rainy season the pond will have standing water from late July to October.

4.1.1 Assessment Surveys

Before any activity (nonintrusive or intrusive) was performed at either consolidated unit, an EOD walk-over survey was conducted. A TA-16 representative, with expertise in the identification of high-energy explosives and components, performed two EOD surveys in August 2006 (one before nonintrusive field activities such as geomorphic and geodetic surveys and the second before actual sampling and disturbance of soils). The HE expert did not find chunk HE using visual inspection and did not detect dispersed HE using the Laboratory-developed HE spot test. The results indicated the soil in the 30s Line and 90s Line areas did not exceed 5% explosive content; thus, it was deemed safe for fieldwork to commence. Throughout the duration of the field activities, soil and sediment samples continued to be field screened for HE and at no time did the HE content exceed 5%.

To mark applicable sampling locations in the field, a geodetic survey was conducted in conjunction with a geomorphic assessment of the area. The surveys were conducted on August 15, 16, and 22, 2006. After the drilling and sampling activities were complete, a geodetic survey was conducted to record final sampling locations. The locations were surveyed on November 28, 2006, January 23, 2007, and completed in October 2007 (Appendix D). Figures 4.1-1 and 2.2-1 present all surveyed/sample locations for the 30s Line and 90s Line. Geodetic survey results are presented in Appendix D.

4.1.2 Surface Sampling

Surface sampling was conducted at four locations in the 90s Line drainage near the confluence with Cañon de Valle. Samples were collected at the surface (0.0 to 0.5 ft) and at the soil/tuff interface (typically encountered at a depth of slightly more than 0.5 ft in the drainage channel). The approved investigation work plan (LANL 2005, 089331; NMED 2005, 091672) called for sampling these locations at depths of 2 ft below the soil/tuff interface as well; however, the drainage contains numerous dacite cobbles, and the tuff underlying the drainage is densely welded (LANL 2005, 089331, pp. 14-16), preventing hand augering to the target sample depth. Furthermore, the drainage channel is steeply incised and prevented accessing the sample locations with a drill rig. Boreholes 16-26688 and 16-26684 are located in the same drainage approximately 500 ft and 600 ft upgradient and were both drilled to 13 ft. Sample results from these boreholes are used to document vertical extent of chemical migration in the drainage. Boreholes 16-26688 and 16-26684 are closer to the source than the down drainage locations (16-26735, 16-26734, 16-26736, and 16-26737), which could not be auger drilled. The 90s Line drainage samples were collected on December 7, 2006, and analyzed for VOCs, SVOCs, HE, inorganic chemicals, cyanide, nitrate, and perchlorate. Appendixes D and I discuss field-screening and analytical results, respectively.

Forty-two surface samples were collected from all of the near-surface and intermediate boreholes. These samples were collected from September 6, 2006 to August 10, 2007, and were analyzed for VOCs, SVOCs, HE, inorganic chemicals, cyanide, nitrate, and perchlorate. Some locations were also analyzed for anions alkalinity, chromium(VI), and total dissolved solids. Field screening indicated no HE or VOCs in the surface soils. Appendixes D and I discuss field-screening and analytical results, respectively.

4.2 Subsurface Conditions at the 30s Line and 90s Line

The subsurface conditions and geology of the TA-16 mesa has been studied by the former ER Project and the Laboratory’s Groundwater Protection Program. Multiple intermediate and deep boreholes have been drilled and logged and have provided information relevant to the interpretation of the subsurface stratigraphy in the vicinity of the 30s Line and 90s Line Ponds. These following reports include descriptions of the stratigraphy of the mesa:

- Regional well R-25, located approximately 3000 ft east of the Ponds area (Broxton et al. 2002, 072640, p. 8)
- Regional well R-26, located approximately 1500 ft northwest of the Ponds area (Kleinfelder 2005, 087846, p. 17)
- Intermediate well CdV-R-37-2, located approximately 8000 ft southeast of the Ponds area (LANL 2002, 073707, p. 16)
- Intermediate well CdV-16-1(i), located approximately 3000 ft northeast of the Ponds area (Kleinfelder 2004, 087844, p. 4)

- Intermediate borehole CdV-16-2(i), located approximately 5000 ft east of the Ponds area (Kleinfelder 2004, 087843, p. 3)
- Intermediate borehole CdV-16-3(i), located approximately 4500 ft southeast of the Ponds area (Kleinfelder 2004, 087845, p. 4)

Locations of the boreholes, wells, and stratigraphy beneath the Pajarito Plateau are shown in Figures 4.2-1 and 4.2-2. A brief description of the geology underlying the consolidated units follows, and further details are provided in the approved 30s Line and 90s Line investigation work plan (LANL 2005, 089331, pp. 14-17).

The Pajarito Plateau (on which the Laboratory and TA-16 are situated) is composed of a thick accumulation of Pleistocene age volcanic and volcaniclastic rocks including the Bandelier Tuff. The Bandelier Tuff is a sequence of ash-flow and air-fall deposits that include three members; they are from bottom to top, the Guaje, Otowi, and Tshirege Members. The Tshirege Member stratigraphically underlies TA-16.

The Tshirege Member comprises several units and resulted from successive ash-flow depositions separated by periods of inactivity allowing for the partial cooling of individual units. Properties related to water flow and contaminant migration (e.g., density, porosity, degree of welding, fracture content, and mineralogy) vary vertically and laterally throughout the unit as a result of variations in local emplacement temperature, cooling history, thickness, gas content, and chemical composition. The Tshirege Member of the Bandelier Tuff is 384 ft thick in regional well R-25 (Broxton et al. 2002, 072640, p. 20). Tshirege Member Unit 4 (Qbt 4) is made up of a series of variably welded vitric to devitrified ash-flow tuffs that extend to a depth of 84 ft in regional well R-25. Unit 4 is characterized by discontinuous, crystal-rich, fine- to coarse-grained volcanic surge deposits. The lower, more indurated parts of unit 4 are also fractured. These fractures and surge beds are potential groundwater pathways. Unit 4 makes up the mesa-top unit at TA-16 and outcrops on the slopes extending into the canyons.

Tshirege Member Unit 3 (Qbt 3 and Qbt 3t) is poorly to moderately welded and indurated to slightly indurated. It tends to be a cliff-forming unit of the Pajarito Plateau. Qbt 3t is transitional and is a devitrified ignimbrite that grades from moderately welded at the top to nonwelded at the base. Qbt 3 is a second devitrified ignimbrite that grades from moderately welded at the top to nonwelded at the base. Qbt 3t and the upper Qbt 3 also contain localized thin, discontinuous, crystal-rich, fine- to coarse-grained surge deposits that may represent potential groundwater pathways. Unit 3 (including Qbt 3 and Qbt 3t) is 145-ft thick in well R-25 (Broxton et al. 2002, 072640, p. 22).

Tshirege Member Unit 2 (Qbt 2) is a competent, resistant unit that forms cliffs where it is exposed on the sides of the mesa. It is a moderately welded, well-indurated, devitrified ignimbrite. Welding grades from moderately welded at the top to partially welded at the base. Unit 2 is 103 ft thick in well R-25 (Broxton et al. 2002, 072640, p. 22). Qbt 2 is extensively fractured in many outcrops across the Laboratory as a result of contraction during postdepositional cooling. The cooling fractures are visible on the mesa edges. In general, such fractures are vertical to subvertical and dissipate near the bottom of the unit. The base of unit 2 has a series of thin, discontinuous, crystal-rich, fine- to coarse-grained surge deposits, some with clearly defined bedding structures.

Tshirege Member Unit 1v (Qbt 1v) is a vapor-phase, altered cooling unit that underlies unit 2. This unit forms sloping outcrops that contrast with the near-vertical cliffs of unit 2. Unit 1v is further subdivided into units 1vu and 1vc. Unit 1v is 29.5 ft thick in well R-25 but was not broken into subunits (Broxton et al. 2002, 072640, p. 22). Qbt 1vu is the uppermost portion. It is devitrified and consists of vapor-phase, altered ash-fall and ash-flow tuff. This subunit is unconsolidated at its base and becomes moderately welded near overlying unit 2. Only the most prominent cooling fractures that originate in unit 2 continue into the more welded upper section of unit 1vu, but these end in the less-consolidated lower section of the unit. Qbt 1vc (*c* stands for colonnade) is named for the columnar jointing visible in cliffs forming from this unit. Unit 1vc is poorly welded, devitrified ash-flow tuff at its base and top becoming more welded in its interior.

The basal contact of unit 1vc is characterized by an abrupt change from devitrified (crystallized) matrix to vitric (glassy) matrix in the underlying unit 1g (*g* stands for glassy). Vitric pumices in unit 1g stand out in relief against the weathered outcrops, but 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 or compositional break associated with the vapor-phase notch; the abrupt transition indicates this feature is the base of the devitrification front that occurred in the hot interior of the cooling ash-flow sheets after emplacement. Unit 1g is a massive, poorly consolidated, vitric ash-flow tuff. Few fractures are observed in outcrops of this unit, and the weathered cliff faces have a distinct Swiss-cheese appearance that reflects the variable hardness of the unit. The upper portion of unit 1g is resistant to erosion, which helps to preserve the vapor-phase notch in outcrop. A distinctive pumice-poor surge bed forms the base of unit 1g. The unit is about 20 ft thick in well R-25 (Broxton et al. 2002, 072640, p. 22).

The Tsankawi Pumice Bed is the basal Plinian air-fall deposit of the Tshirege Member of the Bandelier Tuff. It is a thin bed of gravel-sized vitric pumice. The unit thickness in well R-25 is 2.2 ft (Broxton et al. 2002, 072640, p. 22).

The Cerro Toledo interval separates the Tshirege and Otowi Members of the Bandelier Tuff and consists of thin beds of tuffaceous sandstones, paleosols, siltstones, ash, and pumice falls. 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. Numerous large lithics, including dacite lava derived from Sawyer Dome, were present in well R-25. The interval is 125-ft thick in well R-25 (Broxton et al. 2002, 072640, p. 22). This anomalously large thickness indicates that well R-25 was located in a paleodrainage on the surface of the underlying Otowi Member of the Bandelier Tuff.

The Otowi Member tuff is 341.5 ft thick in well R-25 (Broxton et al. 2002, 072640, p. 22). The tuff is massive, poorly consolidated, nonwelded, pumice-rich, and mostly vitric ash flows. The pumices are fully inflated and support tubular structures that have not collapsed as a result of welding. The matrix is an unsorted mix of glass shards, phenocrysts, perlite clasts, and broken pumice fragments.

The Guaje Pumice Bed forms the lowermost 6.7 ft of the Otowi Member in well R-25. It is the basal air-fall deposit of the Otowi Member of the Bandelier Tuff. The occurrence of the Guaje Pumice Bed at well R-25 is thinner than occurrences farther to the east and north, indicating this area was either south of the main dispersal axis for this fall deposit or that this deposit was partly eroded before or during emplacement of the main Otowi ignimbrite. Two cycles of pumice fall were noted in well R-25. The Puye Formation in well R-25 is an alluvial fan deposit made up primarily of coarse clastic rocks derived from the rhyodacite units of the Tschicoma Formation that crop out in the Jemez Mountains west of the Pajarito Fault. Because of the proximity of these source rocks, these fanglomerate deposits consist of poorly consolidated and poorly sorted boulders, cobble, gravels, and sands. Boulders up to 2 ft in diameter are present in well R-25.

The Puye Formation is more than 1090 ft thick in well R-25, extending from a depth of 852 ft to below the total depth of 1942 ft (Broxton et al. 2002, 072640, p. 22). It is overlain by a 1.5-ft-thick late-Miocene paleosol deposit characterized by brown, massive, generally fine-grained sediment with highly scattered pebbles. Two subunits of the Puye Formation are recognized in well R-25 and are classified based on the provenance of their dominant clasts: (1) the upper Pajarito Mountain unit at depths from 852 to 1657 ft and (2) the Rendija Canyon unit at depths from 1657 to 1942 ft. The upper Pajarito Mountain unit is the eastern part of a fan that was contemporaneous with eruption of the upper dacite of Pajarito Mountain. The Rendija Canyon unit represents the southern part of a fan that was contemporaneous with eruption of the rhyodacite of Rendija Canyon. Lithification at both units is poor and as such is likely to sustain open fractures.

Lava flows of the Tschicoma Formation occur in well CdV-R-37-2 (LANL 2002, 073707, p. 23), to the southeast of well R-25 but were not found in well R-25. In addition, they were intercepted in the CdV-16-3(i) borehole located southeast of the ponds area (Kleinfelder 2004, 087845, p. 12).

Thus, the transition between subsurface dacite and the Puye Formation probably occurs to the east of the TA-16 ponds. The dacite lavas are massive, apparently homogeneous, locally rubbly intermediate lavas. Minor siltstones are present in the upper 142 ft at the CdV-R-37-2 borehole. The Tschicoma dacite lavas extend from a depth of 1072 ft to total depth (1664 ft) in borehole CdV-R-37-2 and from 900 ft to a total depth of approximately 1400 ft in borehole CdV-16-3(i).

Perched Intermediate Waters

Perched water occurs in the Bandelier Tuff and in basalts of the Pajarito Plateau (LANL 2000, 066802, p. 2-32). Perched water frequently forms at horizons where medium properties change dramatically, such as at paleosol horizons, surge beds, or zones containing clays or caliche. Perched waters have been observed in mesa top boreholes at TA-16 (LANL 1996, 055077, pp. 11-12; LANL 1998, 059891, section 4; Broxton et al. 2002, 072640, pp. 44-47).

Springs and seeps in the canyon bottoms of TA-16 represent discharge points of shallow (less than 200 ft depth) perched water in the vadose zone. The Phase II RFI report for TA-16-260 (LANL 1998, 059891, section 4) and the Phase III RFI report (LANL 2003, 077965, section 4) provide details on these springs, seeps, and the perched zones. The investigations for the TA-16-260 outfall have shown that (1) connectivity between the mesa top and springs is rapid (less than 6 months), based on a tracer study; (2) the springs are manifestations of zones of saturated ribbons in the vadose zone (most boreholes drilled on the mesa top have not intersected perched waters); (3) the perched zones appear to be concentrated within the transition zone between Tshirege units 3 and 4, which is characterized by several localized basal surge units; and (4) there are multiple recharge zones for these shallow perched zones, including outfalls from buildings used for processing, mesa-top ponding areas (such as the 90s Line Pond), and diffuse recharge from east of the Pajarito Fault Zone (LANL 2003, 077965, section 4).

Two mesa-top boreholes (16-02666 and 16-02665) drilled during previous investigations intersected water but dried up soon after drilling and only occasionally rewet during high-recharge time periods (LANL 1998, 059891, p. 4-6). A third borehole (16-02669) drilled during this investigation intersected water at a depth of approximately 145 ft bgs (LANL 1998, 059891, p. 4-6). Analytical results from one of these wells (monitoring well 16-02669 located adjacent to the 90s Line Pond) indicated that HE has migrated vertically to at least the first perched groundwater interval at approximately 120 ft bgs (LANL 2003, 077965, p. 4-58). Results for the well installed during this investigation are discussed below. Water identified as perennial perched intermediate waters has been found in wells SHB-3, R-25, R-26, borehole CdV-16-1(i), and well CdV-16-2(i)r (Figures 4.2-1). Well SHB-3 had a static water level of 664 ft in 1992, which is consistent with its containing a perennial perched zone. Perched water was encountered in well R-25 at a depth of 747 ft within the Otowi Member of the Bandelier Tuff and extending intermittently to a depth of 1132 ft within the Puye Formation (Broxton et al. 2002, 072640, p. ix). Hydraulic head measurements in this zone decrease with depth, indicating that there is a downward vertical gradient and that this well is located in a recharge area. Well R-26 encountered what is probably a perched zone at 604 ft (Kleinfelder 2005, 087846, p. 9). Well CdV-16-1(i) encountered water at a depth of 563 ft (Kleinfelder 2004, 087844, p. 4), which is roughly consistent with the depth to the perched zone in well R-25. Well CdV-16-2(i)r intersected water at depth of 836 ft.

Borehole video logs and drilling observations for boreholes CdV-R-15-3, CdV-R-37-2, and CdV-16-1(i) record small quantities of what may be perched water (Kopp et al. 2002, 073179, p. 27; LANL 2002, 073707, p. 27; Kleinfelder 2004, 087843, p. 10). However, the screens installed to capture water from these zones have never produced enough for sampling. Small, ephemeral perched water zones apparently existed in these boreholes, but they were not of the scale of the perched zones in well R-25. Well CdV-16-2(i)r has produced sufficient water for sampling and appears to intersect a saturated zone several feet thick; however, test data indicate the zone is extremely limited in aerial extent (Kleinfelder 2004, 087843).

The groundwater from the perched zone in well R-25 contains concentrations of RDX (Broxton et al. 2002, 072640, p. 59) greater than the EPA lifetime health advisory (HA) limit (maximum RDX concentration of 84 µg/L compared with the current EPA lifetime HA limit of 2 µg/L) (EPA 2004, 085204, p. 6). Data from recently drilled boreholes CdV-16-1(i) and CdV-16-2(i)r also have levels of RDX greater than the EPA HA limit (LANL 2007, 098734; LANL 2007, 095787), although the levels are lower than those observed in well R-25 (Broxton et al. 2002, p. 58, 072640, p. 59).

Regional Aquifer

The regional aquifer of the Pajarito Plateau is the only aquifer capable of supporting a large-scale municipal water supply (Purtymun 1984, 006513, p. 1). The regional aquifer extends throughout the Española Basin (an area of roughly 6000 km^2) and reaches its maximum thickness beneath the Pajarito Plateau (Cordell 1979, 076049). The regional aquifer is located primarily in the Santa Fe Group and the Puye Formation.

The depths to the regional aquifer range between about 1500 ft (along the western edge of the plateau) to about 600 ft (to the east). The depths to the regional aquifer at TA-16 are 1490.5 ft (at well R-26 west of the TA-16 ponds) (Kleinfelder 2005, 087846, p. 22), 1245 ft (at well CdV-R-15-3 east of Cañon de Valle), 1197 ft (at well CdV-R-37-2 southeast of TA-16), and 1286 ft (at well R-25 northeast of the TA-16 ponds) (LANL 2003, 077965, p. B-20). The regional aquifer may have been penetrated at a depth of 1350 ft in the CdV-16-3(i) borehole (Kleinfelder 2004, 087845). The nearest production well to TA-16 is PM-2 in Pajarito Canyon 4 to 5 mi east of the operational areas at TA-16. Figure 4.2-3 depicts water-table elevations in the regional aquifer across the Pajarito Plateau.

The regional aquifer at well R-25 also exhibits a downward head gradient, indicating that this area is a zone of recharge (Broxton et al. 2002, 072640, p. 47). Lateral gradients in the regional aquifer are typically on the order of 0.02 to 0.03. Estimates of groundwater flow and contaminant transport have been evaluated using the existing aquifer model (Nylander 2003, 076059.1) well as using site-specific modeling in support of the deep groundwater corrective measure evaluation for Consolidated Unit 16-021(c)-99 and the evaluation of TA-16 monitoring wells (LANL 2007, 098734; LANL 2007, 095787) These evaluations consider the three-dimensionality of the groundwater flow paths, the spatial distribution of recharge along the canyons, media heterogeneity, and the time variation of pumping in water-supply wells.

Vadose Zone

The region beneath the ground surface and above the regional aquifer is called the vadose (unsaturated) zone. This discussion focuses on the vadose zone beneath the TA-16 mesa top. The principal source of moisture in the vadose zone is either rain or snowmelt. Infiltration occurs either on mesa tops or canyon bottoms. Subsurface movement of moisture is predominantly vertical and is influenced by the properties and conditions of the vadose zone. Lateral flow can also occur when there are significant contrasts in hydrologic properties between adjacent units. Surge beds may be a particularly favorable zone of lateral mobility because of their high porosity; however, the bed thickness and lateral extent can be very discontinuous.

The geologic properties of the Bandelier Tuff that most influence fluid flow in the vadose zone are the degree of welding and the presence of fractures or deformation bands (LANL 2007, 095787, p. 35-38). There are significant heterogeneities in these properties within the TA-16 vadose zone. Welded tuffs tend to have less matrix porosity and more fractures than nonwelded tuffs. Fractures in welded tuffs may include relatively closely spaced cooling joints as well as tectonic fractures. Nonwelded tuffs also have fractures but generally fewer than welded tuffs. Saturated hydraulic conductivities in the Bandelier Tuff beneath the TA-16 mesa top range over 5 orders of magnitude between subunits in units 4 and 3t (LANL 2003, 077965, p. 4-58). In boreholes drilled at TA-16, saturated hydraulic conductivity ranges from 3.8×10^{-3}cm/s in a surge unit to 9.8×10^{-9} cm/s in a densely welded subunit.

Several competing effects determine moisture content, degree of saturation, and resultant likelihood of flow and contaminant transport. Although water moves slowly through unsaturated tuff matrix, it can move relatively rapidly through fractures and surge beds if saturated conditions exist (Hollis et al. 1997, 063131). Because of the higher precipitation levels at TA-16, volumetric moisture levels at TA-16 tend to be higher than at TAs east of TA-16. Isolated intermittent saturated zones have been found in boreholes at TA-16 near the 90s Line Pond and near the head of Martin Spring Canyon (LANL 2003, 077965, p. 4-55). Such zones are the basis for the saturated ribbons on the conceptual model diagram (Figure 4.2-4).

4.2.1 Exploratory Characterization Drilling

The 2006–2007 investigation at the 30s Line and 90s Line was implemented in two stages. The majority of the work was completed between September 6, 2006 and January 26, 2007. Conditions at the site (water in the 90s Line Pond) prohibited the completion of the fieldwork at this time. The team remobilized when the 90s Line Pond was dry to drill at locations within and adjacent to the pond. This second stage of work was conducted from July 19, 2007, to August 10, 2007. Before exploratory drilling was conducted at the 30s Line and 90s Line, the above- and belowground structures and utilities were located; these structures are described in the TA-16 HIR (LANL 2005, 089331, pp. B-3, B-8, and B-32) and shown in Figure 1.1-2.

Eighty-one boreholes were drilled during the first part of the investigation. Three intermediate boreholes (locations 16-26731, 16-26732, and 16-26733) were drilled to approximate depths of 150 ft, and 78 boreholes were drilled to depths ranging from 10 ft to 50 ft bgs (Table 4.2-1). Nine boreholes were drilled during the second stage of the investigation. Three intermediate boreholes (locations 16-600938, 16-26643, and 16-26644) were drilled to approximate depths of 150 ft bgs, and six boreholes (locations 16-26647, 16-26648, 16-26649, 16-26692, 16-600933, and 16-26673) were drilled to depths ranging from 12 ft to 50 ft bgs. Table 4.2-1 presents the borehole locations and total depth for all boreholes drilled at Consolidated Units 16-007(a)-99 and 16-008(e)-99 for the 2006–2007 investigations. Figure 4.1-1 shows the locations of the boreholes. The shallow boreholes were designed to define lateral and vertical extent of contamination from the 30s Line and 90s Line, and the associated former structures such as sumps, buildings, and drainlines. The intermediate boreholes were designed to define the vertical extent of contamination in the vadose zone associated with the 30s Line and 90s Line.

Detailed lithologic logs were completed for each boring, including information such as percent recovery; lithology, lithologic unit thickness, color, relative moisture content, grain size and distribution; and any other field observations. The borehole logs are presented in Appendix D.

Borehole location 16-26642 (and all the intermediate boreholes drilled in the 30s Line and 90s Line Ponds) is located at a surface elevation of approximately 7600 ft. The soil/tuff interface was encountered at approximately 4 ft; the upper tuff unit is Qbt 4. The thickness of Qbt 4 is approximately 38 ft and is underlain by Qbt 3t to a bottom depth of 150 ft. Fractures were encountered at various depths; the fractures contained clay coatings and had variable (dry to moist) moisture content. Further details on the boreholes are provided in the sections below.

4.2.2 Soil and Rock Characterization Sampling

Soil and rock characterization samples were collected from core recovered from all ninety-nine borehole locations at Consolidated Units 16-007(a)-99 and 16-008(e)-99 to determine the lateral and vertical extent of contamination. A total of 252 samples were collected from soil and tuff media during the investigation.

A summary of all investigation samples collected in solid media by borehole location and corresponding sampled depths, media, and the analyses requested is presented in section 6 and Appendix I. A summary of all QA/QC samples collected in solid media by borehole location and corresponding depths (if applicable), sample type, media, and the analyses requested is also presented in Appendix I. The analytical data program QA and QC review of the rejected data is presented in Appendix G. All analytical data are presented with field COC forms in Appendix F. The sample locations are shown in Figure 4.1-1. Sampling strategy and selection of laboratory analytical procedures are discussed in section 3.1.3.2. Field screening results are presented in Appendix D.

All soil and tuff samples were submitted to the SMO for processing and transport to off-site contract laboratories that are on the EP Directorate-approved list of suppliers. The soil and tuff samples were analyzed for VOCs, SVOCs, HE, inorganic chemicals, cyanide, nitrate, and perchlorate. Samples collected from the locations at, and downgradient from, drainages associated with former building 16-93 were also analyzed for hexavalent chromium [chromium(VI)], based on previous results noted during the 1996 VCA investigation (LANL 1997, 087847, pp. 89–91). Samples collected from all locations associated with this investigation were analyzed for target analyte list (TAL) metals including chromium, but not chromium(VI). The samples located at the former drum storage area were analyzed for total petroleum hydrocarbons (diesel).

4.2.3 Environmental Field Screening

All samples were qualitatively screened for health and safety purposes and to select sample locations for fixed-laboratory analysis. Field-screening methods included (1) screening for gross radioactivity (beta-gamma) using a sodium iodide detector; (2) HE spot testing; (3) immunoassay testing for RDX; (4) total organic vapor headspace screening using a PID; and (5) total metals screening, primarily for barium, using an XRF analyzer. Section 3.1.4 describes these methods.

D-TECH immunoassay test kits from Strategic Diagnostics, Inc., were used to field screen both soil and tuff samples for RDX and TNT. This semiquantitative field-screening method was used to guide drilling and sampling investigation activities and enable the volume of contaminated soil/tuff to be estimated.

Organic vapors in soil and tuff samples were screened by placing a sample in a plastic 125-mL jar or resealable bag; these containers were partially filled and allowed to stand for a minimum of 5 min to allow for vapor equilibration. Vapors in the container headspace were measured using a PID with the probe inserted through a small opening. A QUANTEX XRF instrument was used to field screen for barium, chromium, nickel, copper, and lead in the lowermost depth interval of each boring.

Field screening was used to guide the selection of samples submitted to off-site laboratories for analysis and to confirm the total depth of drilling at all locations. Sample locations 16-26719, 16-26721, 16-26723, 16-26730, 16-26732, 16-26652, 16-26690, 16-26692, 16-26693, 16-26706, 16-26710, 16-26840, 16-26662, 16-26680, and 16-26680 contained RDX at concentrations exceeding 1 ppm (based on D-TECH analysis). Screening samples from within the boreholes that contained the highest RDX concentrations were collected and submitted for off-site analyses. Drilling of these boreholes continued until RDX was not detected with the D-TECH screening.

Borehole location 16-26692 contained barium at concentrations that ranged from 1536 ppm (at 10-ft depth) and 5000 ppm (at 35-ft depth) based on XRF screening. This borehole location was drilled to a bottom depth of 44.5 ft where barium was not detected above background based on XRF screening.

Appendix D presents all environmental field-screening results.

4.2.4 Exploratory Borehole Geophysical Logging

The intermediate boreholes (locations 16-26731, 16-26732, 16-26733, 16-600938, 16-26643, and 16-26644) were moisture-logged with a neutron probe, after drilling to TD. Logging was conducted at 1-ft intervals to TD in accordance with SOP-7.05, Subsurface Moisture Measurements Using a Neutron Probe. Appendix D presents the neutron-probe results.

4.2.5 Exploratory Borehole Abandonment

All boreholes drilled in the 2006–2007 investigation have been plugged and abandoned. The boreholes were abandoned by emplacement of a bentonite and cement mixture (grout) from the bottom of the boring to the surface using a tremie pipe. All boreholes less than 20 ft deep were abandoned with bentonite chips.

4.3 Groundwater Conditions at 30s and 90s Line Ponds

Saturated conditions were only encountered at one borehole location at the 90s Line: location 16-26644. All boreholes drilled at the 30s Line were dry.

4.3.1 Perched-Intermediate Water Near 90s Line Pond

During drilling of borehole location 16-26644, a saturated interval was identified from 140 to 145 ft bgs. This zone was a densely welded tuff with clay-filled fractures. The target depth of this borehole was 150 ft bgs. After the drill string was pulled from the bottom of the hole, a standing water level was measured at 138 ft bgs. Water samples were collected using a bailer attached to a wire line. A total of 10 L of water was collected for off-site analyses. The water was extremely turbid, probably from the clay filled fractures. The closest monitoring well, location 16-02669, remained dry. Location 16-02669 is 169 ft deep and is sited less than 100 ft northeast of borehole location 16-26644.

4.3.2 Monitoring Well Installation

A single completion monitoring well was installed at location 16-26644. The design was approved by NMED (Young 2007, 098733). The well is a 2-in.-diameter PVC pipe with a 15 ft screened interval from 147 to 132 ft bgs. The well completion diagram is presented in Appendix D. The most recent water-level measurement (October 10, 2007) indicated the water level remains at ~135 ft bgs.

4.4 Surface Water Conditions at the 90s Line Pond

Fall rainstorms in 2006 and snow pack in 2007 were greater than in the previous few years, and standing water persisted in the 90s Line Pond until mid-July 2007. Consecutive rainstorms in August 2007 quickly refilled the dry pond.

4.4.1 Surface-Water Sampling at the 90s Line Pond

Surface-water samples were collected quarterly from the 90s Line Pond as part of the corrective measures study (CMS) for Consolidated Unit 16-021(c)-99. Additionally, a single grab sample of surface water was collected in August 2007 during the drilling of borehole location 16-26644.

4.5 Summary of Current Site Conditions

Surface and near-surface conditions at 30s and 90s Lines include soil/fill overburden and seasonal ponded water. Both lines are capped by a mixture of native soil and fill overburden, ranging in thickness from 2 to 18 ft bgs, thicker overburden corresponding to areas excavated and backfilled (e.g., base of former 30s Line Pond). The soil/fill is underlain by Qbt 4. As a result of previously conducted D&D activities at both sites, much of the surface and near surface is disturbed, recontoured, and reseeded, resulting in relatively flat surface contours across each site hosting grassy fields bounded by the surrounding ponderosa pine woodland. Another result of facility operations and D&D activities is that undisturbed native soil of the TA-16 mesa is rare: most of the surface and near-surface samples collected were a combination of native soil and introduced soil, fill, or crushed tuff.

During wet seasons, standing water collects and temporarily resides (primarily in the 90s Line Pond) on the surface at the 90s Line; the 30s Line does not appear to retain standing surface water. At 90s Line, water runoff remains at the surface for a few days and often, in the case of 90s Line Pond, for months on up to a year. Although the former drainages remain intact at both sites, the very low gradient (probably from regrading) of 90s Line results in little to no drainage of stormwater off-site; therefore, much of the seasonal precipitation can leave the boundaries of the site only via slow infiltration into the subsurface and/or evaporation. Only the former drainages associated with former buildings 16-92 and 16-93 appear to have sufficient gradient to allow noticeable runoff to the drainage northeast of 90s Line into Cañon de Valle.

Subsurface conditions at both 30s Line and 90s Line include an expansive vadose zone (greater than 700 ft thick), isolated perched saturated zones within the vadose zone, and the regional aquifer. Although the 2006–2007 investigation only characterized the upper section of the vadose zone (to 150 ft bgs) beneath 30s Line and 90s Line, investigation results confirmed the presence of multiple fractures, surge beds, and other heterogeneities (including variations in degree of welding) within the underlying tuff beneath both 30s Line and 90s Line. Fractures were encountered at multiple depths, were often clay-filled, and had variable (dry to moist) moisture content. Surge beds or unconsolidated sediment were encountered in two of the intermediate borings: at 69 to 71 ft bgs and 147 to 149 ft bgs at location 16-26731 (30s Line) and at 28 to 30 ft bgs at location 16-26643 (90s Line). Isolated sections within individual tuff units (e.g., Qbt 4 and Qbt 3) varied greatly in degree of welding, often causing difficult drilling conditions.

Results of the 2006–2007 investigation also confirmed that the subsurface at the 30s Line and 90s Line, though predominantly unsaturated, does also contain an isolated pocket of saturation. Water was encountered at 90s Line in location 16-26644 at approximately 135 to 145 ft bgs. The saturated zone occurred in densely welded, fractured (clay-filled) Qbt 3 tuff. These observations are consistent with the current TA-16 conceptual site model where saturated zones exist in the vadose zone and are associated with surge beds or fractures (Figure 4.2-4) (LANL 2007, 095787, section 5). The recharge source for this zone is unknown but may include, in part, water infiltrating from 90s Line Pond.

4.5.1 Contaminant Fate and Transport

Site conditions at 30s Line and 90s Line as observed during the 2006–2007 Investigation confirm the results of previous investigations conducted on the TA-16 mesa top and are consistent with the current understanding of the TA-16 conceptual site model (Figure 4.2-4). The TA-16 conceptual site model indicates that infiltration of water into the subsurface and the subsequent transport of water, natural solutes, and contaminants within the subsurface via one or more of the following; faults, fractures, deformation bands, and/or surge beds, is the primary mechanism by which contamination travels from TA-16 source areas through the vadose zone and potentially reaches the waters of the regional aquifer.

Based on analytical results obtained from previous investigations the primary contaminants potentially released within 30s Line include: HE (principally HMX, RDX, TNT) and HE byproducts (e.g., DNT, DNB, TNB); VOCs; SVOCs, including PAHs (LANL 2005, 089331, Appendix B); and inorganic chemicals. Contaminants potentially released at 90s Line include uranium, HE (principally TNT and RDX), HE byproducts, VOCs, SVOCs, cyanide, and inorganic chemicals associated with electroplating activities (LANL 2005, 089331, Appendix B). Barium, chromium, copper, nickel, and uranium are the inorganic chemical contaminants of greatest concern because these metals are known to have been associated with 90s Line HE-processing and plating operations.

The relevant release and transport processes associated with these contaminants are a function of chemical-specific properties that include the relationship between the physical form of the constituents and the nature of the constituent transport processes in the environment. Specific properties include the degree of saturation and the potential for ion exchange (barium and other metals) or sorption and the potential for natural bioremediation. The transport of VOCs occurs primarily in the vapor phase by diffusion or advection in subsurface air. Relatively water-soluble low-vapor-pressure constituents, such as HE and metals, are especially susceptible to release and transport by infiltration of water through the vadose zone or by alluvial water pathways (Reid et al. 2005, 093660, pp. 645–657).

The primary potential release and transport mechanisms for contaminants at 30s and 90s Lines are direct discharge, precipitation, sorption, mechanical transport, dissolution and advective transport in water, volatilization, diffusion, and dispersion. Less significant transport mechanisms include wind entrainment and dispersal of surface soil and uptake of contaminants from soil and water by biota.

Studies of contaminant distributions at such TA-16 sites as TA-16-260 (LANL 1998, 059891), the 90s Line (LANL 1997, 087847), and V-Site (LANL 1999, 063973) indicate that, after the initial deposition of contaminants at outfall discharge points or sump and drainline leak points, high levels of contaminants tend to remain concentrated in the vicinity of these deposition points. The specific gravity of RDX and HMX tends to cause particulates of these compounds discharged from sumps and drainlines to be deposited at water settling areas (e.g., outfall discharge areas or points of leakage).

Many inorganic chemicals, such as barium, have a high affinity for adsorption on clays, oxides, and hydrous oxides, with literature values for sorption coefficients in soil ranging from 66 to 2800 mL/g (Myers 2003, 076188, p. 3). These inorganic compounds tend to bind to fine particulates or precipitates as new phases and are transported by physical processes such as sediment transport via stormwater runoff and redeposition. In Cañon de Valle and presumably other canyons, the fine particle-sized fraction appears to contain the highest inventories of highly adsorbing contaminants such as barium (LANL 2003, 077965, p. 5-16; Reid et al. 2005, 093660, pp. 645-657).

Dissolution and advective transport in water is a particularly important mechanism for HE compounds. Many HE constituents, such as RDX and HMX, do not tend to adsorb on particulates in the environment and tend to be transported in the dissolved phase (LANL 2003, 077965, p. 5-17). Rain, vadose-zone water, or melting snow becomes primary transport mechanisms for these types of contaminants through surface water, the vadose zone, or alluvial systems. At TA-16, transport through the vadose zone is known to be primarily along fast pathways such as fracture zones and surge beds (LANL 1998, 059891, p. 4-96; LANL 2003, 077965, section 5) that are intermittently saturated.

Gas or vapor-phase contaminants such as VOCs are likely to volatilize to the atmosphere from near-surface soils and sediments and/or migrate by diffusion through air-filled pores in the vadose zone. Migration of vapor-phase contaminants from tuff into ambient air may occur by diffusion or advection driven by barometric pressure changes.

Previous investigations indicate that mesa vadose zone contamination is concentrated beneath source-area SWMUs, such as 30s Line and 90s Line but also confirm the importance of hydrologic heterogeneity in the mesa vadose zone groundwater flow regime and its role in transporting contaminants through the vadose zone and into deep groundwater (LANL 2007, 095787). Analytical results obtained from samples collected during the 2006–2007 investigation, summarized in the following section, will help to confirm or determine whether

- the nature of contamination and the primary COPCs are consistent with the results obtained from previous investigations,
- contamination remains concentrated in the vadose zone beneath 30s and 90s Line Pond (as predicted by the TA-16 site conceptual model) or whether a significant lateral component of contaminant transport exists at these sites, and
- contamination levels are of sufficient levels in the solid media and/or water to pose recommendations of additional removal and/or clean-up.

5.0 REGULATORY CRITERIA

This section describes the criteria used for screening COPCs and for evaluating potential risk to ecological and human receptors. Regulatory criteria identified by medium in the Consent Order include cleanup standards, risk-based screening levels, and risk-based cleanup goals.

The objective of the current investigation is the characterization of the nature and extent of contamination at 30s Line and 90s Line. For each consolidated unit, the regulatory criteria and the data gathered during the investigation are used to identify COPCs (Appendix I), their distribution in the environment (sections 6.1 and 6.2 and Appendix I), and the resulting potential human and ecological risks (sections 7.2 and 7.4 and Appendix J). The results of the data assessment as well as the screening-level risk evaluations will determine whether additional corrective actions are required at the sites.

5.1 Current and Future Land Use

The current land use within and surrounding the 30s Line and 90s Line consolidated units is industrial. NMED has approved industrial land use at TA-16 for the 260 outfall CME (NMED 2000, 070649). TA-16 is a Laboratory high-security site maintained by fencing and manned access control points. It is expected that the land use will remain industrial for the reasonably foreseeable future. However, as both sites have been abandoned since the mid-1990s and all former structures removed, their location may be favorable to potential development in the future, supporting additional Laboratory industrial activities. Therefore, potential construction activity is assessed for both consolidated units. The residential scenario is also evaluated for both consolidated units, as required by the Consent Order, for comparison purposes.

5.2 Screening Levels

Human health screening assessments were conducted for both 30s Line and 90s Line using NMED soil screening levels (SSLs) for chemicals (NMED 2006, 092513). For chemicals for which NMED SSLs were not available, EPA Region 6 (EPA 2007, 095866) or EPA Region 9 (http://www.epa.gov/region09/waste/sfund/prg/index.html) screening levels were used. An ecological screening assessment was performed using the Laboratory's ecological screening levels (ESLs) (LANL 2005, 090032). Surface water and groundwater were compared to available water-quality standards including New Mexico Water Quality Control Commission (NMWQCC) surface water standards (20.6.4 New Mexico Administrative Code [NMAC]), NMWQCC groundwater standards (20.6.2 NMAC), the EPA maximum contaminant levels (MCLs) (EPA 2003, 076871), and Region 6 tap water screening levels (EPA 2003, 076871; EPA 2007, 095866).

5.2.1 Screening Levels for Soil and Tuff

Human health risk screening assessments (Appendix J) were performed according to NMED (NMED 2006, 092513) and EPA Region 6 guidance (EPA 2007, 095866). SSLs are used to evaluate the COPCs in soil, sediment, and tuff for the industrial, construction worker, and residential scenarios. If an NMED SSL is not available for a chemical, the EPA Region 6 or Region 9 human screening level is used (adjusted to a risk level of 10^{-5} for carcinogens) (EPA 2007, 095866). SSLs used for noncarcinogenic and carcinogenic COPCs at the 30s Line and 90s Line are presented in Appendix J (Tables J-4.2-1 to J-4.2-14).

The Laboratory's ecological risk screening methodology (LANL 2004, 087630) and ESLs from the ECORISK Database, Version 2.2 (LANL 2005, 090032) were used to evaluate potential ecological risk. The ESLs used are presented in Appendix J (Table J-4.1-3).

5.2.2 Screening Levels for Surface Water

The Laboratory has not established BVs for chemicals in surface water; therefore, all detected chemicals in the surface water collected from 90s Line Pond are screened against available state surface water quality standards. The NMWQCC standards for interstate and intrastate surface waters are the primary standards for comparing all constituents detected in the 90s Line surface water (20.6.4 NMAC). As multiple NMWQCC standards for surface water are available based on the criteria for surface water usage, all COPCs identified in surface water at 90s Line were compared to the following NMWQCC surface water standards, as available: domestic water supply, irrigation, livestock, wildlife habitat, aquatic life (acute), and human health (Appendix J).

5.2.3 Screening Levels for Groundwater

All detected chemicals in the perched groundwater samples collected at 90s Line are screened against state and federal promulgated water standards (Appendix J). The standards used for screening groundwater include

- NMWQCC numeric standards for groundwater (20.6.2 NMAC),
- EPA MCLs (EPA 2003, 076871), and
- EPA Region 6 tap water screening levels (EPA 2007, 095866).

5.3 Cleanup Goals

The cleanup goals specified in Section VIII of the Consent Order are a target risk of 10^{-5} for carcinogens or a hazard index of 1 for noncarcinogens. The SSLs described in section 5.2 are based on these cleanup goals. As specified in Section VIII.B.1 of the Consent Order, the screening levels will be used as cleanup levels unless determined to be impracticable or unless SSLs do not exist for current and reasonably foreseeable future land use.

6.0 SITE CONTAMINATION

All site data representative of current conditions were reviewed to identify COPCs for Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line) and to establish the spatial distributions of site COPCs. In addition, the site data set was evaluated to determine if the nature and extent of contamination were defined.

The data included in this review were derived from multiple investigations, including a 1995 and 2004 RFI conducted at the 30s Line (LANL 2005, 089331, Appendix B), a 1996 VCA at the 90s Line (LANL 1997, 087847), and the 2006–2007 investigation at the 30s and 90s Lines, as prescribed in the approved investigation work plan (LANL 2005, 089331; LANL 2005, 089653; NMED 2005, 091672). Only data of acceptable quality from off-site analytical laboratories and accompanied by all supporting documentation were subjected to the review and used for decision making. A comprehensive discussion of the chemical analyses performed, the quality of the analytical results, and the data meeting the requirements for inclusion in the data review, are presented in Appendix G. Screening data were not included but were used to guide sample collection decisions and other elements of the investigations.

For solid media, COPC identification differs depending on whether an analyte is an inorganic chemical, an organic chemical, or a radionuclide. In general, inorganic chemicals are identified as COPCs if they are present at concentrations above media-specific BVs in any of the site samples; organic chemicals are identified as COPCs if they are detected in any of the site samples. Radionuclides are divided into two groups: fallout and naturally occurring radionuclides. Fallout values (FVs) have been established for fallout radionuclides and are applicable to the top 0 to 6 in. of soil. If a fallout radionuclide is present at activities above the FV in surface-soil samples or if it is detected in samples collected from deeper intervals, it is identified as a COPC. If a naturally occurring radionuclide is present in site samples at activities above the media-specific BV, it is also identified as a COPC.

For surface and groundwater, any detected chemical or radionuclide is identified as a COPC.

Appendix I discusses the method for identifying COPCs, including additional criteria, and a result-by-result application of the method to the site data set.

Only the inorganic chemicals, organic chemicals, and radionuclides identified as COPCs were evaluated further to establish the nature and extent of contamination distribution within Consolidated Units 16-007(a)-99 and 16-008(a)-99. Several factors, such as decreasing lateral and vertical concentration trends and presence of contaminants only at “trace” concentration levels, were considered in determining if the nature and extent of a COPC is defined, based on the existing data. The 150 ft boreholes are used to define the vertical nature and extent of contamination of large zones at each consolidated unit, because contaminants released at the surface would diffuse over a wide area by that depth. A detailed discussion of these factors and the analysis of the nature and extent of site releases for all site COPCs is presented in Appendix I.

The following sections summarize the COPCs identified at Consolidated Units 16-007(a)-99 and 16-008(a)-99 and present an overview of the nature and extent of contamination. The discussions presented in these sections are based on the analyses presented in Appendix I. The sampling locations for Consolidated Units 16-007(a)-99 and 16-008(a)-99 are shown in Figure 4.1-1, and the distributions of contaminants at these locations are presented in Plates 1 through 5.

6.1 Site Contamination at Consolidated Unit 16-007(a)-99, 30s Line

The subsections below summarize the results of laboratory analyses for soil, fill, and tuff at Consolidated Unit 16-007(a)-99.

6.1.1 Soil and Rock Analytical Results

The data set reviewed for Consolidated Unit 16-007(a)-99 includes 96 soil and tuff samples from the 1995 investigation, the 2004 RFI, and the 2006–2007 investigation. Samples were typically analyzed for TAL metals, uranium, total cyanide, anions, nitrate (in 2006–2007), perchlorate, HE, VOCs, and SVOCs. Gamma spectroscopy was performed on some samples. Table 6.1-1 presents a summary of the soil, fill, and tuff samples collected and the associated analyses requested for Consolidated Unit 16-007(a)-99.

Twenty QC samples were collected in association with the samples included in the data review. QC samples included 3 field duplicates, 4 rinsate samples, and 13 trip blanks. For the 2006–2007 investigation, QC samples were collected at the frequency specified in the approved investigation work plan (LANL 2005, 089331). The QC data are not included in the data set reviewed for COPC identification; QC data are discussed in Appendix G.

Nineteen inorganic chemicals and 31 organic chemical COPCs were identified at Consolidated Unit 16-007(a)-99; no radionuclide COPCs were identified. The COPCs are summarized in Table 6.1-2.

6.1.1.1 Inorganic Chemicals

The inorganic COPCs identified in soil, fill, and tuff at the 30s Line include aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, total cyanide, fluoride, iron, lead, magnesium, manganese, nickel, nitrate, perchlorate, selenium, and vanadium.

6.1.1.2 Organic Chemicals

The organic chemical COPCs identified in soil, fill, and tuff at 30s Line include predominantly HE, organic solvents, phthalates, and PAHs. The HE detected at 30s Line include amino-2,6-dinitrotoluene[4-]; amino-4,6-dinitrotoluene[2-]; dinitrotoluene[2,4-]; HMX; RDX; trinitrobenzene[1,3,5-]; and TNT. Organic solvents detected at 30s Line include acetone; chloroform; methylene chloride; tetrachloroethene;

toluene; and xylene[1,3-]+xylene[1,4-]. Phthalates include bis(2-ethylhexyl)phthalate; di-n-butylphthalate; and di-n-octylphthalate. PAHs include acenaphthene; acenaphthylene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(g,h,i)perylene; benzo(k)fluoranthene; chrysene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; phenanthrene; and pyrene. Other detected organic chemicals include benzoic acid; dichlorobenzene[1,4-]; and trichlorofluoromethane.

6.1.2 Nature and Extent of Contamination at Consolidated Unit 16-007(a)-99, 30s Line

The inorganic chemical and organic chemical distributions at Consolidated Unit 16-007(a)-99 are described in the following sections. An interpretation of the results is presented in section 7.

6.1.2.1 Inorganic Chemicals

The distribution of inorganic COPCs at Consolidated Unit 16-007(a)-99 is depicted in Plate 1; analytical results are presented in Table 6.1-3.

Barium is the most notable inorganic COPC at 30s Line and is a known process chemical used at the site. Barium occurred at concentrations substantially above the BV and the range of background concentrations in 28 soil and tuff samples collected from 20 locations and is present across the site. Barium appears to be concentrated at the base of the former settling ponds. The maximum detected concentration of 2270 mg/kg was sampled from 7 to 8 ft bgs near the base of the northernmost former pond. Other elevated barium concentrations occur in samples collected from locations within the perimeters of the former 30s Line ponds, at depths ranging from 5.2 to 14 ft bgs. These samples are either soil samples collected adjacent to the soil/tuff interface or weathered tuff samples. In both cases, the samples probably correlate to the base of the excavated and backfilled ponds. Barium (172 mg/kg) was detected at one location outside the settling ponds; this location correlates to the drainline and sump of former building 16-33. Concentrations decrease laterally to levels near or below the BV south and west of the former pond perimeters; data from Consolidated Unit 16-008(a)-99 indicate that concentrations decrease to the north and east as well. At depth (60 to 150 ft bgs), barium is present at concentrations below the BV or was not detected.

The maximum cobalt, copper, and manganese concentrations occur in samples collected from the footprints of the former 30s Line buildings; the concentrations range to 60.9 mg/kg, 37.9 mg/kg, and 4450 mg/kg, respectively. These inorganic chemicals were detected in 10 or fewer samples, and the concentrations decrease both laterally downgradient and vertically from locations with the highest concentrations, with one exception. Copper was detected at a concentration of 9.34 mg/kg, slightly above the maximum tuff background concentration of 6.2 mg/kg, in one sample collected at 147 to 149 ft bgs. The sample was collected in a surge bed that was encountered at TD, and other metals (e.g., aluminum) were also found to be elevated in this sample. Copper concentrations at depth are below the BV in the other two deep boreholes drilled at the 30s Line.

Selenium is identified as a COPC in both soil and tuff because it is either detected above BV or because the detection limits are above the BV and/or the range of background concentrations. Selenium is detected in 12 soil and tuff samples collected from seven locations; the detection limits for more than 50 other soil and tuff samples ranged from 0.499 to 1.8 mg/kg, slightly above the BV. The highest detected concentrations occur in surface samples collected from the northernmost 30s Line Pond and from the former building footprints. The results show concentrations decreasing laterally and vertically from these locations to levels at or below analytical detection limits.

Aluminum, iron, magnesium, and nickel are detected in nine or fewer samples; all samples with above background concentrations were collected from the soil/tuff interface (which contains a fraction of soil in the sample), from clay-lined fractures, from fine-grained weathered tuff, or from surge bed material.

Fluoride, perchlorate, and nitrate are identified as COPCs because they are detected in site samples, and no established BVs are available for these chemicals. The concentrations of fluoride and perchlorate are low (with maximum concentrations of 9.02 mg/kg and 0.00586 mg/kg, respectively) and do not vary significantly. The maximum detected nitrate concentration of 7.96 mg/kg occurs in a sample collected within the perimeter of the southernmost former pond; the concentrations decrease laterally and vertically from this location to concentrations that are low and consistent across the site.

Lead is detected at concentrations above the range of background concentrations in three soil/tuff samples; beryllium, vanadium, and chromium are each detected at concentrations above the range of background concentrations in two to four samples. At adjacent and deeper sampling locations, these inorganic chemicals are not present at concentrations above background concentrations.

Antimony and cadmium are identified as COPCs because certain analyses for these chemicals resulted in detection limits greater than their respective BVs; elevated antimony and cadmium detection limits affected six samples. Antimony was not detected in investigation samples; cadmium was detected in a few samples but was not detected above the range of background concentrations in the 2006–2007 sampling. Similarly, cyanide was detected in one sample at a concentration (0.579 mg/kg) just above the BV (0.5 mg/kg); the detection limits for cyanide exceeded the BV in three samples.

6.1.2.2 Organic Chemicals

The distribution of organic chemicals detected at Consolidated Unit 16-007(a)-99 is depicted in Plate 2; the analytical results are presented in Table 6.1-4.

Of the HE compounds detected at the 30s Line, amino-2,6-dinitrotoluene[4-], HMX, RDX, and TNT were detected in one or more samples at elevated concentrations. The maximum concentrations (amino-2,6-dinitrotoluene[4-], 64.1 mg/kg; HMX, 84.4 mg/kg, RDX, 1040 mg/kg; and TNT, 359 mg/kg) occur in a single tuff sample collected at location 16-23739 from 7.5 to 8 ft bgs, within the perimeter of the northernmost former 30s Line pond. These concentrations are orders of magnitudes greater than concentrations in all other samples collected at the 30s Line. This location had been identified during the 2004 investigation and was specifically targeted for further characterization during the 2006–2007 investigation. All four HE constituents were detected in the three nearby 2006–2007 boreholes but at much lower levels. One additional sample, collected immediately south of location 16-23739, contained HE (RDX) at a concentration (60.7 mg/kg) significantly greater than the range of concentrations near the detection limit observed in the other site samples.

All other HE (amino-4,6-dinitrotoluene[2-]; dinitrotoluene[2,4-]; and trinitrobenzene[1,3,5-]) were detected at concentrations within an order of magnitude of the reported estimated quantitation limit (EQL).

The maximum concentration of acetone (0.194 mg/kg) occurs in a soil sample collected from 5 to 6 ft bgs within the perimeter of the southernmost settling pond. Acetone is also detected in the northernmost settling pond and at the footprints of former buildings 16-31 and 16-32. Acetone concentrations decrease both laterally (downgradient) and vertically from these locations. Tetrachloroethene was detected in two soil samples during the 2004 investigation and was not detected in any of the samples collected during the 2006 investigation. Concentrations decrease both laterally and vertically from the locations where tetrachloroethene was detected.

Ten samples contained toluene at concentrations above the EQL, ranging from 0.00064 mg/kg to 0.00262 mg/kg. Most of these toluene concentrations occur in soil samples collected at or near the surface, with the highest concentration occurring in surface/near surface soil samples collected from a former sump location; concentrations decrease away from the sump. Toluene was also detected in four tuff samples, two of which were collected at the total depth (approximately 150 ft) in two of the deep boreholes (locations 16-26731 and 16-26733); concentrations are 0.000938 mg/kg and 0.0016 mg/kg, respectively

The PAHs detected at the 30s Line tend to be collocated and occur mostly in surface soil or soil/tuff interface samples. Maximum concentrations range from 0.1 mg/kg to 0.333 mg/kg. All concentrations above the EQL occur at two locations; also considering data from the southwest perimeter of Consolidated Unit 16-008(a)-99 (as discussed in greater detail in Appendix I), concentrations decrease vertically and laterally to trace levels at or below the EQL from these locations.

Bis(2-ethylhexyl)phthalate was detected in 18 samples from 11 locations collected either during the 2004 or the 2006 investigation. Di-n-butylphthalate and di-n-octylphthalate were each detected in a single, but different, sample and are not detected in any other samples. All of the phthalates are detected slightly above or below the EQLs. In addition, benzoic acid, dichlorobenzene[1,4-], and trichlorofluoromethane were detected in three or fewer site samples and at trace levels. Benzoic acid and dichlorobenzene[1,4-] were detected in a single sample and decreases with depth.

6.2 Site Contamination in Solid Media at Consolidated Unit 16-008(a)-99, 90s Line

The subsections below summarize the results of laboratory analyses for soil, fill and tuff at Consolidated Unit 16-008(a)-99.

6.2.1 Soil and Rock Analytical Results

The data set reviewed for Consolidated Unit 16-008(a)-99 includes 93 soil and tuff samples from the 1996 VCA and 200 soil and tuff samples during the 2006–2007 investigation. Samples were typically analyzed for TAL metals, uranium, total cyanide, anions, nitrate (in 2006–2007), perchlorate HE, VOCs, and SVOCs. Some samples were also analyzed for hexavalent chromium and total petroleum hydrocarbon–diesel range organic (TPH-DRO). Table 6.2-1 presents a summary of the soil, fill, and tuff samples collected and the associated analyses requested for Consolidated Unit 16-008(a)-99.

A total of 53 QC samples were collected with the samples included in the data review. QC samples included 22 field duplicates, 16 rinsate samples, and 14 trip blanks. For the 2006–2007 investigation, QC samples were collected at the frequency specified in the approved investigation work plan (LANL 2005, 089331). The QC data are not included in the data set reviewed for COPC identification; the QC data are discussed in Appendix G.

A total of 23 inorganic COPCs and 46 organic COPCs were identified in soil, fill, and tuff for Consolidated Unit 16-008(a)-99. No radionuclide COPCs were identified. The COPCs are summarized in Table 6.1-2. The table includes results for magnesium, potassium, and sodium, although these inorganic constituents are not COPCs.

6.2.1.1 Inorganic Chemicals

The inorganic COPCs identified in the soil, fill, and tuff at 90s Line include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, chromium(VI), cobalt, copper, total cyanide, iron, lead, manganese, mercury, nickel, nitrate, perchlorate, selenium, silver, thallium, uranium, and zinc.

6.2.1.2 Organic Chemicals

The organic COPCs identified in soil, fill, and tuff at 90s Line include predominantly HE and related compounds, organic solvents, phthalates, and PAHs. The HE detected at 90s Line include amino-2,6-dinitrotoluene[4-]; amino-4,6-dinitrotoluene[2-]; 3,5-dinitroaniline; dinitrotoluene[2,4-]; HMX; nitrotoluene[2- and 4-]; RDX; TNT; and trinitrobenzene[1,3,5-]. Organic solvents detected at 90s Line include acetone; butanone[2-]; chloroform; dichloroethene[1,1-]; dichloroethene[cis-1,2-]; hexanone[2-]; isopropyltoluene[4-]; methylene chloride; methylphenol[4-]; tetrachloroethene; toluene; trichloroethane[1,1,1-]; and trichloroethene. PAHs detected include acenaphthene; acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(g,h,i)perylene; benzo(k)fluoranthene; chrysene; fluoranthene; fluorene, indeno(1,2,3-cd)pyrene; phenanthrene; and pyrene. Phthalates include bis(2-ethylhexyl)phthalate; butylbenzylphthalate; and di-n-octylphthalate. Other organic chemicals detected at the 90s Line include benzoic acid; dibenzofuran; trichlorofluoromethane; trichloro-1,2,2-trifluoroethane[1,1,2-]; and TPH–DRO.

6.2.1.3 Nature and Extent of Contamination in Solid Media at Consolidated Unit 16-008(a)-99, 90s Line

The inorganic and organic chemical distributions in soil, fill, and tuff at Consolidated Unit 16-008(a)-99 are described in the following sections. An interpretation of the results is presented in Section 7.

Inorganic Chemicals

The distribution of inorganic COPCs at Consolidated Unit 16-008(a)-99 is depicted in Plate 3; the analytical results are presented in Table 6.2-2.

Barium is the most prominent inorganic COPC at the 90s Line. It is present across the entire site but is primarily concentrated within and adjacent to the 90s Line Pond. Barium was detected above BVs (295 mg/kg in soil/fill and 46 mg/kg in tuff) in 117 samples from 91 locations with 39 samples containing barium at concentrations exceeding 3 times BV. In the pond area, soil and fill barium concentrations decreased laterally toward the perimeter of the pond. In addition, barium decreased laterally from 622 mg/kg in a sample collected near the top of the 90s Line drainage to concentrations below BV farther down the drainage. Barium concentrations were also greater than BV in the subsurface; however, the borehole data show decreasing concentrations with depth.

Copper is detected at concentrations exceeding the range of background concentrations in 42 soil, fill, and tuff samples collected from 38 locations during the 1996 VCA and the 2006–2007 investigation. In soil and fill, copper concentrations range up to 2210 mg/kg. In tuff, copper concentrations range from 6.6 to 166 mg/kg. The highest copper concentrations occur in soil collected in the footprints of former buildings 16-92 and 16-93 and their associated drainages. Copper was also detected at concentrations above the range of background concentrations in the 90s Line drainage. Copper is much lower downgradient than at the building footprints; however, the data do not show a decreasing trend down the drainage. In addition, copper is detected at concentrations exceeding the background concentrations in the bottom (at a depth of approximately 150 ft bgs) of all three intermediate borings but show decreasing concentrations in two of the three borings. Copper concentrations in the other intermediate borehole (location 16-26643) increase with depth to 23.6 mg/kg (approximately 4 times the maximum background concentration).The nickel distribution is similar, with the highest concentrations occurring in locations associated with the buildings 16-92 and 16-93 footprints and drainages as well as in the 90s Line drainage. However, the data show decreasing concentrations laterally, including down the 90s Line drainage, and vertically in boreholes, down to concentrations near the BV in the bottom of the three deep boreholes.

Arsenic concentrations exceeded the range of background concentrations in 10 tuff samples collected from eight locations. The maximum detected concentration (28.8 mg/kg), occurred in a sample collected from a depth of 22 to 24 ft bgs; concentrations decreased with depth. Arsenic was not observed at concentrations above the BV in any sample collected from depths greater than 81 ft bgs. In addition, arsenic concentrations decreased laterally downgradient of levels below the BV at all locations.

Chromium(VI) was detected in three samples, all from the former building 16-93 footprint and its associated drainage. The footprint concentration (67.7 mg/kg) is substantially higher than the drainage concentrations. Chromium(VI) is not detected adjacent to and downgradient from all three locations. Total chromium concentrations were also elevated in the building 16-93 area at two sampling locations; chromium in all other 90s Line samples is below the BV.

Total cyanide was detected at concentrations above BV at three locations in the 90s Line building footprints and at two locations in the 90s Line drainage. Cyanide concentration decreases to levels below the detection limit vertically and laterally downgradient of the footprint samples; the 90s Line drainage sample concentrations are near the BV. Cyanide was not detected in multiple other samples; however, some analytical detection limits were elevated slightly above the BV.

Lead was detected at concentrations above the BV (in excess of 3 times the BV in one sample) in several samples in the building footprints, building drainages, the 90s Line Pond, and the 90s Line drainage to Cañon de Valle. Lead concentrations decrease laterally to levels below the BV from all locations. In addition, lead was not detected at concentrations above the BV at depths greater than 117 ft.

Nitrate is a process chemical formerly used in association with HE operations at the 90s Line. BVs are not available for nitrate, and it has been identified as a COPC because it was detected in site samples. The highest nitrate concentrations (7.36 mg/kg and 6.35 mg/kg) occur in two subsurface samples collected beneath building footprints. Concentrations decrease laterally and vertically from these sampling points. All other detections of nitrate occur in a narrow concentration range (from 0.772 to 3.03 mg/kg) in samples collected across the site and at varying depths. As with nitrate, perchlorate is identified as a COPC because there are no established BVs and it was detected in site samples. The concentrations are consistently low across the site and decrease with depth at all locations where multiple depths were sampled. Perchlorate was detected at TD at locations 16-26643 and 16-26677 at concentrations below the estimated detection limits.

Selenium is detected above the range of background concentrations in soil and above the BV in tuff with the maximum concentrations of 17.7 mg/kg and 10.5 mg/kg occurring at the head of the 90s Line drainage and the footprint of former building 16-93. Selenium concentrations decrease laterally down the drainage to levels below BV and vertically from the highest concentration location. The other samples containing elevated selenium concentrations are spread out across the site; the sample concentrations are fairly consistent and do not differ significantly with depth. Where selenium is detected at multiple depths within a given borehole, the concentrations do not substantially change or decrease slightly with depth.

Silver and uranium were identified at concentrations above BVs at multiple locations during the 1996 VCA. These chemicals were not detected in samples collected from adjacent locations during the 2006-2007 investigation. Most of the locations where uranium was detected above BV had one depth sampled. However, locations 16-02415 and 16-02418 had two depths sampled, and uranium concentrations decreased with depth at both locations. Silver was detected in samples from both the top end and at the distal end of the 90s Line drainage to Cañon de Valle during the 2006–2007 investigation.

Zinc and cobalt were detected at concentrations above the range of background concentrations almost exclusively in samples collected during the 1996 VCA. Sampling data from the 2006–2007 investigation show concentrations decreasing laterally and vertically as compared to the 1996 sampling locations. Beryllium was detected above the range of background concentrations in two tuff samples from a single location and was not detected in samples adjacent to and downgradient of that location.

Aluminum was detected at concentrations above the range of background concentrations in multiple samples. Two samples contained aluminum concentrations greater than twice the maximum background concentration (8370 mg/kg) at 20,100 mg/kg and 40,300 mg/kg. Concentrations decreased with depth at both locations. Other samples where the aluminum concentrations were above the range of background concentrations were collected between 8 to 16 ft bgs and correspond to the soil/tuff interface. Aluminum concentrations decrease both laterally and vertically from these locations and down the 90s Line drainage to Cañon de Valle. Antimony was detected in three samples, and manganese was detected in four samples at concentrations above the range of background concentrations, and its concentrations decrease both laterally and vertically from high-concentration sampling points for both chemicals. Similarly, cadmium, mercury, and thallium were detected (or the detection limit exceeded the BVs) in few samples, and their concentrations decrease both laterally and vertically from these locations.

Organic Chemicals

The distribution of HE detected at Consolidated Unit 16-008(a)-99 is shown in Plate 4, and Plate 5 presents VOC and SVOCs detected; the analytical results are presented in Table 6.2-3.

The HE are present at low concentrations at multiple locations across the site with the greatest number of HE detected and the highest concentrations occurring in samples in the drainage between former buildings 16-90 and 16-91. The maximum concentrations of RDX (8.89 mg/kg), TNT (26.4 mg/kg), and trinitrobenzene[1,3,5-] (10.4 mg/kg) occur in this area; no other HE occurs at concentrations greater than 2.0 mg/kg in this or any other area in the 90s Line. All HE show decreasing concentrations laterally and vertically from locations with higher concentrations, typically to concentrations below detection limits. RDX and trinitrobenzene[1,3,5-] are exceptions; although concentrations for these chemicals decrease significantly, they are both present at concentrations greater than detection limits at the bottom of one of the deep boreholes. RDX was present at a concentration of 0.122 mg/kg at the bottom of borehole 16-26643 and trinitrobenzene[1,3,5-] was observed at concentration of 0.221 mg/kg at the TD of borehole 16-2664.

None of the other organic chemicals are detected pervasively across the site. Most are detected at trace concentrations (below or near the EQL) and/or show decreasing concentrations laterally and vertically from locations with positive detections. Acetone and a few PAHs are possible exceptions. Location 16-600938 contained a low-level concentration of acetone (0.0149 mg/kg) at the TD of 150.5 ft and several PAHs exist in the 90s Line drainage to Cañon de Valle and persist at concentrations slightly above the EQLs at the distal end of the drainage.

6.2.2 Site Contamination in Groundwater at Consolidated Unit 16-008(a)-99

Three groundwater samples were collected from two locations associated with the 90s Line Pond. Table 6.2-4 presents a summary of the samples collected and the associated analyses. The samples were analyzed for HE, metals, cyanide, VOCs, SVOCs, perchlorate, and alkalinity. Twenty-eight inorganic COPCs and 13 organic COPCs were identified. The inorganic chemical and organic chemical results are presented in Table 6.2-5 and Table 6.2-6, respectively.

6.2.3 Surface-Water Analytical Results at Consolidated Unit 16-008(a)-99

Twenty-three surface-water samples were collected from the 90s Line Pond. Table 6.2-7 presents a summary of the samples collected and the associated analyses. The samples were analyzed for HE, metals, cyanide, VOCs, SVOCs, perchlorate, humic acid, anions, and tritium. A total of 39 inorganic COPCs, 11 organic COPCs, and tritium are present in the surface water at the 90s Line Pond. The inorganic chemical, organic chemical, and tritium results are presented in Table 6.2-8, Table 6.2-9, and Table 6.2-10, respectively.

7.0 CONCLUSIONS

Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line) are adjacent and have similar historical processes and contaminant sources. Soil, fill, and tuff were sampled at both consolidated units during the 2006–2007 investigation in an effort to complete characterization of both sites. In addition, groundwater and surface water were sampled at Consolidated Unit 16-008(a)-99. Data from investigations conducted in 1995, 1996, and 2004 were combined with the 2006–2007 investigation data, collected in accordance with the approved investigation work plan (LANL 2005, 089331) to provide a comprehensive understanding of site contamination and potential human health and ecological risk. Where necessary and as applicable based on proximity, data associated with one consolidated unit are used to complete the understanding of contaminant distributions in the other consolidated unit.

The following sections present a summary of investigations at Consolidated Units 16-007(a)-99 and 16-008(a)-99, and an overview of the risk evaluations for both sites.

7.1 Summary of Investigations at Consolidated Unit 16-007(a)-99, 30s Line

Consolidated Unit 16-007(a)-99 consists of four former settling ponds, three former HE-machining buildings and their associated sumps and drainlines, and two former HE magazines. All structures were destroyed by intentional burning in 1960 and/or demolished and removed shortly thereafter (LANL 1994, 039440, pp. 5-305-5-513). The settling ponds were excavated and filled in the 1960s (Thrap 1970, 005784, p. 2), and the area was leveled and seeded with grasses.

The site was initially investigated in 1995 following the EPA-approved work plan for Operable Unit 1082 (LANL, 1993, 020948, section 5.12). The RFI Phase I was continued in 2004; the investigation prescribed in the approved work plan was completed in 2006-2007. The site was characterized by drilling and collecting surface and subsurface samples.

7.1.1 Soil and Tuff

A total of 96 samples collected from 32 locations across the site are representative of current site conditions; 19 inorganic COPCs and 31 organic COPCs were identified at the 30s Line.

The nature and extent of inorganic COPCs have been defined by detects at or near the BV at depth or in lateral bounding samples or are present at these locations at trace levels.

Barium, beryllium, chromium, cobalt, manganese, lead, and vanadium concentrations decrease laterally and vertically from all locations with greater than BV concentrations, typically to levels near or below the BV. Selenium data also demonstrate decreasing concentrations, again to levels below the BV or, in some cases, to levels below detection limits slightly above the BV.

Nitrate concentrations decrease laterally and vertically; however, nitrate has no BV, and its concentrations tend to decrease to residual levels that are narrow in range, and consistent across the site. These concentrations likely indicate naturally occurring levels. Similarly, the fluoride and perchlorate concentrations are low, consistent across the site, and occur in a narrow concentration range and thus probably do not indicate a site release.

No evidence was found of a release of aluminum, iron, magnesium, and nickel. The maximum concentrations for these inorganic chemicals occur in horizons that are expected to contain a higher percentage of clay minerals than the unweathered tuff and, therefore, have higher concentrations than the unweathered tuff of which the background data set is representative. The elevated copper concentration present at the bottom of one of the deep boreholes occurred in a surge bed, which is also likely to contain higher clay mineral content.

Antimony and cadmium are not detected at concentrations above the BV and detection limits for a few of the analyses exceeded BVs. No evidence was found of a release of these chemicals.

The nature and extent of nearly all organic COPCs is defined.

Nearly all organic chemicals decrease in concentrations laterally and vertically from locations with elevated concentrations to levels below detection limits or to trace concentrations. Bis(2-ethylhexyl)phthalate, chloroform, and RDX are present at trace levels at 150 ft depth in 30s Line boreholes. Toluene is an exception. Toluene persists at slightly greater than trace concentrations at the TD of two deep boreholes; however, It is unlikely that toluene is present at deeper intervals at concentrations greater than those observed and further sampling at greater depth to fully define the extent of toluene or the trace organics is not warranted.

7.2 Summary of Risk Screening Assessments for Consolidated Unit 16-007(a)-99, 30s Line

Screening-level human health and ecological risk assessments were performed using several scenarios to support site decisions. The potential risks associated with COPCs were assessed under construction-worker and industrial scenarios for the consolidated unit; the site was also assessed under a residential scenario as required by the Consent Order for comparison purposes. Details of the risk assessment methods, scenario parameters, supporting data, and risk calculations are presented in Appendix J.

7.2.1 Human Health Risk Screening Assessment

A human health screening assessment was conducted to determine if COPCs in soil and tuff at Consolidated Unit 16-007(a)-99 pose a potential unacceptable risk to human receptors. Based on the current and reasonably foreseeable land use, the industrial scenario was designated as the decision scenario for the consolidated unit.

The exposure point concentrations (EPCs) for carcinogenic COPCs were divided by the appropriate SSL and multiplied by 1×10^{-5} to estimate the excess lifetime cancer risk. The sum of the carcinogenic risks was compared to the NMED target risk level of 1×10^{-5} (NMED 2006, 092513). A hazard quotient (HQ) was generated for each noncarcinogenic COPC by dividing the EPC by the appropriate SSL. The HQs were summed to generate a hazard index (HI). The HI was compared with the NMED target HI of 1.0 (NMED 2006, 092513).

None of the individual EPCs for carcinogenic COPCs exceeded their respective industrial SSLs. The estimated total excess lifetime cancer risk for the industrial receptor at the consolidated unit is approximately 3×10^{-7}. Individual EPCs for the noncarcinogenic COPCs also did not exceed their respective industrial SSLs. The industrial HI is 0.3.

The estimated total excess lifetime carcinogenic risk under the construction-worker scenario is approximately 5×10^{-6}, below the NMED target risk of 1×10^{-5}. The construction worker HI is approximately 9. Manganese and aluminum contributed approximately 83% of the construction worker HI; however, the EPCs for both chemicals are within the range of background concentrations for soil. Eliminating manganese and aluminum as COPCs for the construction worker reduces the HI to approximately 1.0.

7.2.2 Ecological Risk Screening Assessment

An ecological screening assessment was conducted to determine whether COPECs at Consolidated Unit 16-007(a)-99 result in a potential unacceptable risk to ecological receptors. All of the COPECs were eliminated in the uncertainty analysis by analyzing the following factors: background concentrations, the analysis for potential effects to populations as well as to individuals for T&E species, the area of contamination, the relative toxicity of related compounds, and the infrequency of detection. The results of the ecological risk screening assessment indicate no potential risk to ecological receptors at the site, and further investigation or corrective action is not warranted based on ecological risk.

7.3 Summary of Investigations at Consolidated Unit 16-008(a)-99, 90s Line

Consolidated Unit 16-008(a)-99 (90s Line) consists of five former buildings and sumps, four former drainlines and outfalls, one former drum storage area, a surface drainage to Cañon de Valle, and an ephemeral settling pond. In 1996, D&D activities removed all the buildings and their associated structures and nearby contaminated soils: a more extensive soil removal and remediation for the site was conducted under the 1996 VCA (LANL 1997, 087847). All excavations were backfilled and reseeded. The inactive 90s Line settling pond remains intact and seasonally collects and retains water. Drainages from the former outfalls discharge either into the 90s Line Pond or into Cañon de Valle.

The site was initially investigated in 1996 as part of the VCA. The investigation prescribed in the approved work plan was completed in 2006–2007. The site was characterized by drilling and collecting surface and subsurface samples of solid media, and surface and groundwater samples. Data collected as part of the ongoing hydrogeologic investigation of Cañon de Valle is also applicable to the site.

7.3.1 Soil and Tuff

A total of 293 samples collected from 151 locations across the site are representative of current site conditions; 23 inorganic COPCs and 46 organic COPCs were identified at the 90s Line.

The nature and extent of most inorganic COPCs have been defined.

The concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, chromium(VI), cobalt, manganese, mercury, selenium, thallium, uranium, and zinc decrease laterally and vertically from locations with elevated concentrations, typically to levels below BVs. The nature and extent of these chemicals is defined.

The concentrations of barium, cyanide, lead, nickel, and selenium decrease laterally and vertically from locations with elevated concentrations. All of these COPCs are present at concentrations above background in the 90s Line drainage to Cañon de Valle; the data show decreasing concentrations laterally down the drainage. Samples were not collected at greater depths beneath the surface samples in the distal drainage channel; however, these inorganic chemicals are expected to preferentially migrate laterally down the surface drainage with the sediment rather than dissolve and infiltrate vertically into the tuff. The extent of these COPCs is defined both laterally and vertically at the 90s Line.

Nitrate concentrations decrease laterally and vertically; however, as discussed previously, nitrate has no BV. The concentrations decrease to residual levels that are narrow in range and consistent across the site. As at Consolidated Unit 16-007(a)-99, these concentrations probably indicate naturally occurring levels and not site contamination. Similarly, perchlorate concentrations are low, consistent across the site, and occur in a narrow concentration range; there is no evidence of a perchlorate release at the site.

The extent of copper is not fully defined vertically, as indicated by the concentrations above the range of background concentrations in the bottom of the three deep boreholes. Further, copper and silver concentration data do not show decreasing concentrations laterally down the 90s Line drainage to Cañon de Valle.

The nature and extent of nearly all of the organic COPCs is defined, with the following exceptions.

RDX and trinitrobenzene[1,3,5-] are historical process-related chemicals and are present at concentrations slightly above the EQLs in samples collected from the total depth in a subset of the deep boreholes. The vertical extent of these chemicals is not defined. In addition, the vertical extent of acetone and methylene chloride and the lateral extent of certain PAH are not defined. Acetone is present at a concentration slightly above trace levels at the TD of one deep borehole and the PAHs persist at concentrations greater than EQLs at the distal end of the 90s Line drainage to Cañon de Valle.

7.3.2 Groundwater

The following inorganic chemicals were present in one or more of the four (one filtered and three unfiltered) samples collected for the 90s Line groundwater at concentrations exceeding one or more groundwater standards (Appendix J):

- Aluminum, iron, and manganese exceeded the EPA MCL in a filtered sample and all three groundwater standards (NMWQCC groundwater, EPA MCL, and EPA Region 6 tap water screening level) in an unfiltered sample.
- Arsenic and lead exceeded all three groundwater standards in an unfiltered sample.
- Barium, chromium, and uranium exceeded the EPA MCL and the NMWQCC groundwater standards in an unfiltered sample.
- Beryllium and cadmium exceeded the EPA MCL in an unfiltered sample.
- Cobalt and nickel exceeded the NMWQCC groundwater standard in an unfiltered sample.
- Vanadium exceeded the EPA Region 6 tap water screening level in an unfiltered sample.

The following organic chemicals were present in one or more of the four (one filtered and three unfiltered) samples collected for the 90s Line groundwater at concentrations exceeding one or more groundwater standards (Appendix J):

- RDX exceeded the EPA Region 6 tap water screening level in 2 unfiltered samples.
- The solvents tetrachloroethene and trichloroethene exceeded the EPA Region 6 tap water screening level in a single unfiltered sample.

In the absence of a groundwater standard for the chemicals amino-4,6-dinitrotoluene[2-] and amino-4,6-dinitrotoluene[4-], the published groundwater standard for dinitrotoluene[2,6-] was used. This substitution was based on chemical similarity. No groundwater standard is available for 3,5-dinitroaniline.

7.3.3 Surface Water

The following inorganic chemicals were present in one or more of the 38 (14 filtered and 24 unfiltered) samples collected for the 90s Line surface water at concentrations exceeding one or more surface water standards (Appendix J):

- Aluminum exceeded the NMWQCC surface water aquatic life (acute) and irrigation standards in 29 filtered and 15 unfiltered samples.
- Arsenic exceeded the NMWQCC surface water human health standard in eight unfiltered samples.
- Chromium and copper exceeded the NMWQCC surface water irrigation standard in a single unfiltered sample.
- Cobalt exceeded the NMWQCC surface water irrigation standard in two unfiltered samples.
- Lead exceeded the NMWQCC surface water livestock standard in three unfiltered samples.
- Mercury exceeded the NMWQCC surface water wildlife habitat standard in two unfiltered samples.
- Vanadium exceeded the NMWQCC surface water livestock and irrigation standards in five unfiltered samples.

For cadmium, chromium, copper, lead, nickel, silver, and zinc, the NMWQCC surface water aquatic life (acute) standard was calculated using guidance presented in 20.6.4 NMAC 900 Section I. Standards were derived using an average water hardness of 138,660 µg/L, calculated from the water-quality parameter data available for the 90s Line surface water.

The following inorganic surface water COPCs have no published surface water standards: ammonia, barium, beryllium, chloride, cyanide, fluoride, iron, lithium, manganese, nitrate, perchlorate, strontium, sulfate, tin, phosphorous, and uranium.

The following organic chemicals were present in one or more of the 38 (14 filtered and 24 unfiltered) samples collected for the 90s Line surface water at concentrations exceeding one or more surface water standards (Appendix J):

- Acrolein exceeded the NMWQCC surface water domestic and human health standards in a single unfiltered sample.

The following organic surface water COPCs do not have published surface water standards: acetone; amino-4,6-dinitrotoluene[2-]; amino-4,6-dinitrotoluene[4-]; butanone[2-]; dinitrotoluene[2,6-]; HMX; methyl-2-pentanone[4-]; and RDX.

7.4 Summary of Risk-Screening Assessments for Consolidated Unit 16-008(a)-99, 90s Line

Screening-level human health and ecological risk assessments were performed using the same scenarios as for 16-007(a)-99 to support site decisions. The potential risks associated with COPCs were assessed under construction-worker and industrial scenarios; the site was also assessed under a residential scenario as required by the Consent Order for comparison purposes. Details of the risk assessment methodology, scenario parameters, supporting data, and risk calculations are also presented in Appendix J.

7.4.1 Human Health Risk Screening Assessment

A human health screening assessment was conducted to determine if COPCs in soil and tuff pose a potential unacceptable risk to human receptors. Based on the current and reasonably foreseeable land use, the industrial scenario was designated as the decision scenario.

The EPCs for carcinogenic chemicals were divided by the appropriate SSL and multiplied by 1×10^{-5} to estimate the excess lifetime cancer risk. The sum of the carcinogenic risks was compared to the NMED target risk level of 1×10^{-5} (NMED 2006, 092513). A HQ was generated for each noncarcinogenic COPC by dividing the EPC by the appropriate SSL. The HQs were summed to generate a HI. The HI was compared with the NMED target HI of 1.0 (NMED 2006, 092513).

None of the individual EPCs for carcinogenic COPCs exceeded their respective industrial SSLs. The estimated total excess lifetime cancer risk for the industrial receptor is approximately 2×10^{-6}. Individual EPCs for the noncarcinogenic COPCs also do not exceed their respective industrial SSLs. The industrial HI is 0.2.

The estimated total excess lifetime carcinogenic risk under the construction worker scenario is approximately 2×10^{-5}, above the NMED target risk of 1×10^{-5}. The construction worker HI is approximately 4. Manganese and aluminum contributed approximately 66% of the construction worker HI; however, the EPCs for both chemicals are within the background range for soil. Eliminating manganese and aluminum as COPCs for the construction worker reduces the HI to 0.2, which is less than NMED's target level and does not indicate a potential unacceptable risk to the construction worker.

7.4.2 Ecological Risk Screening Assessment

An ecological screening assessment was conducted to determine whether COPECs at Consolidated Unit 16-008(a)-99 result in a potential unacceptable risk to ecological receptors. All of the COPECs were eliminated in the uncertainty analysis by analyzing the following factors: background concentrations, the analysis for potential effects to populations as well as to individuals for T&E species, the area of contamination, the relative toxicity of related compounds, and the infrequency of detection. The results of the ecological risk screening assessment indicate no potential risk to ecological receptors at the site, and further investigation or corrective action is not warranted based on ecological risk.

8.0 RECOMMENDATIONS

Consolidated Unit 16-007(a)-99 has been thoroughly investigated and characterized. At location 16-23739, the 7.5–8.0-ft interval has elevated HE concentrations including 1050 mg/kg RDX. Although vertical extent of this contamination is defined and poses no potential unacceptable risk to human or ecological receptors, the sampled horizon represents a potential source for HE contamination to groundwater. To reduce this potential source, remediation and confirmation sampling is recommended at this location (Figure 8.0-1). Further sampling targeting the near-trace concentrations of toluene and other chemicals at depth is not proposed, as discussed above.

Consolidated Unit 16-008(a)-99 has been thoroughly investigated. At location 16-02384, the 3.5–4.0-ft interval has an elevated hexavalent chromium concentration of 67.7 mg/kg. Nature and extent of hexavalent chromium are defined, but this location poses a potential unacceptable risk to the construction worker. To reduce the risk to the construction worker remediation and confirmation sampling is recommended at this location (Figure 8.0-1).

- The vertical extent of all soil and tuff COPCs has been defined with the exception of copper, RDX, and trinitrobenzene[1,3,5-], and possibly acetone. To determine the vertical extent of these chemicals, a single 300-ft deep borehole is proposed adjacent to location 16-26669 (Figure 8.0-1). This location is at the confluence of the pond and central to the three previously drilled 150 ft boreholes. This borehole will be sampled every 50 ft for HE, inorganic chemicals, and VOCs.
- The lateral extent of copper, silver, and some PAHs in soil and tuff has not been defined down the tributary drainage to Cañon de Valle. No additional sampling is proposed as part of this investigation. Any further lateral migration of these COPCs is being addressed as part of the near-surface corrective measure evaluation for Consolidated Unit 16-021(c)-99. These COPCs were evaluated as part of the RFI of Cañon de Valle (LANL 2003, 077965). In addition, the Canyons' investigation of lower Cañon de Valle and Water Canyon will further evaluate these COPCs. None of these COPCs contributed to a potential risk that requires cleanup in Cañon de Valle, nor did any of these constituents exceed water-quality standards in the surface water or alluvial groundwater in Cañon de Valle (LANL 2003, 085531). All are part of the monitoring program for the corrective measures implementation in the canyon (LANL 2007, 096003)
- The monitoring well at location 16-26644 is not fully characterized. The well will be developed and sampled on a quarterly basis for one year. Results from the four sample rounds will be evaluated in the context of the goals of the intermediate and deep groundwater corrective measure evaluation for Consolidated Unit 16-021(c)-99 (LANL 2007, 098734).
- The surface water in the 90s Line Pond is fully characterized. No further sampling is required and no cleanup recommendations are proposed.

9.0 REFERENCES AND MAP DATA SOURCES

9.1 References

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

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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9.2 Map Data Sources

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11x17

Figure 1.1-1 **Location of TA-16 with respect to Laboratory TAs; Consolidated Units 16-007(a)-99 and 16-008(a)-99 are also shown**

11x17

Figure 1.1-2 Locations of Consolidated Units 16-007(a)-99 and 16-008(a)-99 and associated features

11x17

Figure 2.1-1 Locations of AOCs and SWMUs that make up Consolidated Units 16-007(a)-99 and 16-008(a)-99

back of 11x17

Figure 2.1-2 1950s aerial photograph of the 30s- and 90s-Line complex (looking southeast) taken during construction of the 90s Line

Figure 2.1-3 1987 aerial photograph of the 30s- and 90s-Line complex (looking south) after reclamation of the 30s Line pond; the 90s Line pond is still visible

11x17

Figure 2.2-1 Pre-2006 RFI sampling locations for Consolidated Units 16-007(a)-99 and 16-008(a)-99

11x17

Figure 2.3-1 **SWMUs, AOCs, and consolidated units in the vicinity of Consolidated Units 16-007(a)-99 and 16-008(a)-99**

11x17

Figure 4.1-1 **Surveyed sampling locations associated with the 2006–2007 investigation at Consolidated Units 16-007(a)-99 and 16-008(a)-99**

back of 11x17

Figure 4.2-1 Regional wells and cross section transect for Pajarito Plateau

Figure 4.2-2 West to east cross section showing primary subsurface hydrogeology beneath the Pajarito Plateau

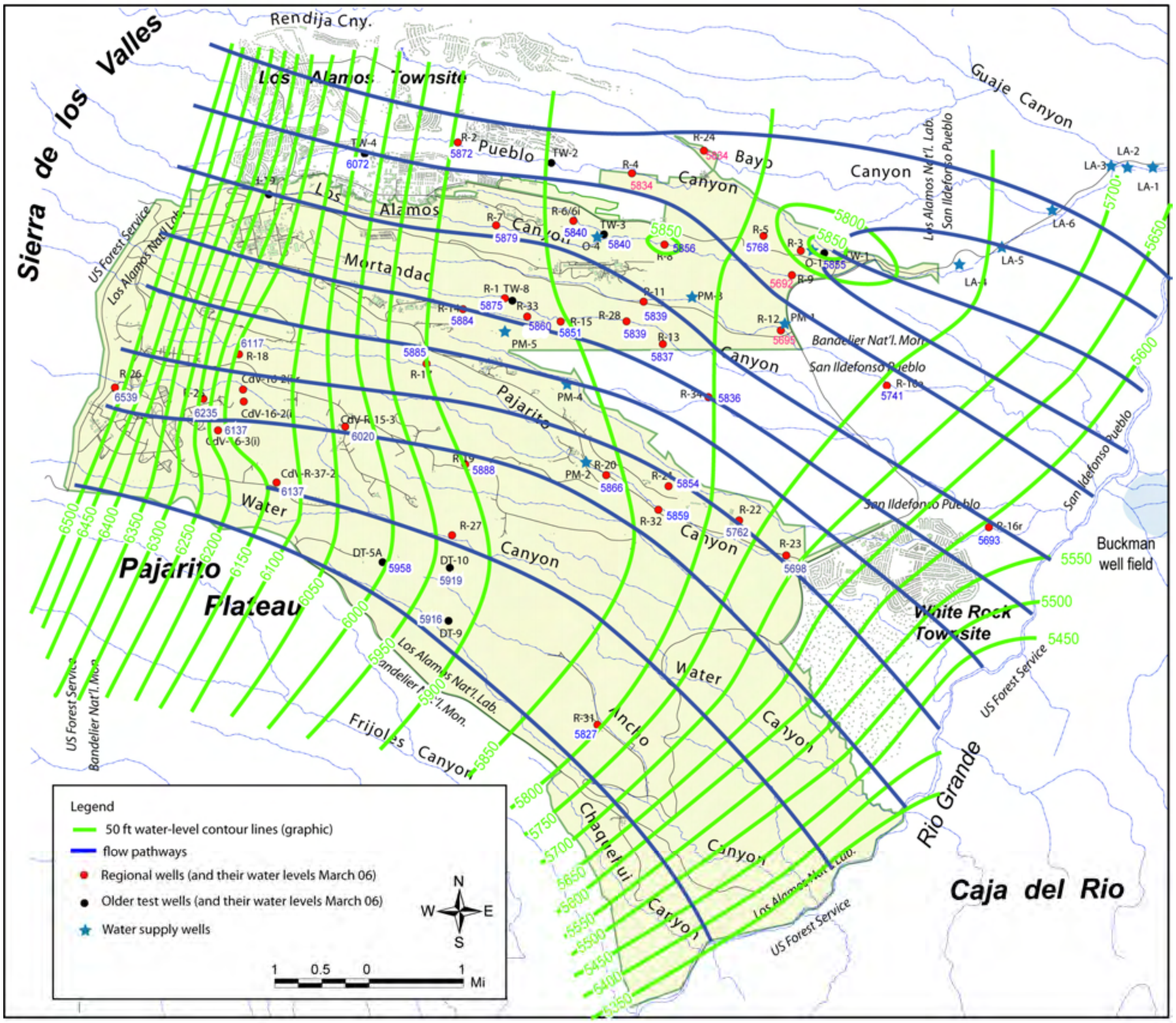
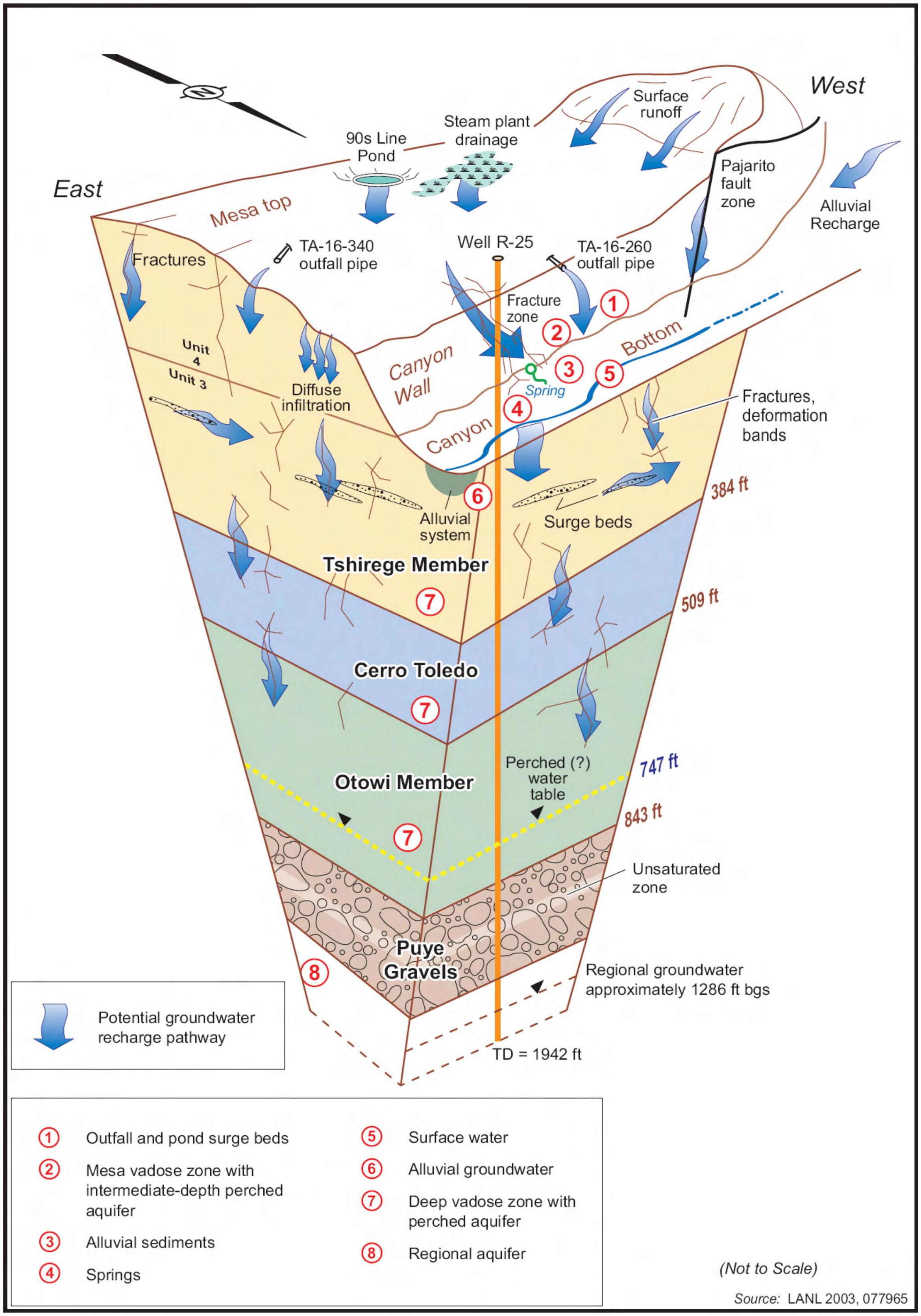


Figure 4.2-3 Groundwater contours and flow paths for regional groundwater on the Pajarito Plateau



Source: LANL 2003, 077965

Figure 4.2-4 TA-16 conceptual site model

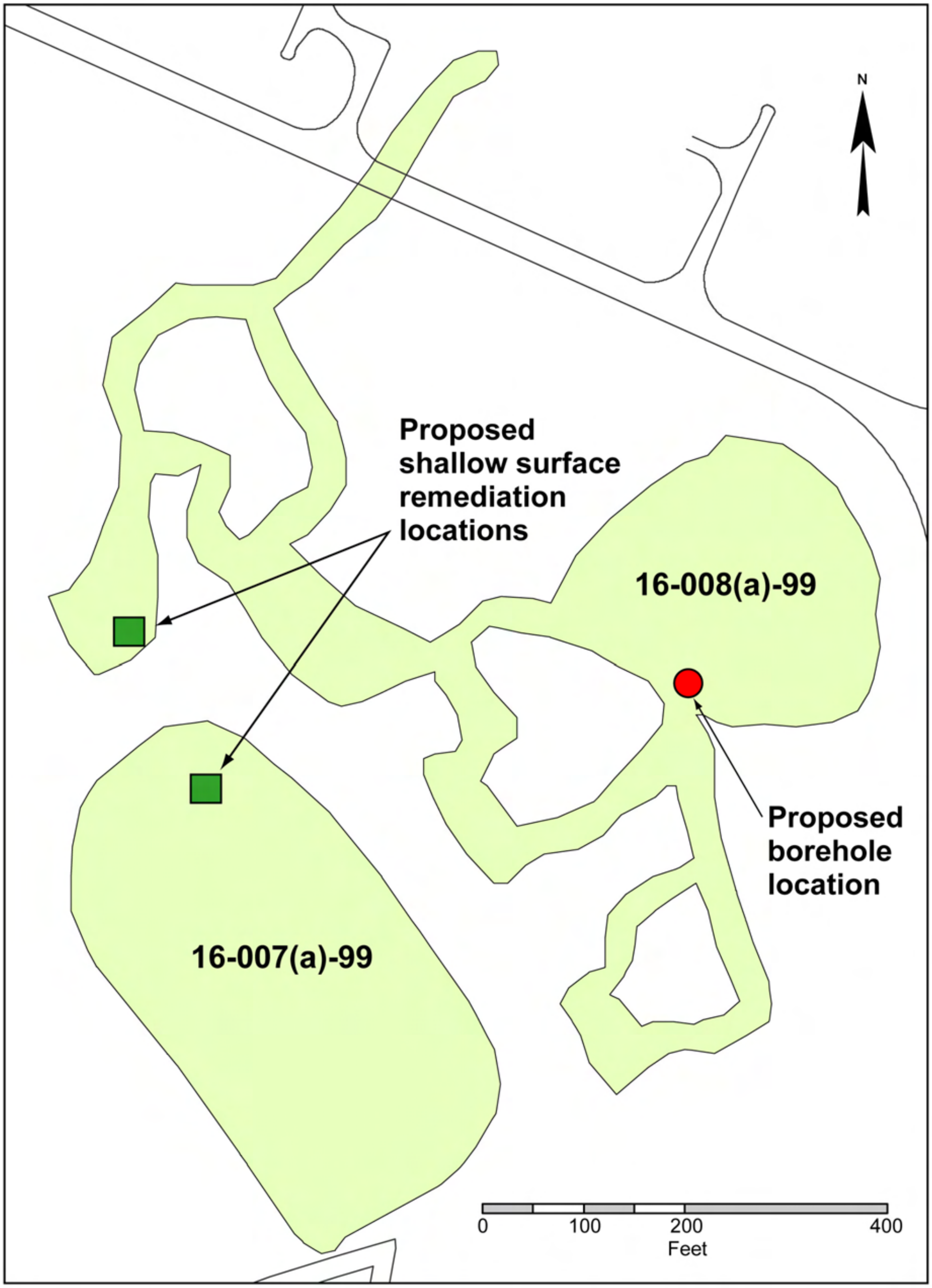


Figure 8.0-1 **Proposed locations for future drilling and remediation at Consolidated Units 16-007(a)-99 and 16-008(a)-99**