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Investigation Work Plan for Lower Water/Indio Canyons Aggregate Area

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EXECUTIVE SUMMARY

The Lower Water/Indio Canyons Aggregate Area, located in Technical Area 15 (TA-15) and TA-49 at Los Alamos National Laboratory, includes a total of 3 solid waste management units (SWMUs) and 8 areas of concern (AOCs). Of these 11 sites, 4 sites have been approved for no further action, and 1 site is being addressed under another investigation. This investigation work plan identifies and describes the activities needed to complete the investigation of the remaining 6 SWMUs and AOCs. Details of previous investigations and analytical results for the 6 sites included in this work plan are provided in the historical investigation report for the Lower Water/Indio Canyons Aggregate Area.

The objective of this investigation work plan is to evaluate the historical data and, based on that evaluation, propose sampling to define the nature and extent of contamination associated with the sites within the Lower Water/Indio Canyons Aggregate Area.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, 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 approximately 39 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 above mean sea level (amsl). Figure 1.0-1 shows the location of Lower Water/Indio Canyons Aggregate Area with respect to Laboratory technical areas and surrounding land holdings.

The Laboratory is participating in a national effort by DOE to reduce risk to human health and the environment at its facilities. The goal of the Laboratory effort 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, the Laboratory is currently investigating sites potentially contaminated by past Laboratory operations. The sites under investigation are designated as solid waste management units (SWMUs) and areas of concern (AOCs).

The SWMUs and AOCs (the sites) addressed in this investigation work plan are potentially contaminated with hazardous and radioactive components. The New Mexico Environment Department (NMED), pursuant to the New Mexico Hazardous Waste Act, regulates cleanup of hazardous wastes and hazardous constituents. DOE regulates cleanup of radioactive contamination, pursuant to DOE Order 458.1, Administrative Change 3, “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 NMED in accordance with DOE policy.

Corrective actions at the Laboratory are subject to a Compliance Order on Consent (the Consent Order). This investigation work plan describes work activities that will be executed and completed in accordance with the Consent Order.

1.1 Work Plan Overview

The Lower Water/Indio Canyons Aggregate Area includes 3 SWMUs and 8 AOCs located in Technical Area 15 (TA-15) and TA-49 (Plate 1). Of these 11 sites, 5 have been previously investigated and 6 require additional characterization. Of the 5 sites previously investigated, 4 sites have been approved for no further action (NFA) status, and 1 site at TA-49 requiring additional characterization is being investigated under another aggregate area investigation (Table 1.1-1). These 5 sites are not discussed further in the work plan. This work plan addresses the 6 remaining sites using the information from previous field investigations to evaluate current conditions at each site.

Section 2 of this investigation work plan presents the general site information, operational history, preliminary conceptual site model, and a data overview. General site conditions at TA-15 are presented in section 3. Section 4 presents summaries of previous investigations and data collected and describes the scope of proposed investigation activities for each site. Section 5 presents investigation methods for proposed field activities. Ongoing monitoring and sampling programs in the Lower Water/Indio Canyons Aggregate Area are presented in section 6. Section 7 is an overview of the anticipated schedule of the investigation and reporting activities. The references cited in this work plan and the map data sources are provided in section 8.

Appendix A of this work plan includes a list of acronyms and abbreviations, a metric conversion table, and a data qualifier definitions table. Appendix B describes the investigation-derived waste (IDW) management plan. Appendix C contains site photographs.

1.2 Work Plan Objectives

The objective of the investigation activities described in this work plan is to finalize determinations of the nature and extent of contamination at the six sites.

To help accomplish this objective, this work plan

- presents historical and background information on the sites,
- describes the rationale for proposed data collection activities, and
- identifies and proposes appropriate methods and protocols for collecting and analyzing data to characterize these sites.

2.0 BACKGROUND

2.1 General Site Information

TA-15, also known as R-Site, occupies portions of Threemile Mesa on the Pajarito Plateau near the southwestern boundary of the Laboratory (Plate 1). TA-15 occupies approximately 1200 acres and is used for high-explosives (HE) research, development, and testing, primarily through hydrodynamic testing and dynamic experimentation. TA-15 contains the Pulsed High-Energy Radiographic Machine Emitting X-rays (PHERMEX) facility and the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, both of which are or were formerly used for testing weapons under development. Other activities at TA-15 include the investigation of weapons functioning and systems behavior in nonnuclear testing. The sites addressed in this investigation work plan are all at or near the PHERMEX facility.

2.2 Operational History

TA-15 has been used from the mid-1940s to the present for explosives experiments. In that capacity, test explosions ranging from a few kilograms of HE to as much as 650 kg were conducted. These experiments used natural uranium, depleted uranium (DU), lesser quantities of beryllium, and other metals. In most cases, the tests were carried out aboveground, which resulted in the test materials being scattered over areas. Based on estimates from Laboratory records, approximately 75 metric tons of natural uranium and DU have been expended at the TA-15 firing sites since the mid-1940s (LANL 1993, 020946, pp. E2, E9).

Most of the sites in this investigation work plan are located near the PHERMEX facility, which became operational in 1961. During the time period 1961 to 1971, a maximum of 4000 kg of DU was expended at the PHERMEX site. During that same time period, about 150 kg of beryllium, 250 kg of lead, 40 kg mercury, and 40 kg of thorium were expended. Since 1971, less than 1000 kg per year of uranium-238 was expended at the PHERMEX firing site. Beryllium usage decreased from about 10 kg per year in 1971 to about 3 kg per year in 1987 (LANL 1993, 020946, p. 6-5).

2.3 Conceptual Site Model

The sampling proposed in this investigation work plan uses a conceptual site model to predict areas of potential contamination and allow for adequate characterization of these areas. A conceptual site model describes potential contaminant sources, transport mechanisms, and receptors.

2.3.1 Potential Contaminant Sources

Releases at sites within Lower Water/Indio Canyons Aggregate Area may have occurred as a result of normal site operations or potential spills/leaks. Previous sampling results, provided in the historical investigation report (HIR) (LANL 2016, 601539) indicate contamination from uranium. Additional sampling is needed to determine the nature and extent of contamination.

Potential contaminant sources associated with TA-15 include a firing site, septic system, drainlines and outfalls, a former underground tank, and a storage area.

2.3.2 Potential Contaminant Transport Mechanisms

Current potential transport mechanisms that may lead to exposure include

- airborne transport of contaminated surface soil,
- dissolution and/or particulate transport of surface contaminants during precipitation and runoff events,
- disturbance of contaminants in shallow soil and subsurface tuff by Laboratory operations,
- continued dissolution and advective/dispersive transport of chemical contaminants contained in subsurface soil and tuff as a result of past operations, and
- disturbance and uptake of contaminants in shallow soil by plants and animals.

2.3.2.1 Surface Processes

Laboratory operations, disturbance and uptake by plants and animals, surface water runoff, and wind can disturb contaminants present in shallow soils. During summer thunderstorms and spring snowmelt, runoff from the mesa top may flow down the hillsides and into the perennial and ephemeral streams present in Lower Water and Indio Canyons. Surface water runoff and erosion of contaminated surface soil may lead to contamination of bench areas on the hillside and contamination of the surface water off-site. Surface water may also access subsurface contaminants exposed by soil erosion. Soil erosion can vary significantly depending on factors that include soil properties, the amount of vegetative cover, the slope of the contaminated area, and the intensity and frequency of precipitation. Surface transport of contaminants represents the dominant potential transport pathway in the Lower Water/Indio Canyons Aggregate Area.

2.3.2.2 Subsurface Processes

Studies have shown that infiltration of natural precipitation is quite low across the mesa tops of the Pajarito Plateau. The average annual potential evapotranspiration rates far exceed precipitation rates. Under these conditions, infiltration events that propagate beneath the root zone are sporadic and occur only when the short-term infiltration rate exceeds the evapotranspiration rate, such as during summer thunderstorms and spring snowmelt. However, these events more commonly produce runoff into neighboring canyons resulting in infiltration rates below the root zone on the order of a few millimeters or less per year for mesa-top sites (Collins et al. 2005, 092028, pp. 2-84−2-88; Kwicklis et al. 2005, 090069).

This slow infiltration rate generally leads to present-day subsurface contaminant migration of only a few meters deep. Geochemical interactions between the contaminants and the rocks generally act to retard migration further. Therefore, groundwater transport of contaminants through the unsaturated zone to the regional aquifer does not represent a pathway for contaminant transport in the Lower Water/Indio Canyons Aggregate Area.

2.3.3 Potential Receptors and Pathways

The potential human receptors of contaminants are on-site Laboratory workers who could potentially be exposed to contaminants in soil, tuff, and sediment by direct contact, ingestion, or inhalation. Ecological receptors, such as plants and animals, may also be exposed to soil and sediment contaminants.

The current and reasonably foreseeable future land use at TA-15 is industrial. No residential or recreational land use currently exists or is expected to occur at any of the sites in the foreseeable future.

2.3.4 Cleanup Standards

As specified in Section VIII.B.1 of the Consent Order, NMED soil screening levels (SSLs) (NMED 2015, 600915) or Laboratory screening action levels (LANL 2015, 600929) will be used as soil cleanup levels unless they are determined to be impractical (details of the process are outlined in the Consent Order, Section VIII.E, Requests for Variance from Cleanup Goal or Cleanup Level) or unless SSLs do not exist for the current and reasonably foreseeable future land use (i.e., neither NMED nor the U.S. Environmental Protection Agency [EPA] has determined SSLs for some analytes under some land-use scenarios). If NMED SSLs do not exist, EPA regional screening values will be used (http://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016).

2.4 Data Overview

The existing data from these sites are approximately 20 yr old and are therefore screening-level data. Screening-level data are appropriate for applications that require only determination of areas of gross contamination and/or for site characterization. Screening-level data are also often used to specify areas where additional data should be collected. The screening-level data are presented in the Lower Water/Indio Canyons Aggregate Area HIR (LANL 2016, 601539).

3.0 SITE CONDITIONS

3.1 Surface Conditions

The SWMUs and AOCs that comprise the Lower Water/Indio Canyons Aggregate Area under investigation are located on the mesa top in the southeast portion of TA-15. The mesa-top sites in this aggregate area are bounded by steep-walled Water Canyon to the south and east.

TA-15, also known as R-Site, occupies approximately 1200 acres of Threemile Mesa on the Pajarito Plateau near the southwestern boundary of the Laboratory. TA-15 ranges in elevation from 6719 to 7217 ft amsl. Most, if not all, of the disturbances associated with TA-15 activities (site development, open-air explosions, and disposal) have been on this mesa top. Topographically, the area consists of the hill slopes, canyon walls, canyon bottoms, and mesa tops with intermittent streams in the canyon bottoms. Groundcover of unpaved areas include common shrub species including Gambel oak, wavyleaf oak, mountain mahogany, cliffbush, and Colorado barberry, along with grasses including mountain muhly, little bluestem, and blue grama. Some of the most common forbs found are golden aster, bittersweet, and wormwood. Dominant tree species found within TA-15 include juniper, piñon, and ponderosa pine. Most disturbed areas have only a thin soil layer (LANL 1993, 020946, p. 3-5).

3.1.1 Soil

Soil on the Pajarito Plateau was initially mapped and described by Nyhan et al. (1978, 005702). The soil on the slopes between the mesa tops and canyon floors was mapped as mostly steep rock outcrops consisting of approximately 90% bedrock outcrop and patches of shallow, weakly developed colluvial soil. South-facing canyon walls are generally steep and usually have shallow soil in limited, isolated patches between rock outcrops. In contrast, the north-facing canyon walls generally have more extensive areas of shallow, dark-colored soil under thicker forest vegetation. The canyon floors generally contain poorly developed, deep, well-drained soil on floodplain terraces or small alluvial fans (Nyhan et al. 1978, 005702).

The soil in the bottom of Lower Water and Indio Canyons consists of deep, well-drained soil of the Totavi series, which formed in alluvium in canyon bottoms. The surface soil is a brown gravelly loamy sand, or sandy loam, with 15% to 20% gravel. The permeability of this soil is high, runoff is very slow, and erosion hazard rating is low (Nyhan et al. 1978, 005702, p. 31).

The sites addressed in this investigation work plan are located in the center of PHERMEX Mesa, which is covered by Nyjack loam. Nyjack loam is derived from weathered tuff on level to gently sloping terrains and has medium water capacity and permeability and slight erosion susceptibility. This soil grades to the north to Seaby loam and Hackroy loam on the northeast rim of Potrillo Canyon. Seaby loam forms on gently to moderately sloping mesas and is also formed on weathered tuff. Permeability is moderate in the upper soil and very rapid below. Water capacity is low and erosion rates are moderate. Hackroy loam is a shallow soil formed from tuff. It exhibits low permeability and low water capacities and medium runoff and moderate water erosion hazard. The Seaby grades to the west and east of the PHERMEX site with a small pod of Nyjack located on the extreme eastern edge of TA-15 on the mesa. The northern rim of Water Canyon shows Pogna loam on the west and Hackroy loam on the east. Pogna loam is derived from tuff on gently to strongly sloping mesa tops. It has low water capacity, moderate permeability, medium runoff and moderate erosion rates. A pod of Seaby loam is located in the bottom of Water Canyon at the eastern edge of TA-15.

3.1.2 Surface Water

Most surface water in the Los Alamos area occurs as ephemeral, intermittent, or interrupted streams in canyons cut into the Pajarito Plateau. Springs on the flanks of the Jemez Mountains, west of the Laboratory's western boundary, supply flow to the upper reaches of Cañon de Valle and to Guaje, Los Alamos, Pajarito, and Water Canyons (Purtymun 1975, 011787; Stoker 1993, 056021). These springs discharge water perched in the Bandelier Tuff and Tschicoma Formation at rates from 2 to 135 gal./min (Abeele et al. 1981, 006273). The volume of flow from the springs maintains natural perennial reaches of varying lengths in each of the canyons.

Mesas of the Pajarito Plateau are generally dry, both on the surface and within the bedrock forming the mesas. The surface water and alluvial groundwater hydrology of the south canyons watersheds is related to several primary factors, including the location and discharge volume of natural and anthropogenic water sources, seasonal events (e.g., snowmelt runoff and storm water runoff), and general regional climatic conditions. Surface water flow in the south canyons system is generally ephemeral and occurs primarily as short-duration storm water runoff. Locally persistent surface water has been observed in bedrock pools or where alluvial groundwater discharges from springs or seeps. Intermittent flow also occurs during snowmelt runoff or is associated with the discharge of alluvial groundwater from stream beds.

Most stream channels that drain the south canyons watersheds are dry for most of the year and are characterized by ephemeral or intermittent flow with only localized areas of perennial flow. In the south canyons watersheds, only Cañon de Valle and Water Canyon support perennial flow. Perennial flow is derived from springs in the eastern Jemez Mountains or the western Pajarito Plateau, but the volume is insufficient to maintain surface flows across the Laboratory before the water is depleted by evaporation, transpiration, and infiltration (LANL 2005, 091523, p. 24). In Water Canyon, snowmelt runoff can extend from the Jemez Mountains to the Rio Grande following heavy winter snowfalls. Storm water runoff also occasionally extends across the Laboratory to the Rio Grande in the south canyons but is transient and associated with heavy rainfall events.

The mesa-top portion of the Lower Water and Indio Canyons Aggregate Area is currently an industrially developed area. No natural surface water is present in this area. During summer thunderstorms and spring snowmelt, runoff flows from the mesa top down the hillsides and into the ephemeral streams in Lower Water and Indio Canyons. Surface runoff from the mesa top enters both canyons by way of several drainages (LANL 1992, 007672).

Indio Canyon has a small drainage area (0.7 mi^2) that originates at TA-39 at an elevation of approximately 6860 ft. The canyon extends southeast from TA-39 to Water Canyon at TA-71 for a distance of approximately 6.5 mi. Streamflow in Indio Canyon is ephemeral and results primarily from natural runoff. The Indio Canyon watershed has no perennial springs or tributaries on Laboratory property (LANL 1997, 055622). Lower Water Canyon has a relatively small drainage area of approximately (2.5 mi^2) that originates near the boundary between TA-15 and TA-49 at an elevation of approximately 7100 ft. The canyon extends southeast before it is joined by Potrillo Canyon in TA-71 before entering the Rio Grande in TA-70 at an elevation of approximately 5427 ft amsl. A small perennial spring in Lower Water Canyon, below the confluence with Potrillo Canyon, supports a very short perennial reach (LANL 1997, 055622).

3.1.3 Land Use

Currently, land use within the Lower Water/Indio Canyons Aggregate Area is industrial. The area's land use is anticipated to remain as industrial through continued use by the Laboratory and will not change in the foreseeable future. Public access to TA-15 is prohibited and is controlled through physical controls, including fencing and limited access via guard stations.

3.2 Subsurface Conditions

3.2.1 Stratigraphic Units

The stratigraphy of the Lower Water/Indio Canyons Aggregate Area is summarized in this section. Additional information on the geologic setting of the area and information on the Pajarito Plateau can be found in the hydrogeologic conceptual site model for the Laboratory (LANL 2016, 601506).

The bedrock at or near the surface of the mesa top is the Tshirege Member of the Bandelier Tuff (Qbt). There are approximately 1250 ft of volcanic and sedimentary materials between any potential contaminant-bearing units at the mesa-top surface and the regional aquifer. The upper stratigraphic units present within the Lower Water/Indio Canyons Aggregate Area are described briefly in the following sections. The descriptions begin with the oldest (deepest) and proceed to the youngest (topmost). The generalized stratigraphy is shown in Figure 3.2-1.

3.2.1.1 Guaje Pumice Bed

The Guaje Pumice Bed occurs at the base of the Otowi Member of the Bandelier Tuff, making a significant and extensive marker horizon. The Guaje Pumice Bed (Bailey et al. 1969, 021498; Self et al. 1986, 021579) contains well-sorted pumice fragments whose mean size varies between 0.8 and 1.6 in. Its thickness averages approximately 28 ft below most of the Pajarito Plateau, with local areas of thickening and thinning. The distinctive white color and texture make it easily identifiable in borehole cuttings and core, and it is an important marker bed for the base of the Bandelier Tuff.

3.2.1.2 Otowi Member of the Bandelier Tuff

Griggs and Hem (1964, 092516); Smith and Bailey (1966, 021584); Bailey et al. (1969, 021498); and Smith et al. (1970, 009752) described the Otowi Member. It consists of moderately consolidated (indurated), porous, and nonwelded vitric tuff (ignimbrite) that forms gentle colluvium-covered slopes along the base of canyon walls. The Otowi ignimbrites contain light gray to orange pumice that is supported in a white to tan ash matrix (Broxton et al. 1995, 050121; Broxton et al. 1995, 050119; Goff 1995, 049682). The ash matrix consists of glass shards, broken pumice, crystal fragments, and fragments of perlite.

3.2.1.3 Tephra and Volcaniclastic Sediment of the Cerro Toledo Interval

The Cerro Toledo interval is an informal name given to a sequence of volcaniclastic sediment and tephra of mixed provenance that separates the Otowi and Tshirege Members of the Bandelier Tuff (Broxton et al. 1995, 050121; Broxton and Reneau 1995, 049726; Goff 1995, 049682). Although it is located between the two members of the Bandelier Tuff, it is not considered part of that formation (Bailey et al. 1969, 021498). The unit contains primary volcanic deposits described by Smith et al. (1970, 009752) as well as reworked volcaniclastic sediment. The occurrence of the Cerro Toledo interval is widespread; however, its thickness is variable, ranging between several feet to more than 100 ft.

The predominant rock types in the Cerro Toledo interval are rhyolitic tuffaceous sediment and tephra (Heiken et al. 1986, 048638; Stix et al. 1988, 049680; Broxton et al. 1995, 050121; Goff 1995, 049682). The tuffaceous sediment is the reworked equivalent of Cerro Toledo rhyolite tephra. Oxidation and clay-rich horizons indicate at least two periods of soil development occurred within the Cerro Toledo deposits. Because the soil is rich in clay, it may act as a barrier to the movement of vadose zone moisture. Some of the deposits contain both crystal-poor and crystal-rich varieties of pumice. The pumice deposits tend to form porous and permeable horizons within the Cerro Toledo interval and locally may provide important pathways for moisture transport in the vadose zone. A subordinate lithology within the Cerro Toledo interval includes clast-supported gravel, cobble, and boulder deposits derived from the Tschicoma Formation (Broxton et al. 1995, 050121; Goff 1995, 049682; Broxton and Reneau 1996, 055429).

3.2.1.4 Tshirege Member of the Bandelier Tuff

The Tshirege Member is the upper member of the Bandelier Tuff and is the most widely exposed bedrock unit of the Pajarito Plateau (Griggs and Hem 1964, 092516; Smith and Bailey 1966, 021584; Bailey et al. 1969, 021498; Smith et al. 1970, 009752). Emplacement of this unit occurred during eruptions of the Valles Caldera approximately 1.2 million years ago (Izett and Obradovich 1994, 048817; Spell et al. 1996, 055542). The Tshirege Member is a multiple-flow ignimbrite sheet that forms the prominent cliffs in most of the canyons on the Pajarito Plateau. It is a cooling unit whose physical properties vary vertically and laterally. The consolidation in this member is largely from compaction and welding at high temperatures after the tuff was emplaced. Its light brown, orange-brown, purplish, and white cliffs have numerous, mostly vertical fractures that may extend from several feet up to several tens of feet. The Tshirege Member includes thin but distinctive layers of bedded, sand-sized particles called surge deposits that demark separate flow units within the tuff. The Tshirege Member is generally over 200 ft thick.

The Tshirege Member differs from the Otowi Member most notably in its generally greater degree of welding and compaction. Time breaks between the successive emplacement of flow units caused the tuff to cool as several distinct cooling units. For this reason, the Tshirege Member consists of at least four cooling subunits that exhibit variable physical properties vertically and horizontally (Smith and Bailey 1966, 021584; Crowe et al. 1978, 005720; Broxton et al. 1995, 050121). The welding and crystallization variability in the Tshirege Member produce recognizable vertical variations in its properties, such as density, porosity, hardness, composition, color, and surface-weathering patterns. The subunits are mappable based on a combination of hydrologic properties and lithologic characteristics.

Broxton et al. (1995, 050121) provide extensive descriptions of the Tshirege Member cooling units. The following paragraphs describe, in ascending order, subunits of the Tshirege Member present at the Lower Water/Indio Canyons Aggregate Area.

The Tsankawi Pumice Bed forms the base of the Tshirege Member. Where exposed, it is commonly 20 to 30 in. thick. This pumice-fall deposit contains moderately well-sorted pumice lapilli (diameters reaching about 2.5 in.) in a crystal-rich matrix. Several thin ash beds are interbedded with the pumice-fall deposits.

Subunit Qbt 1g is the lowermost tuff subunit of the Tshirege Member. It consists of porous, nonwelded, and poorly sorted ash-flow tuff. This unit is poorly indurated but nonetheless forms steep cliffs because of a resistant bench near the top of the unit; the bench forms a harder protective cap over the softer underlying tuff. A thin (4- to 10-in.) pumice-poor surge deposit commonly occurs at the base of this unit.

Subunit Qbt 1v forms alternating clifflike and sloping outcrops composed of porous, nonwelded, crystallized tuff. The base of this unit is a thin horizontal zone of preferential weathering that marks the abrupt transition from glassy tuff below (in unit Qbt 1g) to the crystallized tuff above. This feature forms a widespread marker horizon (locally termed the vapor-phase notch) throughout the Pajarito Plateau. The lower part of Qbt 1v is orange-brown, is resistant to weathering, and has distinctive columnar (vertical) joints; hence, the term “colonnade tuff” is appropriate for its description. A distinctive white band of alternating cliff- and slope-forming tuffs overlies the colonnade tuff. The tuff of Qbt 1v is commonly nonwelded (pumices and shards retain their initial equant shapes) and has an open, porous structure.

Unit Qbt 2 forms a distinctive medium-brown vertical cliff that stands out in marked contrast to the slope-forming, lighter-colored tuff above and below. It exhibits the greatest degree of welding in the Tshirege Member. A series of surge beds commonly mark its base. It typically has low porosity and permeability relative to the other units of the Tshirege Member.

Unit Qbt 3 is a nonwelded to partially welded, vapor-phase altered tuff that forms the upper cliffs. Its base consists of a purple-gray, unconsolidated, porous, and crystal-rich nonwelded tuff that forms a broad, gently sloping bench developed on top of Qbt 2. Abundant fractures extend through the upper units of the Bandelier Tuff, including the ignimbrite of Qbt 3 of the Tshirege Member. The origin of the fractures has not been fully determined, but the most probable cause is brittle failure of the tuff caused by cooling contraction soon after initial emplacement (Vaniman 1991, 009995.1; Wohletz 1995, 054404).

Unit Qbt 4 consists of a series of variably welded vitric to devitrified ash-flow tuffs characterized by localized thin, discontinuous, crystal-rich, fine- to coarse-grained, volcanic surge deposits. The lower, more indurated parts of Qbt 4 are also significantly fractured. These fractures and surge beds are potential groundwater pathways (LANL 2006, 091698).

3.2.2 Hydrogeology

The hydrogeology of the Pajarito Plateau is generally separable in terms of mesas and canyons forming the plateau. Mesas are generally devoid of water, both on the surface and within the rock forming the mesa. Canyons range from wet to relatively dry; the wettest canyons contain continuous streams and contain perennial groundwater in the canyon-bottom alluvium. Dry canyons have only occasional streamflow and may lack alluvial groundwater. Intermediate-perched groundwater has been found at certain locations on the plateau at depths ranging between 100 and 700 ft. The regional aquifer is found at depths of about 600 to 1200 ft (Collins et al. 2005, 092028).

In the Los Alamos area, groundwater occurs as (1) water in shallow alluvium in some of the larger canyons, (2) an intermediate-perched groundwater body, which lies above a less permeable layer and is separated from the underlying aquifer by an unsaturated zone, and (3) the regional aquifer.

Contamination of the perched water and/or regional groundwater aquifer can occur only by recharge of infiltrating precipitation from contamination at or near the surface to the underlying groundwater. The hydrogeologic conceptual site model for the Laboratory (Collins et al. 2005, 092028) shows that, under natural conditions, relatively small volumes of water move beneath mesa tops because of low rainfall, high evaporation, and efficient water use by vegetation. Atmospheric evaporation may extend into mesas, further inhibiting downward flow.

3.2.2.1 Vadose Zone

The unsaturated zone from the mesa surface to the top of the regional aquifer is referred to as the vadose zone. The source of moisture for the vadose zone is precipitation, but much of it runs off, evaporates, or is absorbed by plants. The subsurface vertical movement of water is influenced by properties and conditions of the materials that make up the vadose zone.

The Bandelier Tuff is generally dry and does not readily transmit moisture. Most of the pore spaces in the tuff are of capillary size and have a strong tendency to hold water against gravity by surface-tension forces. Vegetation is very effective at removing moisture near the surface. During the summer rainy season when rainfall is highest, near-surface moisture content is variable because of higher rates of evaporation and of transpiration by vegetation, which flourishes during this time.

The various units of the Bandelier Tuff tend to have relatively high porosities. Porosity ranges between 30% and 60% by volume, generally decreasing for more highly welded tuff. Permeability varies for each cooling unit of the Bandelier Tuff. The moisture content of tuff beneath the mesa tops is low, generally less than 5% by volume throughout the profile (Kearl et al. 1986, 015368; Purtymun and Stoker 1990, 007508).

Based on the hydrogeologic conceptual model for mesas (Collins et al. 2005, 092028), moisture movement through the vadose zone in the Lower Water/Indio Canyons Aggregate Area is expected to be very slow because of low precipitation, the lack of surface water on the mesa top (including artificial water sources such as ponds), and the drying effect of air exchange along mesa edges. Net infiltration beneath dry mesas is low, with rates generally believed to be less than tens of millimeters per year and commonly on the order of 1 mm/yr or less. Transport times to the regional aquifer beneath dry canyons are expected to exceed hundreds of years (Birdsell et al. 2005, 092048).

3.2.2.2 Alluvial Groundwater

Intermittent and ephemeral stream flows in the canyons of the Pajarito Plateau have deposited alluvium as thick as 100 ft. The alluvium in canyons that originate from the Jemez Mountains is generally composed of sands, gravels, pebbles, cobbles, and boulders derived from the Tschicoma Formation and Bandelier Tuff on the flank of the mountains. The alluvium in canyons that originate from the plateau (such as Water Canyon) is comparatively more fine grained, consisting of clays, silts, sands, and gravels derived from the Bandelier Tuff (Purtymun 1995, 045344).

In contrast to the underlying volcanic tuff and sediment, alluvium is relatively permeable. Ephemeral runoff in some canyons infiltrates the alluvium until downward movement is impeded by the less permeable tuff and sediment, which results in the buildup of a shallow alluvial groundwater body. Depletion by evapotranspiration and movement into the underlying rock limit the horizontal and vertical extent of the alluvial water (Purtymun et al. 1977, 011846). The limited saturated thickness and extent of the alluvial groundwater preclude its use as a viable source of water for municipal and industrial needs. Lateral flow of the alluvial perched groundwater is in an easterly, downcanyon direction (Purtymun et al. 1977, 011846).

There is no alluvial groundwater in the Lower Water/Indio Canyons Aggregate Area. Threemile Mesa lacks well-defined drainages and surface-water flow is ephemeral, occurring as overland runoff, primarily following infrequent, intense thunderstorms or during snowmelt.

3.2.2.3 Intermediate-Perched Water

Identification of perched groundwater systems beneath the Pajarito Plateau comes mostly from direct observation of saturation in boreholes, wells, or piezometers or from borehole geophysics. Perched groundwater is widely distributed across the northern and central part of the Pajarito Plateau with depth-to-water ranging from 118 to 894 ft below ground surface (bgs). The principal occurrences of perched groundwater occur in (1) the relatively wet Los Alamos and Pueblo Canyon watersheds, (2) the smaller watersheds of Sandia and Mortandad Canyons that receive significant volumes of treated effluent from Laboratory operations, and (3) the Cañon de Valle area in the southwestern part of the Laboratory. Perched water is most often found in Puye fanglomerates, Cerros del Rio basalt, and in units of Bandelier Tuff. Based on a few reported occurrences in the southern part of the Laboratory, a few deep boreholes are located in that area. Additional perched zones probably occur beneath the adjacent watersheds of Pajarito and Water Canyons (Collins et al. 2005, 092028, pp. 2-96–2-97).

3.2.2.4 Regional Aquifer

The regional aquifer of the Los Alamos area is the only aquifer capable of providing a large-scale municipal water supply (Purtymun 1984, 006513). The surface of the regional aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Formation beneath the central and western part of the Pajarito Plateau. The depths to groundwater below the mesa tops range between about 1200 ft along the western margin of the plateau and about 600 ft at the eastern margin. The locations of wells and the generalized water-level contours on top of the regional aquifer are described in the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2016, 601506). The regional aquifer is typically separated from the alluvial groundwater and intermediate-perched groundwater by 350 to 620 ft of tuff, basalt, and sediment (LANL 1993, 023249).

Groundwater in the regional aquifer flows east-southeast toward the Rio Grande. The velocity of groundwater flow ranges from about 20 to 250 ft/yr (LANL 1998, 058841, pp. 2–7). Details of depths to the regional aquifer, flow directions and rates, and well locations are presented in various Laboratory documents (Purtymun 1995, 045344; LANL 1997, 055622; LANL 2000, 066802). Groundwater monitoring is conducted under annual updates to the Interim Facility-Wide Groundwater Monitoring Plan (LANL 2016, 601506).

4.0 SITE DESCRIPTION AND PROPOSED INVESTIGATION ACTIVITIES

The following section presents site descriptions, summaries of previous investigation activities, proposed sampling activities, and proposed remedial activities for each SWMU and AOC addressed in this plan. A variety of resources aided in defining and revising the boundaries of each site; which are shown in figures corresponding to each site description. Existing structures, roads, and other features that could readily be observed in the field were of prime importance in defining site boundaries. If these features could still be observed in the field, site boundaries were then established relative to these landmarks. Other types of data references were also used, particularly for former site locations where significant changes have occurred over time. Historic aerial photographs have been an excellent resource. Drawings and sketches were used, particularly for locating structures and utilities, as well as engineering drawings produced for construction or record purposes. For each site, available information was reviewed, conflicting information was resolved as satisfactorily as possible, and site locations and boundaries were revised accordingly.

4.1 AOC 15-001, Storage Area

4.1.1 Site Description

AOC 15-001 consists of a storage area, referred to as “The Boneyard,” located within TA-15 adjacent to inactive Firing Site G [SWMU 15-004(g)] (Figure 4.1-1). AOC 15-001 is located just northeast of a former firing bunker (structure 15-9). The area was used to store materials associated with activities at the DARHT and PHERMEX facilities. These materials, which included equipment, steel, experimental vessels, and construction debris, were stored in the open, on the ground surface, and within transportainers and small storage sheds. Materials stored at AOC 15-001 before the mid-1990s have been removed, but small pieces of debris (e.g., metal scrap) may still be present. The area is currently being used to store equipment associated with ongoing activities at TA-15 (Appendix C, Figure C-1).

4.1.2 Previous Investigations

Although previous investigations have not specifically addressed AOC 15-001, they have addressed the general area that could have been impacted by Firing Site G [SWMU 15-004(g)], including the area occupied by AOC 15-001. A 1982 aerial radiological survey identified no radionuclides above background levels at Firing Site G or adjacent areas. However, during surface surveys performed at the site in 1991 and 1996, several areas of radiological surface contamination were identified. This contamination is believed to be associated with uranium debris from tests conducted at Firing Site G. Although investigation of AOC 15-001 was proposed in the Operable Unit (OU) 1086 RFI work plan, investigation of this site was deferred during the 1995–1996 RFI because it was an active site (LANL 1996, 054977, p. 5-1). However, three surface samples were collected at three locations within and adjacent to AOC 15-001 from depth intervals of 0–0.25 ft, 0–0.33 ft, and 0–0.5 ft below ground surface (bgs). The samples were submitted to an off-site contract analytical laboratory for analysis of uranium.

The data for this investigation are screening level and are presented in the HIR.

4.1.3 Proposed Activities

The nature and extent of contamination have not been defined at this site. A total of 42 samples will be collected from 14 locations (Figure 4.1-1). At each location, samples will be collected at 0.0–1.0 ft bgs, 2.0–3.0 ft bgs, and 4.0–5.0 ft bgs. Samples will be collected from within the footprint and around the perimeter of the former storage area to define the nature and extent of contamination from historical storage activities at this site.

Because this site is associated with firing site activities, including radiography, all samples will be analyzed for target analyte list (TAL) metals, nitrate, perchlorate, pH, explosive compounds, gamma-emitting radionuclides, and isotopic uranium. Investigation samples collected from this site will not be analyzed for cyanide, dioxins/furans, polychlorinated biphenyls (PCBs), and volatile organic compounds (VOCs) because these constituents are not associated with storage or firing site activities. However, samples will be analyzed for semivolatile organic compounds (SVOCs) because the exact nature of the materials stored at the site is not known. Table 4.1-1 summarizes the proposed sampling locations, depths, and analytical suites.

4.2 AOC 15-004(h), Firing Site H

4.2.1 Site Description

AOC 15-004(h) is inactive Firing Site H located northwest of the PHERMEX facility at TA-15 (Figure 4.2-1). Firing Site H is located approximately 100 ft north of the PHERMEX power control building (structure 15-185). The explosives testing firing site was constructed in 1948 and included a concrete pad, a protective berm, an instrument chamber (former structure 15-17), and a camera chamber (structure 15-92). The exact nature of the materials used during tests is not known but may have included DU, beryllium, lead, and HE. Firing site operations were discontinued in approximately 1953 (LANL 1993, 020946, p. 8-23), and the instrument chamber was demolished in 1967. The camera chamber and the concrete pad remain on-site, but the concrete pad has been partially covered with fill.

4.2.2 Previous Investigations

Although the investigation of AOC 15-004(h) was proposed in the OU 1086 Resource Conservation and Recovery Act facility investigation (RFI) work plan, the investigation of this site was deferred during the 1995–1996 RFI because it was within the active PHERMEX hazard area (LANL 1996, 054977, p. 5-1). However, 11 surface samples (0.0–0.17 ft bgs to 0.0–0.5 ft bgs) and 7 subsurface samples (1.08–1.58 ft bgs or 1.5–2.0 ft bgs) were collected from 11 locations. The samples were submitted to an off-site contract analytical laboratory for analysis of uranium.

The data for this investigation are screening level and are presented in the HIR.

4.2.3 Proposed Activities

The nature and extent of contamination have not been defined at this site. A total of 60 samples will be collected from 20 locations (Figure 4.2-1). Sampling locations will be sited around the perimeter of the former firing pad and within the area potentially impacted by the former firing site to define the nature and extent of contamination. Samples will be collected adjacent to each side of the firing pad and at accessible step-out locations 50, 100, and 200 ft from the center of the firing site. At each location, samples will be collected at depth intervals of 0.0–1.0 ft bgs, 2.0–3.0 ft bgs, and 4.0–5.0 ft bgs.

The firing site ceased operation in 1953, before the PHERMEX facility was constructed (1959–1961). During construction of PHERMEX, the access road to the south side of PHERMEX was constructed directly west of Firing Site H. The road cut was excavated through the tuff bedrock, and the current ground surface adjacent to the road consists of the side slopes of the road cut. The ground surface that existed when the firing site was operational was excavated during construction of the road, and the current ground surface consists primarily of exposed tuff and is not representative of the ground surface that could have been impacted by firing site operations (Appendix C, Figure C-2). Therefore, no samples will be collected from the side slopes adjacent to the road west of the firing site.

Because this site is associated with firing site activities, all samples will be analyzed for TAL metals, nitrate, perchlorate, pH, explosive compounds, and isotopic uranium. Investigation samples collected from this site will not be analyzed for cyanide, dioxins/furans, PCBs, SVOCs, and VOCs because these constituents are not associated with firing site activities. Table 4.2-1 summarizes the proposed sampling locations, depths, and analytical suites.

4.3 SWMU 15-009(g), Septic System

4.3.1 Site Description

SWMU 15-009(g) consists of an inactive septic system at the PHERMEX facility that is located south of the chamber building (structure 15-184) (Figure 4.3-1). The septic system consists of a septic tank (structure 15-205), leach field, and inlet and outlet drainlines. The 4 ft × 8 ft × 5 ft reinforced concrete septic tank was installed in 1960 and has a capacity of 605 gal. The septic tank discharged to a 10 ft × 75 ft leach field (LASL 1959, 601541). The septic system received sanitary wastes from restrooms, sinks, and a water fountain within the power control building (structure 15-185) and from floor drains, a restroom, and a hot water heater within the detection chamber (structure 15-186) (Santa Fe Engineering Ltd. 1992, 020981). Beginning in 1987, the septic system began receiving discharges from restrooms within the PHERMEX Multidiagnostic Operations Building (structure 15-310). Engineering drawing C-49874, sheet 5, indicates that in 1996, the noncontact cooling water discharge from building 15-184 was plumbed into the sanitary line connected to the SWMU 15-009(g) septic system (LANL 1996, 601540). All facilities connected to the septic system are now inactive, and there is currently no discharge to the system.

4.3.2 Previous Investigations

No previous investigations have been conducted at SWMU 15-009(g).

4.3.3 Proposed Activities

The nature and extent of contamination have not been defined at this site. If it is determined the septic tank can be released as being free of HE, the septic tank and its contents will be removed and disposed of at an appropriate waste facility in accordance with the methods discussed in section 5.12. Otherwise, the tank contents will be removed and the tank will be closed by plugging the inlet and outlet and filling the tank with concrete or flowable fill. Site characterization will be performed following tank removal or closure. Sampling locations will be targeted at the septic tank, beneath inlet and outlet drainlines, and within and around the leach field to define nature and extent of contamination (Figure 4.3-1). Twenty-four samples will be collected from eight locations adjacent to the inlet drainlines, including locations where drainlines from buildings join. Samples will be collected from three depths (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the drainline) at each location. Six samples will be collected beneath the tank inlet and tank outlet. Samples will be collected from three depths (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the inlet and outlet). Three samples will be collected from one location below the tank if the tanks is removed or adjacent to the tank if left in place. Samples will be collected from three depths (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the base of the tank). Nine samples will be collected from three locations beneath the leach field. As described in section 5.5, exploratory trenches will be excavated across the leach field to locate the drainpipes and determine their depths. Samples will be collected from three depths (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the base of the leach field drainlines). Twenty-one samples will also be collected from seven locations around the leach field boundary. Samples will be collected from three depths (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the base of the leach field drainlines).

The SWMU 15-009(g) septic system primarily received sanitary wastewater. Hazardous materials could potentially have been released to the septic system through floor drains, although this is not known to have occurred. The structures connected to the SWMU 15-009(g) septic system generally housed the power supply, detectors, and other equipment associated with PHERMEX, and the specific materials present in these structures are not known. Based on the nature of activities conducted at PHERMEX (i.e., firing site experiments, radiography), all samples will be analyzed for TAL metals, nitrate, perchlorate, pH, explosive compounds, gamma-emitting radionuclides, and isotopic uranium and will not be analyzed for SVOCs and dioxins/furans. Because the system received sanitary wastewater, samples will also be analyzed for cyanide, and because solvents are sometimes associated with maintenance of electrical equipment, samples will be analyzed for VOCs. Although PCBs may have been associated with the building 15-185 power supplies, the septic system received discharges only from restrooms and sinks in that building, and samples will not be analyzed for PCBs. [Floor drains in building 15-185 discharged to AOC 15-014(d) and SWMU 15-014(l) and samples from those sites will be analyzed for PCBs.] Table 4.3-1 summarizes the proposed sampling locations, depths, and analytical suites.

4.4 AOC 15-014(d), Drainline and Outfall

4.4.1 Site Description

AOC 15-014(d) consists of a drainline and outfall located south of the PHERMEX facility in the southeast portion of TA-15 (Figure 4.4-1). The outfall received storm water from roof drains on the power control building (structure 15-185) and discharge from the SWMU 15-014(l) outfall. SWMU 15-014(l) received wash water from floor drains in building 15-185 and cooling tower blowdown from structure 15-202 (Santa Fe Engineering Ltd. 1992, 020981). Engineering drawing ENG-C-37323 (LASL 1969, 601543) indicates that the AOC 15-014(d) drainline, which consists of a corrugated metal pipe connected to the SWMU 15-014(l) outfall and the building 15-185 roof drains, was installed in approximately 1969. Before that time, the roof drain and floor drains from building 15-0185 discharged to the paved area behind the building and flowed to a drainage channel adjacent to the roadway south of PHERMEX. The AOC 15-014(d) outfall is located at the head of a drainage channel that flows to Water Canyon. The outfall still receives storm water from the roof drains on building 15-185, as well as any storm water entering the SWMU 15-014(l) drop inlet.

4.4.2 Previous Investigations

No previous investigations have been conducted at AOC 15-014(d).

4.4.3 Proposed Activities

Twenty-one samples will be collected from seven locations (Figure 4.4-1). Samples will be collected at the AOC 15-014(d) outfall and approximately every 100 ft within the drainage below the outfall to define nature and extent of contamination. Sampling will cease when the drainage becomes too steep to safely collect samples. Samples will be collected from three depth intervals (0.0–1.0 ft bgs, 2.0–3.0 ft bgs, and 5.0–6.0 ft bgs) at each location.

Based on the nature of activities conducted at PHERMEX (i.e., firing site experiments, radiography), all samples will be analyzed for TAL metals, nitrate, perchlorate, pH, explosive compounds, gamma-emitting radionuclides, and isotopic uranium and will not be analyzed for cyanide, SVOCs, and dioxins/furans. Because the site also received discharges of cooling tower blowdown, all samples will be analyzed for hexavalent chromium. Although solvents may have been present in building 15-185, samples will not be analyzed for VOCs because VOCs should not be persistent from historical discharges of wastewater to the surface. Table 4.4-1 summarizes the proposed sampling locations, depths, and analytical suites.

4.5 SWMU 15-014(l), Drainline and Outfall from Building 15-185

4.5.1 Site Description

SWMU 15-014(l) is a drainline and formerly permitted outfall (EPA 03A028) for a cooling tower (structure 15-202) located at the PHERMEX facility in TA-15 (Figures 4.2-1 and 4.5-1). This drainline and outfall received blowdown discharge from the cooling tower, which was installed in 1961. Cooling water was piped to building 15-185 and blowdown discharged to a basement floor drain. The basement floor drain discharged to a concrete gutter in the paved area south of building 15-185 (LASL 1961, 601542). Discharges from the gutter flowed to a drainage ditch adjacent to the roadway and into a culvert that drained to the ground surface south of the roadway. This culvert also received discharges from the floor drains in building 15-184. In 1969, a corrugated metal pipe was installed to convey discharges from the SWMU 15-014(l) outfall to a new outfall south of the parking area and roadway (LASL 1969, 601543). The drainline and outfall installed in 1969 comprise AOC 15-014(d). The SWMU 15-014(l) outfall is currently located within a drop inlet in a paved area outside the southeast corner of building 15-185 (Appendix C, Figure C-3). Outfall 03A028 was removed from the Laboratory's National Pollutant Discharge Elimination System (NPDES) permit in 2007. The outfall currently receives only storm water discharges from the paved area around the drop inlet.

4.5.2 Previous Investigations

No previous investigations have been conducted at SWMU 15-014(l).

4.5.3 Proposed Activities

Fifteen samples will be collected from five locations (Figure 4.5-1). Samples will be collected along the drainlines into and out of the drop inlet and at one location along the drainline between the SWMU 15-014(l) outfall and the AOC 15-014(d) outfall to define the nature and extent of contamination. Samples will be collected at three depth intervals (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below the drainlines) at each location. Samples will also be collected at two locations in the drainage ditch that formerly received discharges from the paved area south of building 15-185, upgradient of where the drainage ditch joins the culvert that formerly received discharges from building 15-184. Samples will be collected at three depth intervals (0.0–1.0 ft bgs, 2.0–3.0 ft bgs, and 5.0–6.0 ft bgs) at each location.

Based on the nature of activities conducted at PHERMEX (i.e., firing site experiments, radiography), all samples will be analyzed for TAL metals, nitrate, perchlorate, pH, explosive compounds, gamma-emitting radionuclides, and isotopic uranium and will not be analyzed for cyanide, SVOCs, and dioxins/furans. Although additives were reportedly not added to the cooling tower, samples will also be analyzed for hexavalent chromium to verify it was not discharged. Because the outfall received discharges from a floor drain in building 15-185, which contains electrical equipment, samples will also be analyzed for PCBs. Although solvents may have been present in building 15-185, samples will not be analyzed for VOCs because VOCs should not be persistent from historical discharges of wastewater to the surface. Table 4.5-1 summarizes the proposed sampling locations, depths, and analytical suites.

4.6 AOC C-15-011, Former Underground Tank

4.6.1 Site Description

AOC C-15-011 consists of a former underground fuel storage tank (structure 15-274) that was located at the PHERMEX facility in the southeast portion of TA-15 (Figure 4.6-1). The galvanized steel storage tank was installed in 1973 and was located immediately south of the power control building (structure 15-185). The storage tank had a capacity of 218 gal., and the bottom of the tank was reported to be 6 ft bgs. The tank was removed in 1987 (LANL 1993, 020946, p. 8-26). The surface of the former tank location is now an asphalt parking lot (Appendix C, Figure C-4).

4.6.2 Previous Investigations

During the 1995–1996 RFI conducted at AOC C-15-011, two subsurface samples were collected from one borehole from depth intervals of 6 ft bgs and 10 ft bgs next to the former tank location. The samples were field-screened for radioactivity and submitted to an off-site contract analytical laboratory for analysis of VOCs and SVOCs.

The data for this investigation are screening level and are presented in the HIR.

4.6.3 Proposed Activities

Six samples will be collected from two locations to define the nature and extent of contamination (Figure 4.6-1). Three samples will be collected at the location of the RFI samples, and three samples will be collected approximately 10 ft downgradient of this location. The bottom of the former tank was reported to be 6 ft bgs; therefore samples be collected at three depth intervals (6.0–7.0 ft bgs, 9.0–10.0 ft bgs, and 14.0–15.0 ft bgs) at each location.

Because the underground tank was used to store gasoline, all samples will be analyzed for TAL metals, pH, VOCs, SVOCs, and total petroleum hydrocarbons gasoline range organics (TPH-GRO) and will not be analyzed for cyanide, nitrate, perchlorate, PCBs, dioxins/furans, explosive compounds, gamma-emitting radionuclides, and isotopic uranium. Table 4.6-1 summarizes the proposed sampling locations, depths, and analytical suites.

5.0 INVESTIGATION METHODS

Table 5.0-1 presents a summary of investigation methods to be implemented. The standard operating procedures (SOPs) used to implement these methods are listed at http://www.lanl.gov/community-environment/environmental-stewardship/_assets/docs/external-plans-procedures.pdf and can be downloaded from http://eprr.lanl.gov/oppie/service. Summaries of the field investigation methods are provided below. Additional procedures may be added as necessary to describe and document activities affecting quality.

Chemical analyses will be performed in accordance with the Laboratory's analytical statement of work. Accredited off-site contract analytical laboratories will use the most recent EPA and industry-accepted extraction and analytical methods for chemical analyses of analytical suites.

5.1 Establishing Sampling Locations

Proposed sampling locations are identified for each site based on engineering drawings, surveyed locations of existing structures, previous sampling locations, and topography or other features identified in the field, such as drainage channels and sediment accumulation areas. The coordinates of proposed locations will be obtained by georeferencing the points from the proposed sampling maps. The coordinates will be used to locate flags or other markers in the field using a differential global positioning system (GPS) unit. If any proposed sampling locations are moved because of field conditions, utilities, or other unexpected reasons, the new locations will be surveyed immediately following sample collection as described in section 5.2.

5.2 Geodetic Surveys

Geodetic surveys will be conducted in accordance with the latest version of SOP EP-ERSS-SOP-5028, Coordinating and Evaluating Geodetic Surveys, to locate historical structures and to document field activities such as sampling and excavation locations. The surveyors will use a Trimble GeoXT handheld GPS or equivalent for the surveys. The coordinate values will be expressed in the New Mexico State Plane Coordinate System (transverse mercator), Central Zone, North American Datum 1983. Elevations will be reported as per the National Geodetic Vertical Datum of 1929. All GPS equipment used will meet the accuracy requirements specified in the SOP.

5.3 Field Screening

The primary field-screening methods to be used on samples include radiological screening, vapor screening using a photoionizing detector (PID), and screening for explosive compounds.

5.3.1 Organic Vapors

Based on site histories and previous RFI results, VOC contamination is not expected to be encountered. Organic vapor screening of surface and subsurface samples will be conducted using a PID with an 11.7-electron-volt lamp. All samples will be screened in accordance with SOP-06.33, Headspace Vapor Screening with a photoionization detector. Before each day's field work begins, the PID will be calibrated to the manufacturer's standard for instrument operation. All instrument background checks, background ranges, and calibration procedures will be documented daily in field logbooks.

5.3.2 Radioactivity

Radiological field screening will be conducted to meet of U.S. Department of Transportation requirements for shipping samples. Each sample will be field-screened by a radiological control technician for gross-alpha, -beta, and -gamma radioactivity before the samples are transported to the Sample Management Office (SMO) for processing as determined by the Laboratory's Deployed Environment, Safety, and Health Services Division (DESHS). Instruments used for field screening will be calibrated in accordance with the DESHS procedures or equivalent procedures. All instrument calibration activities will be documented daily in the field logbooks.

5.3.3 Explosive Compounds

All samples will be field-screened quantitatively for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and TNT (2,4,6-trinitrotoluene) using Strategic Diagnostics, Inc., ENSYS immunoassay test kits.

5.4 Sampling

Soil, fill, sediment, and tuff samples will be collected by the most efficient and least invasive method practicable. The methods will be determined by the field team based on site conditions, such as topography, the nature of the material to be sampled, the depth intervals required, accessibility, and level of disruption to laboratory activities. Typically, samples will be collected using spade and scoop, hand auger, or drill rig.

5.4.1 Surface Sampling

5.4.1.1 Spade-and-Scoop Method

Surface and shallow subsurface soil and sediment samples will be collected in accordance with SOP-06.09, Spade and Scoop Method for the Collection of Soil Samples. Stainless-steel shovels, spades, scoops, and bowls will be used for ease of decontamination. If the surface location is at bedrock, an axe or hammer and chisel may be used to collect samples. Samples collected for analyses will be placed in the appropriate sample containers depending on the analytical method requirement.

5.4.1.2 Sediment Samples

Sediment samples will be collected from areas of sediment accumulation that include sediments judged representative of the historical period of Laboratory operations post-1943. The proposed sediment sampling locations will be selected based on geomorphic relationships in areas likely to have been affected by discharges from Laboratory operations. Selected sediment sampling locations shown in proposed sampling location figures are based on map contours. However, because sediment is dynamic and subject to redistribution by runoff events, some locations may need to be adjusted when this work plan is implemented.

In the course of collecting sediment samples, it may be determined, based on field conditions, that the selected location is not appropriate—for example, the sediment is much shallower than anticipated, the sediment is predominantly coarse-grained, or the sediment shows evidence of being older than the target age. Sediment sampling locations will be adjusted as appropriate, any revised locations will be surveyed, and the updated coordinates will be submitted to the Laboratory for inclusion in the Environmental Information Management database.

5.4.2 Subsurface Samples

Subsurface sampling is proposed to include soil, fill, sediment, and tuff. Any adjustments to sampling locations or sampling intervals will be noted on sample collection logs and recorded in the subsequent investigation report as deviations from this investigation work plan. Subsurface samples will be collected following the current version of SOP-06.24, Sample Collection from Split-Spoon Samplers and Shelby Tube Samplers, and SOP-06.26, Core Barrel Sampling for Subsurface Earth Materials.

5.4.2.1 Hand Auger

Hand augers or power-assisted augers may be used to drill shallow holes at locations that can be sampled without the use of a drill rig and at locations inaccessible by a drill rig. The hand auger is advanced by turning the auger into the soil or tuff until the barrel is filled. The auger is removed and the sample is placed in a stainless-steel bowl. Hand-auger samples will be collected in accordance with ER-SOP-20069, Soil, Tuff, and Sediment Sampling.

5.4.2.2 Hollow-Stem Auger

Boreholes will be drilled using a drill rig equipped with a hollow-stem auger. The hollow-stem auger consists of a hollow-steel shaft with a continuous spiraled steel flight welded onto the exterior of the stem. The stem is connected to an auger bit; when the bit is rotated, it transports cuttings to the surface. The hollow stem of the auger allows insertion of drill rods, split-spoon core barrels, Shelby tubes, and other samplers through the center of the auger so that samples may be retrieved during drilling operations. The hollow stem also acts to case the borehole core temporarily so a well casing (a riser) may be inserted down through the center of the auger when the desired depth is reached, thus minimizing the risk of possible borehole collapse.

A bottom plug or pilot bit can be fastened onto the bottom of the auger to keep out most of the soil and/or water that tends to clog the bottom of the augers during drilling. Drilling without a center plug is acceptable if the soil plug, formed in the bottom of the auger, is removed before sampling or installing a well casing. The soil plug can be removed by washing out the plug using a side-discharge rotary bit or auguring out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger.

During sampling, the auger will be advanced to just above the desired sampling interval. The sample will be collected by driving a split-spoon sampler into undisturbed soil/tuff to the desired depth. Samples will be collected in accordance with SOP-06.26, Core Barrel Sampling for Subsurface Earth Materials.

If samples are collected for VOC analysis, the sampler will be lined with brass sleeves. Immediately upon retrieval of the sampler, it will be opened and a sleeve from the desired depth interval will be collected for VOC analysis. The ends of the sleeve will be covered immediately with Teflon film and capped with plastic caps. Tape will then be used to seal the ends of the cap to the sleeve. Material from the remaining sleeves will be field-screened, visually inspected, and placed in a stainless-steel bowl. Samples for the remaining analysis will be transferred to appropriate sample containers, depending upon the analytical method requirement.

Field documentation will include detailed borehole logs for each borehole drilled using the hollow-stem auger method. The borehole logs will document the matrix material in detail and will include the results of all field screening; fractures and matrix samples will be assigned unique identifiers.

5.4.3 Borehole Abandonment

All hollow-stem auger boreholes will be properly abandoned in accordance with SOP-5034, Monitor Well and RFI Borehole Abandonment. Shallow boreholes, with a total depth of 20 ft or less, will be abandoned by filling the borehole with bentonite chips and then hydrating the chips in 1- to 2-ft lifts. The borehole will be visually inspected while the bentonite chips are being added to ensure bridging does not occur.

Boreholes greater than 20 ft deep will be pressure-grouted from the bottom of the borehole to the surface using the tremie pipe method. Acceptable grout materials include cement or bentonite grout, neat cement, or concrete.

The use of backfill materials such as bentonite and grout will be documented in a field logbook with respect to volumes (calculated and actual), intervals of placement, and additives used to enhance backfilling. All borehole abandonment information will be presented in the investigation report.

5.5 Excavation

Exploratory trenches will be used to locate the drainlines in the leach field at SWMU 15-009(g). Excavations will be completed using a track excavator or backhoe. Excavated soil will be staged a minimum of 3 ft from the edge of the excavation. After completion of sampling, the excavations and/or trenches will be backfilled with the staged overburden.

5.6 Chain of Custody for Samples

The collection, screening, and transport of samples will be documented on standard forms generated by the SMO. These include sample collection logs, chain-of-custody forms, and sample container labels. Sample collection logs will be completed at the time of sample collection and signed by the sampler and a reviewer who will verify the logs for completeness and accuracy. Corresponding labels will be initialed and applied to each sample container, and custody seals will be placed around container lids or openings. Chain-of-custody forms will be completed and signed to verify that the samples are not left unattended.

5.7 Quality Assurance/Quality Control Samples

Quality assurance and quality control samples will include field duplicate, equipment rinsate, and field trip blank samples. These samples will be collected following the current version of SOP 5059, Field Quality Control Samples. Field duplicate samples will be collected at an overall frequency of at least 1 for every 10 regular samples as directed by Section IX.C.3.b of the Consent Order.

5.8 Laboratory Analytical Methods

Analytical suites vary by site as indicated in Tables 4.1-1 through 4.6-1. All analytical methods are presented in the Laboratory’s statement of work for analytical laboratories (LANL 2000, 071233). Sample collection and analysis will be coordinated with the SMO.

5.9 Health and Safety

The field investigations described in this investigation work plan will comply with all applicable requirements pertaining to worker health and safety. An integrated work document and a site-specific health and safety plan will be in place before fieldwork is performed.

5.10 Equipment Decontamination

Equipment for drilling and sampling will be decontaminated before and after sampling activities to minimize the potential for cross-contamination. Dry decontamination methods will be used to avoid the generation of liquid waste and to minimize the IDW. Dry decontamination uses disposable paper towels and over-the-counter cleaner, such as Fantastik or equivalent. All sampling and measuring equipment will be decontaminated in accordance with SOP-5061, Field Decontamination of Equipment.

Dry decontamination may be followed by wet decontamination, if necessary. Wet decontamination may include washing with a nonphosphate detergent and water, followed by a water rinse and a second rinse with deionized water. Alternatively, drilling/exploration equipment that may come in contact with the borehole will be decontaminated by steam cleaning, by hot water pressure-washing, or by another method before each new borehole is drilled. The equipment will be pressure-washed with a high-density polyethylene liner on a temporary decontamination pad. Cleaning solutions and wash water will be collected and contained for proper disposal. Decontamination solutions will be sampled and analyzed to determine the final disposition of the wastewater and the effectiveness of the decontamination procedures.

5.11 Investigation-Derived Waste

IDW generated by the proposed investigation activities may include, but is not limited to, drill cuttings, excavated soil or other environmental media, contact waste such as personal protective equipment, decontamination fluids, spent solvents from HE field screening, and all other waste that has potentially come into contact with contaminants.

All IDW generated during field investigation activities will be managed in accordance with applicable EPA and NMED regulations, DOE orders, and Laboratory requirements. Appendix B presents the IDW management plan.

5.12 Removal Activities

Removal of the inactive septic tank associated with SWMU 15-009(g) is proposed under this investigation work plan if the tank can be shown to be free of HE contamination and released from the site. The procedure for tank removal is described below. If it is determined that the tank cannot be released as being free from HE contamination, the tank will be closed in place rather than removed by removing the contents, plugging the tank inlet and outlet, and filling the tank with flowable fill or concrete.

Soil, fill, or other material covering the septic tank will be excavated and stockpiled next to the excavation. Once exposed, the location of the septic tank and its dimensions will be surveyed. The contents will be sampled and characterized for waste management purposes. The septic tank and its contents will be removed and disposed of at an appropriate waste disposal facility. The inlet and outlet drainlines to the tank will be plugged. Potentially contaminated soil beneath the tank will be excavated, characterized, and disposed of at an appropriate waste disposal facility.

After the septic tank has been removed or closed in place, confirmation samples will be collected from beneath the inlet and outlet, and below or adjacent to the tank. Samples will be collected from three depths below the septic tank inlet and outlet lines (0.0–1.0 ft, 2.0−3.0 ft, and 5.0–6.0 ft below the base of inlet and outlet lines). Samples will be collected from three depths below the septic tank (0.0–1.0 ft, 2.0–3.0 ft, and 5.0–6.0 ft below base of tank). All samples will be analyzed for TAL metals, cyanide, nitrate, perchlorate, pH, VOCs, explosive compounds, gamma-emitting radionuclides, and isotopic uranium. The excavated area will be backfilled with clean fill and material excavated from the surface of the septic tank. Table 4.3-1 summarizes the proposed locations, depths, and analytical suites.

6.0 MONITORING PROGRAMS

Groundwater, sediment, and surface water monitoring within the Lower Water/Indio Canyons Aggregate Area is being performed by the Laboratory as part of other environmental activities. This monitoring is described briefly below.

6.1 Groundwater

Section IV.B.6.b.iii of the Consent Order, as implemented under the Laboratory's annual Interim Facility-Wide Groundwater Monitoring Plan, requires monitoring and sampling of all wells that contain alluvial, intermediate, and regional groundwater located in the Lower Water/Indio Canyons Aggregate Area. Alluvial groundwater monitoring well WCO-1r, intermediate groundwater monitoring well R-27i, and regional groundwater monitoring well R-27 are located in the aggregate area. These wells are monitored as part of the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2016, 601506).

6.2 Sediment and Surface Water

One site monitoring area (SMA), W-SMA-14.1, is located within the aggregate area. This SMA is used to monitor storm water discharges from AOC 15-004(h) and SWMU 15-014(l) that are included in the Laboratory's NPDES individual permit. Rain gage 262.4 is located about 0.5 mi northwest of PHERMEX.

7.0 SCHEDULE

Preparation for investigation activities is anticipated to take approximately 3 mo. Fieldwork is expected to take 3–4 mo, and preparation of the investigation report is anticipated to take approximately 6 mo after field work activities are completed. The total duration to implement the investigation and submit the final report is anticipated to be approximately 1 yr.

8.0 REFERENCES AND MAP DATA SOURCES

8.1 References

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the ESH Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH 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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8.2 Map Data Sources

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SWMU or AOC: er_res_all_reg; Potential Release Sites; Los Alamos National Laboratory, ESH&Q Waste & Environmental Services Division, Environmental Data and Analysis Group, EP2010-1C; 1:2,500 Scale Data; 02 December 2010.

Structure or building: ksl_structures_ply; Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Fence: ksl_fences_arc: Security and Industrial Fences and Gates; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

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Surface Water Sampling Station: er_location_ids_pnt; ER Project Locations; Los Alamos National Laboratory, ESH&Q Waste and Environmental Services Division, 2010-2E; 1:2,500 Scale Data; 04 October 2010.

Lower Water/Indio Canyons Canyon Aggregate Area: er_agg_areas_ply; Aggregate Areas; Los Alamos National Laboratory, ENV Environmental Remediation & Surveillance Program, ER2005-0496; 1:2,500 Scale Data; 22 September 2005.

Technical area boundary: plan_tecareas_arc; Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

LANL boundary: plan_tecareas_ply; Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

River: wqh_drainage_arc: WQH Drainage_arc; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; 1:24,000 Scale Data; 03 June 2003.

Spring: er_springs_pt: Locations of Springs; Los Alamos National Laboratory, Waste and Environmental Services Division in cooperation with the New Mexico Environment Department, Department of Energy Oversight Bureau, EP2008-0138; 1:2,500 Scale Data; 17 March 2008.

Surface Water Monitoring Station: er_location_ids_pnt; ER Project Locations; Los Alamos National Laboratory, ESH&Q Waste and Environmental Services Division, 2010-2E; 1:2,500 Scale Data; 04 October 2010.

Primary paved road: ksl_centerline_arc; Road Centerlines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 15 December 2005; Unknown publication date.

Secondary paved road: ksl_centerline_arc; Road Centerlines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 15 December 2005; Unknown publication date.

Contours: lanl_contour1991_; Hypsography, 2, 10, 20, 100 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

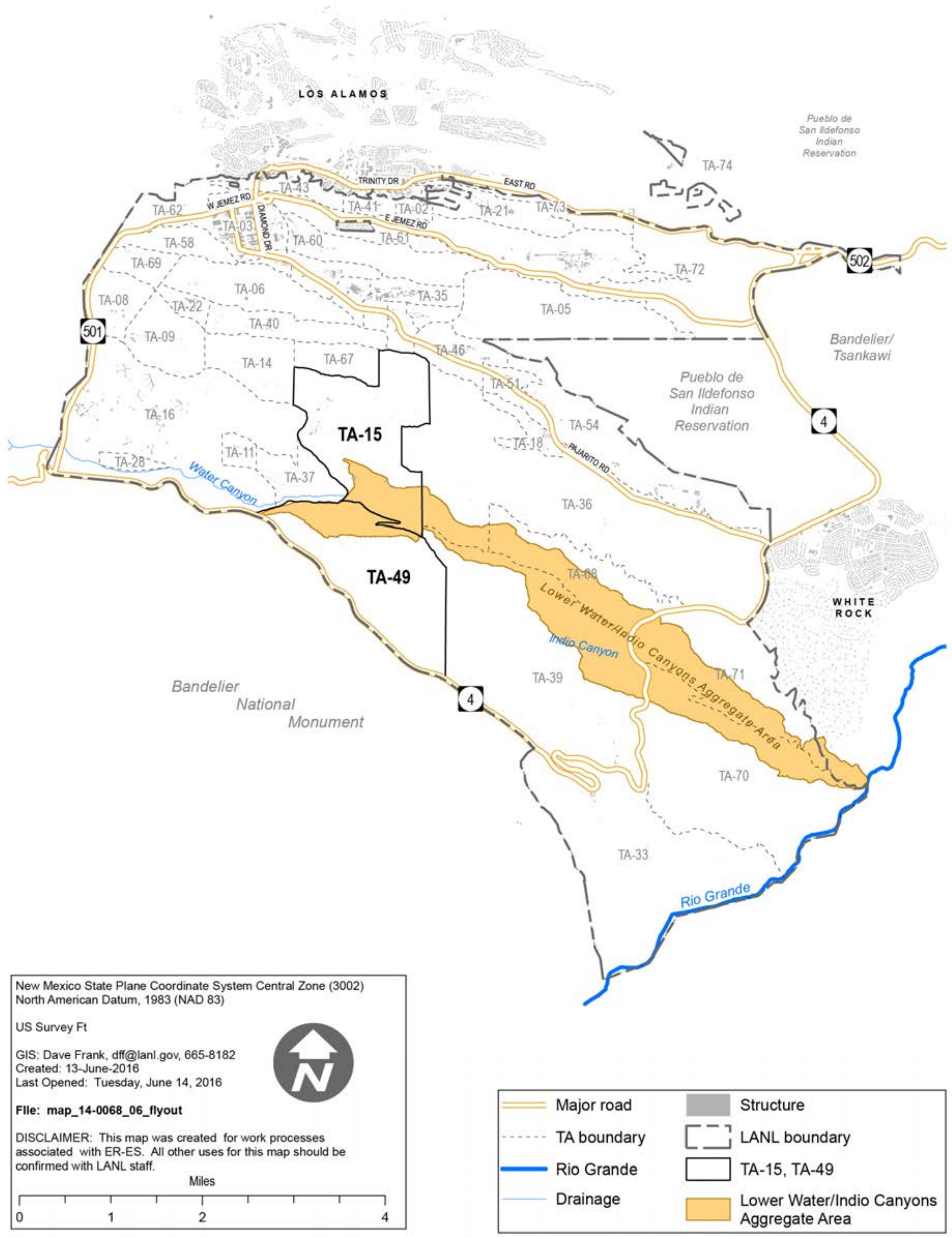

Figure 1.0-1 Location of Lower Water/Indio Canyons Aggregate Area with respect to Laboratory technical areas and surrounding land holdings

Bandelier Tuff	Tshirege Member (Qbt)	Qbt 4	Ash-Flow Units
		Qbt 3	
		Qbt 2	
		Qbt 1v	
		Qbt 1g	
		Tsankawi Pumice Bed	
Cerro Toledo Interval (Qct)		Volcaniclastic Sediments and Ash-Falls	
Bandelier Tuff	Otowi Member (Qbo)	Ash-Flow Units	
		Guaje Pumice Bed (Qbog)	
Puye Formation (Tp)	Fanglomerate	Fanglomerate Facies includes sand, gravel, conglomerate, and tuffaceous sediments	
	Basalt and Andesite	Cerros del Rio Basalts intercalated within the Puye Formation, includes up to four interlayered basaltic flows. Andesites of the Tschicoma Formation present in western part of plateau	
	Fanglomerate	Fanglomerate Facies includes sand, gravel, conglomerate, and tuffaceous sediments; includes "Old Alluvium"	
	Axial facies deposits of the ancestral Rio Grande	Totavi Lentil	
Santa Fe Group	Coarse Sediments	Coarse-Grained Upper Facies (formerly called the "Chaquehui Formation" by Purtymun 1995, 045344)	
	Basalt		
	Coarse Sediments		
	Basalt		
	Coarse Sediments		
	Basalt		
	Coarse Sediments		
	Arkosic clastic sedimentary deposits	Undivided Santa Fe Group (includes Chamita[?] and Tesuque Formations)	

Source: Adapted from (LANL 1999, 064617).

Figure 3.2-1 Generalized stratigraphy of bedrock geologic units of the Pajarito Plateau

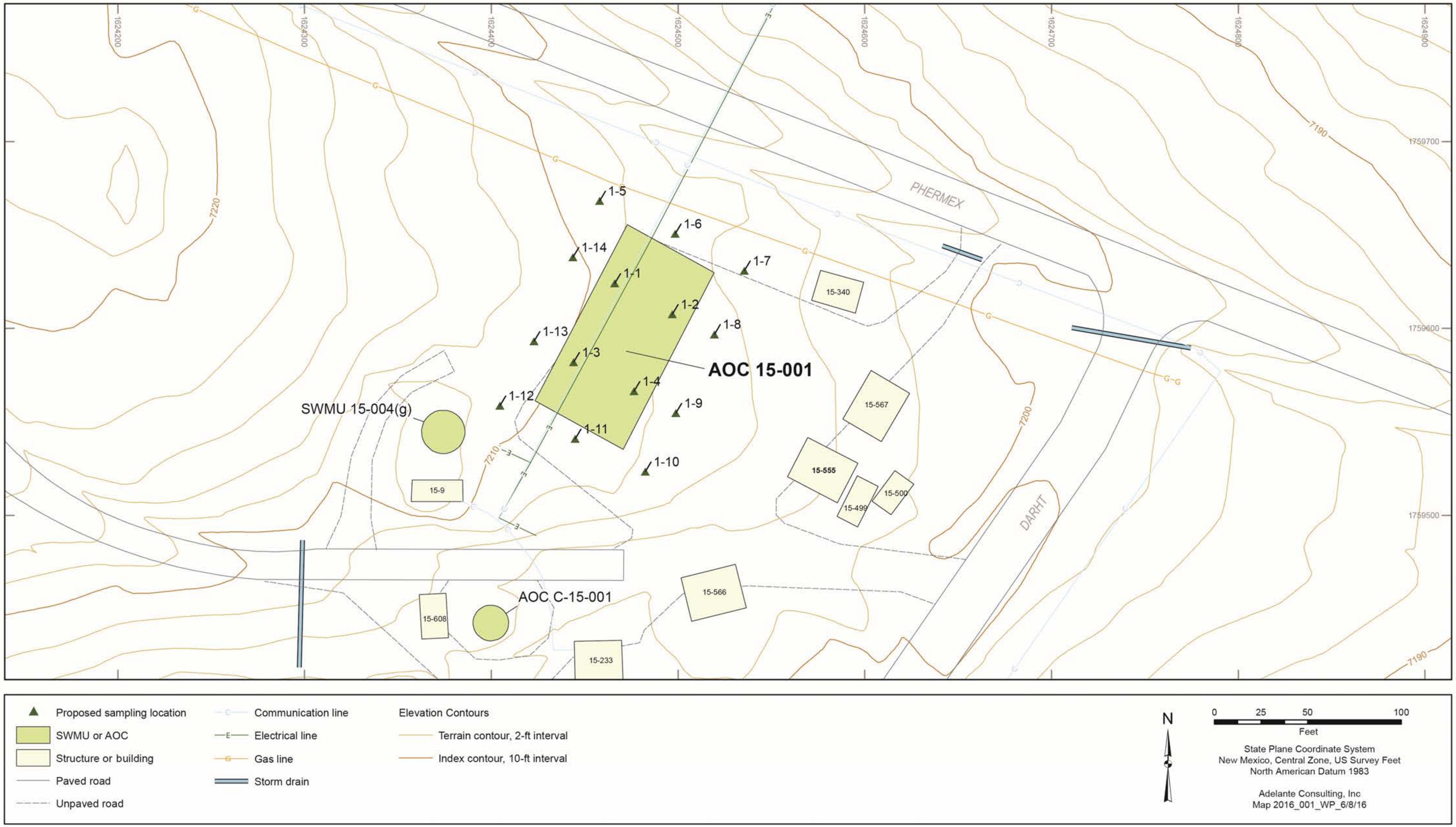

Figure 4.1-1 Proposed sampling locations at AOC 15-001

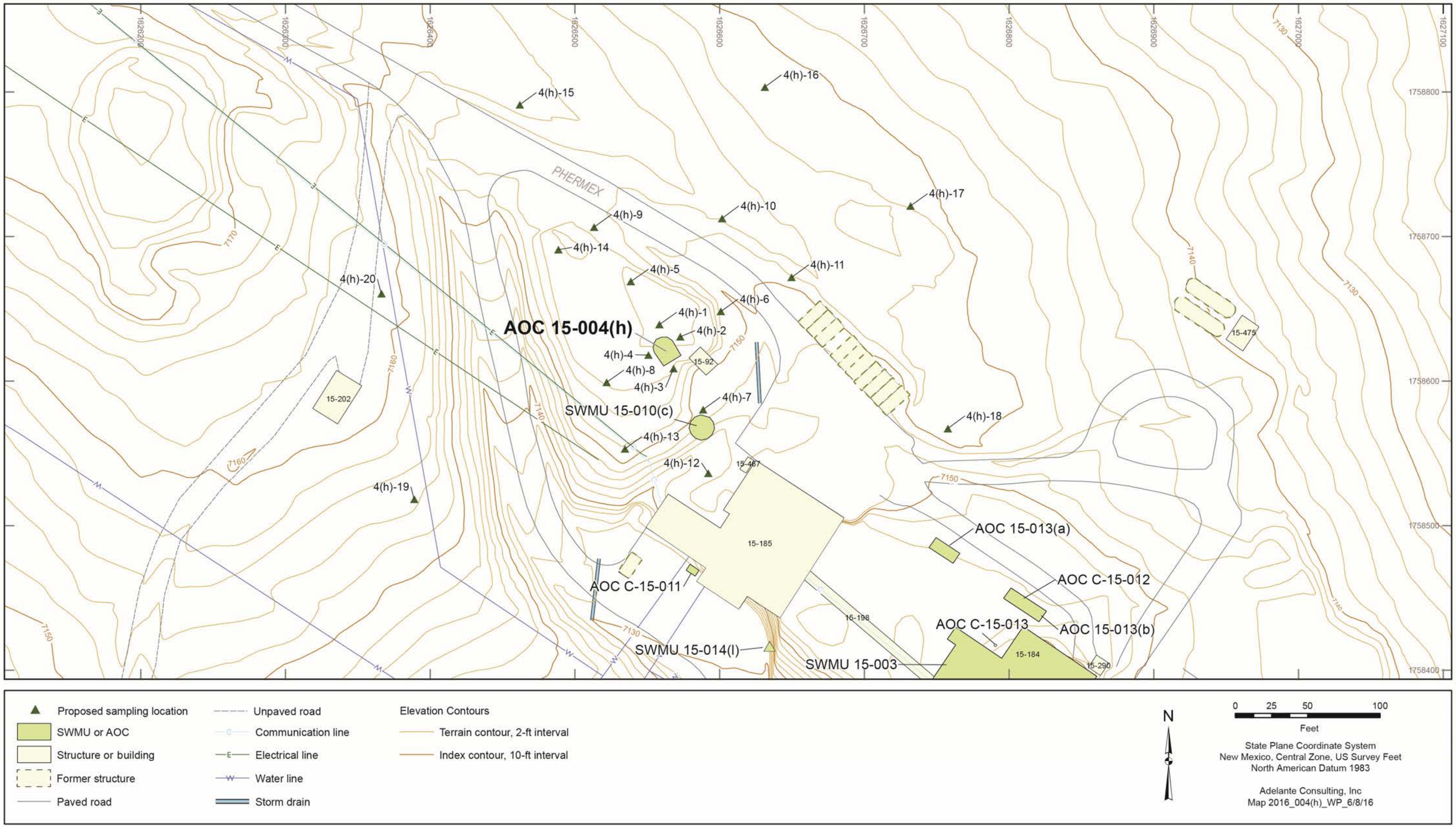

Figure 4.2-1 Proposed sampling locations at AOC 15-004(h)

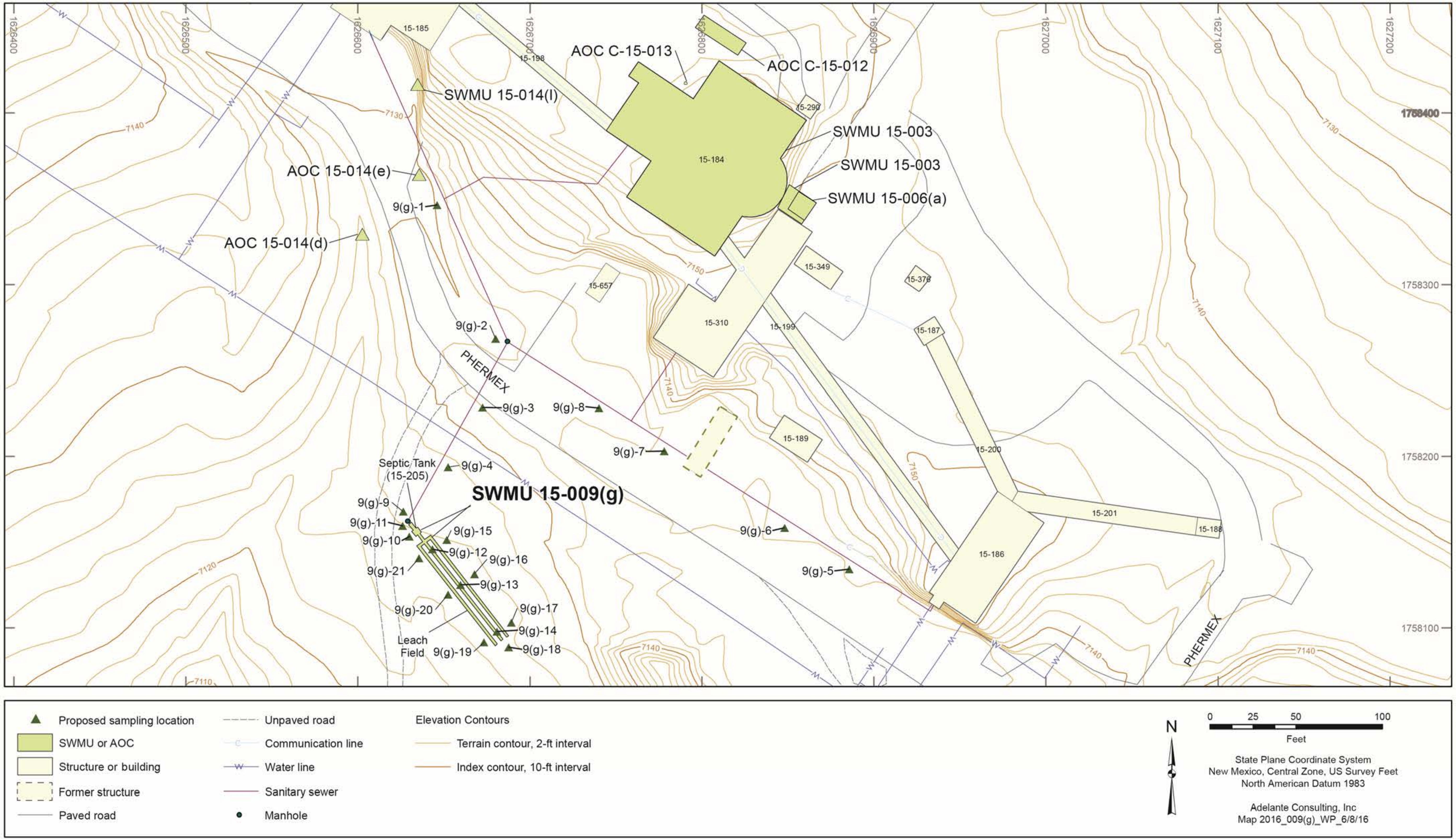

Figure 4.3-1 Proposed sampling locations at SWMU 15-009(g)

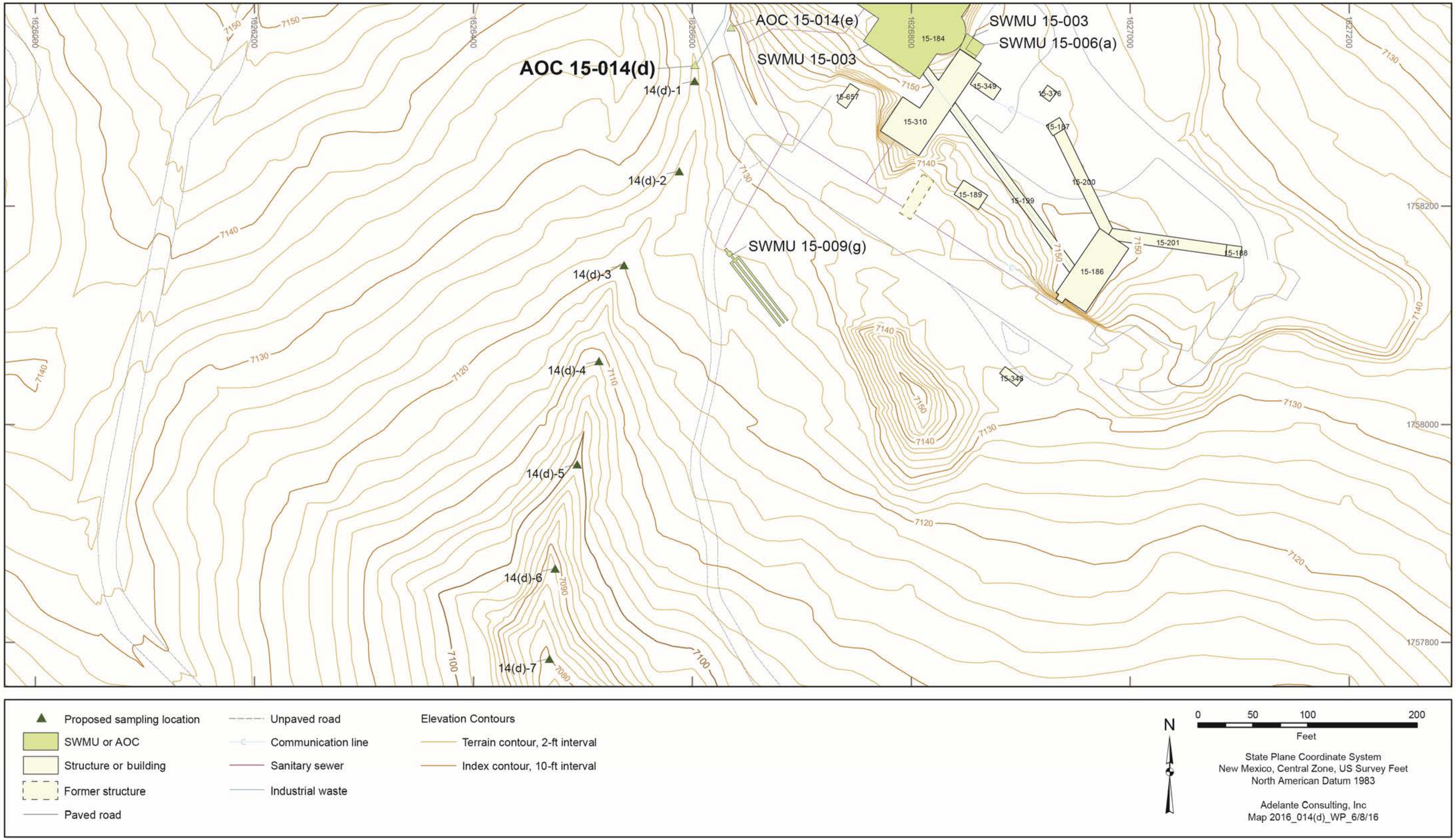

Figure 4.4-1 Proposed sampling locations at AOC 15-014(d)

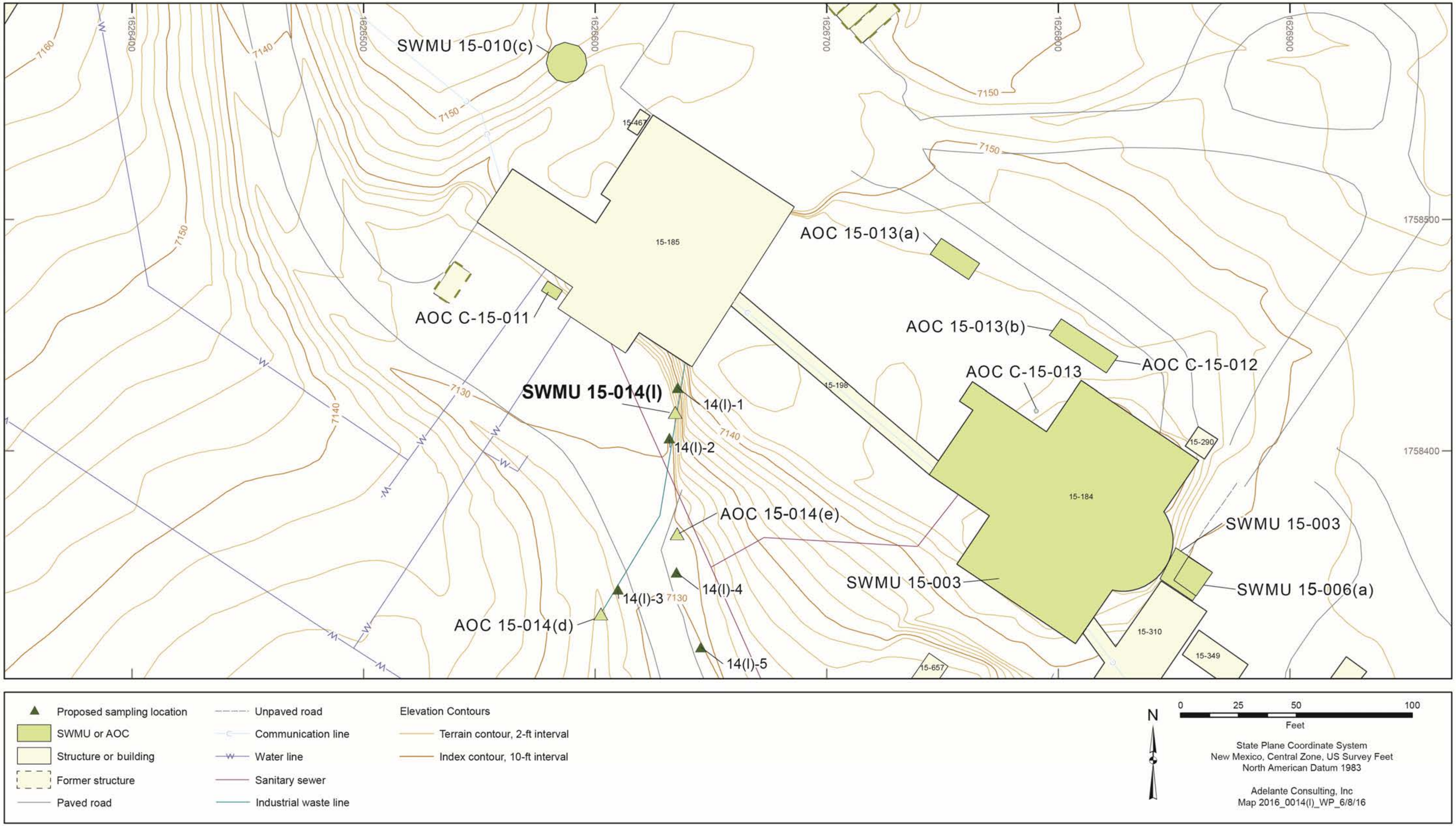

Figure 4.5-1 Proposed sampling locations at SWMU 15-014(l)

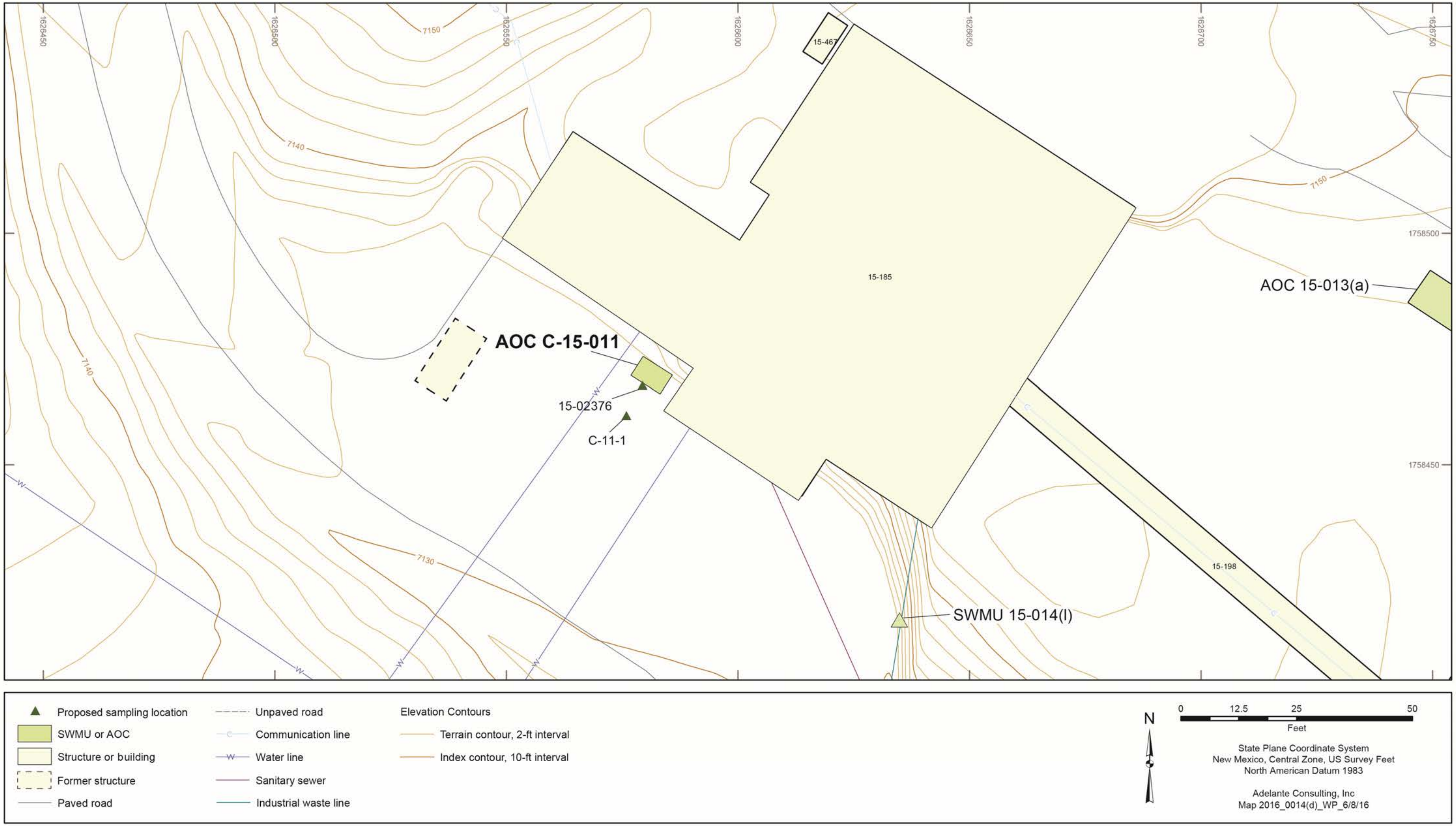

Figure 4.6-1 Proposed sampling locations at AOC C-15-011

Table 1.1-1
Status of SWMUs and AOC in Lower Water/Indio Canyons Aggregate Area

Site ID	Brief Description	Site Status	Reference
TA-15			
AOC 15-001	Storage Area	Under investigation	Work plan section 4.1
AOC 15-004(h)	Firing Site H	Under investigation	Work plan section 4.2
SWMU 15-009(g)	Septic System	Under investigation	Work plan section 4.3
AOC 15-010(c)	Drainline	NFA approved, 03/23/2007	NMED 2007, 095495
AOC 15-013(a)	Underground Tank	NFA approved, 01/21/2005	EPA 2005, 088464
AOC 15-014(d)	Drainline and Outfall	Under investigation	Work plan section 4.4
AOC 15-014(e)	Outfall	NFA approved, 01/21/2005	EPA 2005, 088464
SWMU 15-014(l)	Drainline and outfall from Building 15-185	Under investigation	Work plan section 4.5
AOC C-15-011	Former Underground Tank	Under investigation	Work plan section 4.6
TA-49			
SWMU 49-004	Burn Site and Landfill (Area 6)	Under investigation	LANL 2010, 110654
AOC 49-007(a)	Septic System (Area 6)	NFA approved, 01/21/2005	EPA 2005, 088464

Table 4.1-1
Proposed Sampling at AOC 15-001

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	Nitrate (EPA 300)	Perchlorate (EPA SW-846:6850)	pH (EPA SW-846:9045C)	SVOCs (EPA SW-846:8270C)	Explosive Compounds (EPA SW 846:8231A_MOD)	Gamma-Emitting Radionuclides (EPA 901.1)	Isotopic Uranium (HASL-300)
Determine nature and extent of contamination	1-1 through 1-4	Within former storage area	0–1 ft bgs	X*	X	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	1-5 through 1-14	Around perimeter of former storage area	0–1 ft bgs	X*	X	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X	X	X

* X = Analysis will be performed.

Table 4.2-1
Proposed Sampling at AOC 15-004(h)

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	Nitrate (EPA 300)	Perchlorate (EPA SW-846:6850)	pH (EPA SW-846:9045C)	Explosive Compounds (EPA SW 846:8231A_MOD)	Isotopic Uranium (HASL-300)
Determine nature and extent of contamination	4(h)-1 through 4(h)-4	Adjacent to west, south, east, and north sides of former firing site	0–1 ft bgs	X[a]	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X
Determine nature and extent of contamination	4(h)-5 through 4(h)-8	50-ft step-out from center of former firing site	0–1 ft bgs	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X
Determine nature and extent of contamination	4(h)-9 through 4(h)-14	100-ft radial step-out from center of former firing site in unpaved areas[b]	0–1 ft bgs	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X
Determine nature and extent of contamination	4(h)-15 through 4(h)-20	200-ft radial step-out from center of former firing site in unpaved areas[b]	0–1 ft bgs	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X
			4–5 ft bgs	X	X	X	X	X	X

[a] X = Analysis will be performed.

[b] Samples will not be collected from locations within the road cut west of the firing site.

Table 4.3-1
Proposed Sampling at SWMU 15-009(g)

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	Cyanide (EPA SW-846:9012A)	Nitrate (EPA 300)	Perchlorate (EPA SW-846:6850)	pH (EPA SW-846:9045C)	VOCs (EPA SW 846:8260B)	Explosive Compounds (EPA SW 846:8231A_MOD)	Gamma-Emitting Radionuclides (EPA 901.1)	Isotopic Uranium (HASL-300)
Determine nature and extent of contamination	9(g)-1 through 9(g)-8	Along inlet drainlines	0–1 ft below drainline	X*	X	X	X	X	X	X	X	X
			2–3 ft below drainline	X	X	X	X	X	X	X	X	X
			5–6 ft below drainline	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	9(g)-9 and 9(g)-10	Below septic tank inlet and outlet	0–1 ft below inlet/outlet pipe at septic tank	X	X	X	X	X	X	X	X	X
			2–3 ft below inlet/outlet pipe at septic tank	X	X	X	X	X	X	X	X	X
			5–6 ft below inlet/outlet pipe at septic tank	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	9(g)-11	Below base of septic tank	0–1 ft below septic tank	X	X	X	X	X	X	X	X	X
			2–3 ft below septic tank	X	X	X	X	X	X	X	X	X
			5–6 ft below septic tank	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	9(g)-12 through 9(g)-14	In leach field	0–1 ft below drain pipe	X	X	X	X	X	X	X	X	X
			2–3 ft below drain pipe	X	X	X	X	X	X	X	X	X
			5–6 ft below drain pipe	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	9(g)-15 through (9)g-21	Laterally around leach field	0–1 ft below drain pipe	X	X	X	X	X	X	X	X	X
			2–3 ft below drain pipe	X	X	X	X	X	X	X	X	X
			5–6 ft below drain pipe	X	X	X	X	X	X	X	X	X

*X = Analysis will be performed.

Table 4.4-1
Proposed Sampling at AOC 15-014(d)

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	Hexavalent Chromium (EPA SW-846:7199)	Nitrate (EPA 300)	Perchlorate (EPA SW-846:6850)	pH (EPA SW-846:9045C)	PCBs (EPA SW-846:8082)	Explosive Compounds (EPA SW 846:8231A_MOD)	Gamma-Emitting Radionuclides (EPA 901.1)	Isotopic Uranium (HASL-300)
Determine nature and extent of contamination	14(d)-1 through 14(d)-7	At outfall and in drainage below outfall	0–1 ft bgs	X*	X	X	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X	X	X	X
			5–6 ft bgs	X	X	X	X	X	X	X	X	X

*X = Analysis will be performed.

Table 4.5-1
Proposed Sampling at SWMU 15-014(l)

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	Hexavalent Chromium (EPA SW-846:7199)	Nitrate (EPA 300)	Perchlorate (EPA SW-846:6850)	pH (EPA SW-846:9045C)	PCBs (EPA SW-846:8082)	Explosive Compounds (EPA SW 846:8231A_MOD)	Gamma-Emitting Radionuclides (EPA 901.1)	Isotopic Uranium (HASL-300)
Determine nature and extent of contamination	14(l)-1 and 14(l)-2	Along the inlet and outlet drainlines to the drop inlet	0–1 ft below drainline	X*	X	X	X	X	X	X	X	X
			2–3 ft below drainline	X	X	X	X	X	X	X	X	X
			5–6 ft below drainline	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	14(l)-3	Along the outlet drainline between the drop inlet and the 15-014(d) outfall	0–1 ft below drainline	X	X	X	X	X	X	X	X	X
			2–3 ft below drainline	X	X	X	X	X	X	X	X	X
			5–6 ft below drainline	X	X	X	X	X	X	X	X	X
Determine nature and extent of contamination	14(l)-4 and 14(l)-5	Along the drainage ditch below paved parking area south of building 15-185	0–1 ft bgs	X	X	X	X	X	X	X	X	X
			2–3 ft bgs	X	X	X	X	X	X	X	X	X
			5–6 ft bgs	X	X	X	X	X	X	X	X	X

*X = Analysis will be performed.

Table 4.6-1
Proposed Sampling at AOC C-15-011

Objective Addressed	Location Number	Location	Sample Interval	TAL Metals (EPS SW-846:6010B/6020)	pH (EPA SW-846:9045C)	VOCs (EPA SW 846:8260B)	SVOCs (EPA SW-846:8270C)	TPH-GRO(EPA SW-846: 8015M_PURGABLE)
Determine nature and extent of contamination	15-02376	At RFI location	6–7 ft bgs	X*	X	X	X	X
			9–10 ft bgs	X	X	X	X	X
			14-15 ft bgs	X	X	X	X	X
Determine nature and extent of contamination	C-11-1	Downgradient of former tank location	6–7 ft bgs	X*	X	X	X	X
			9–10 ft bgs	X	X	X	X	X
			14-15 ft bgs	X	X	X	X	X

*X = Analysis will be performed.

Table 5.0-1
Summary of Investigation Methods

Method	Summary
Geodetic Surveys	This method describes the method for coordinating and evaluating geodetic surveys and establishing quality assurance (QA) and quality control for geodetic survey data. The procedure covers evaluating geodetic survey requirements, preparing to perform a geodetic survey, performing geodetic survey field activities, preparing geodetic survey data for QA review, performing QA review of geodetic survey data, and submitting geodetic survey data.
Spade and Scoop Collection of Soil Samples	This method is typically used to collect shallow (e.g., approximately 0-12 in.) soil or sediment samples. The “spade-and-scoop” method involves digging a hole to the desired depth, as prescribed in the sampling and analysis plan, and collecting a discrete grab sample. The sample is typically placed in a clean, stainless-steel bowl for transfer into various sample containers.
Hand-Auger Sampling	This method is typically used for sampling soil or sediment at depths of less than 10–15 ft but may in some cases be used for collecting samples of weathered or nonwelded tuff. The method involves hand-turning a stainless-steel bucket auger (typically 3–4-in. inner diameter), creating a vertical hole that can be advanced to the desired sample depth. When the desired depth is reached, the auger is decontaminated before advancing the hole through the sample depth. The sample material is transferred from the auger bucket to a stainless-steel sampling bowl before filling the various required sample containers.
Hollow-Stem Auger Drilling Methods	In this method, hollow-stem augers (sections of seamless pipe with auger flights welded to the pipe) act as a screw conveyor to bring cuttings of sediment, soil, and/or rock to the surface. Auger sections are typically 5 ft in length and have outside diameters of 4.25 to 14 in. Drill rods, split-spoon core barrels, Shelby tubes, and other samplers can pass through the center of the hollow-stem auger sections for collection of discrete samples from desired depths. Hollow-stem augers are used as temporary casings when setting wells to prevent cave-ins of the borehole walls.
Handling, Packaging, and Shipping of Samples	Field team members seal and label samples before packing and ensure the sample containers and the containers used for transport are free of external contamination. Field team members package all samples so as to minimize the possibility of breakage during transportation. After all environmental samples are collected, packaged, and preserved; a field team member transports the samples to either the SMO or an SMO-approved radiation screening laboratory under chain of custody. The SMO arranges for shipping of samples to analytical laboratories. The field team member must inform the SMO and/or the radiation screening laboratory coordinator when levels of radioactivity are in the action-level or limited-quantity ranges.
Containers and Preservation of Samples	Specific requirements/processes for sample containers, preservation techniques, and holding times are based on EPA guidance for environmental sampling, preservation, and QA. Specific requirements for each sample are printed on the sample collection logs provided by the SMO [size and type of container (glass, amber glass, polyethylene), preservative, etc.]. All samples are preserved by placing in insulated containers with ice to maintain a temperature of 4°C. Other requirements such as nitric acid or other preservatives may apply to different media or analytical requests.

Table 5.0-1 (continued)

Method	Summary
Sample Control and Field Documentation	The collection, screening, and transport of samples are documented on standard forms generated by the SMO. These include sample collection logs, chain-of-custody forms, and sample container labels. Collection logs are completed at the time of sample collection and are signed by the sampler and a reviewer who verifies the logs for completeness and accuracy. Corresponding labels are initialed and applied to each sample container, and custody seals are placed around container lids or openings. Chain-of-custody forms are completed and assigned to verify the samples are not left unattended. Site attributes (e.g., former and proposed soil sampling locations, sediment sampling locations) are located by using a GPS. Horizontal locations will be measured to the nearest 0.5 ft. The survey results for this field event will be presented as part of the investigation report. Sample coordinates will be uploaded into the Laboratory's database system.
Field Quality Control Samples	Field quality control samples are collected as follows: *Field Duplicate*: At a frequency 10%; collected at the same time as a regular sample and submitted for the same analyses. *Equipment Rinsate Blank*: At a frequency of 10%; collected by rinsing sampling equipment with deionized water, which is collected in a sample container and submitted for laboratory analysis. *Trip Blanks*: Required for all field events that include the collection of samples for VOC analysis. Trip blank containers of certified clean sand are opened and kept with the other sample containers during the sampling process.
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination is the preferred method to minimize generating liquid waste. Dry decontamination may include the use of a wire brush or other tool to remove soil or other material adhering to the sampling equipment, followed by use of a commercial cleaning agent (nonacid, waxless) and paper wipes. Dry decontamination may be followed by wet decontamination if necessary. Wet decontamination may include washing with a nonphosphate detergent and water, followed by a water rinse and a second rinse with deionized water. Alternatively, steam cleaning may be used.
Management, Characterization, and Storage of IDW	IDW is managed, characterized, and stored in accordance with an approved waste characterization strategy form that documents site history, field activities, and the characterization approach for each waste stream managed. Waste characterization shall be adequate to comply with on-site or off-site waste acceptance criteria. All stored IDW will be marked with appropriate signage and labels, as appropriate. Drummed IDW will be stored on pallets to prevent the containers from deterioration. Generators are required to reduce the volume of waste generated as much as technically and economically feasible. Means to store, control, and transport each potential waste type and classification shall be determined before field operations that generate waste begin. A waste storage area shall be established before waste is generated. Waste storage areas located in controlled areas of the Laboratory shall be controlled as needed to prevent inadvertent addition or management of wastes by unauthorized personnel. Each container of waste generated shall be individually labeled as to waste classification, item identification number, and radioactivity (if applicable), immediately following containerization. All waste shall be segregated by classification and compatibility to prevent cross-contamination. Appendix B presents additional information regarding IDW.

Appendix A

Acronyms and Abbreviations,
Metric Conversion Table, and Data Qualifier Definitions

A-1.0 ACRONYMS AND ABBREVIATIONS

AK	acceptable knowledge
amsl	above mean sea level
AOC	area of concern
bgs	below ground surface
Consent Order	Compliance Order on Consent
DARHT	Dual-Axis Radiographic Hydrodynamic Test
DESHS	Deployed Environment, Safety, and Health Services Division
DOE	Department of Energy (U.S.)
DU	depleted uranium
EPA	Environmental Protection Agency (U.S.)
ESH	Environment, Safety, and Health
GPS	global positioning system
HE	high explosives
HIR	historical investigation report
IDW	investigation-derived waste
LANL	Los Alamos National Laboratory
LLW	low-level waste
NDA	no detectable activity
NFA	no further action
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
PCB	polychlorinated biphenyl
PHERMEX	Pulsed High-Energy Radiographic Machine Emitting X-rays
QA	quality assurance
PID	photoionization detector
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	Resource Conservation and Recovery Act facility investigation
SMA	site monitoring area
SMO	Sample Management Office
SOP	standard operating procedure
SSL	soil screening level
SVOC	semivolatile organic compound

SWMU	solid waste management unit
TA	technical area
TAL	target analyte list [EPA]
TNT	2,4,6-trinitrotoluene
TPH-GRO	total petroleum hydrocarbons–gasoline range organics
VOC	volatile organic compound
WAC	waste acceptance criteria
WCSF	waste characterization strategy form

A-2.0 METRIC CONVERSION TABLE

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

A-3.0 DATA QUALIFIER DEFINITIONS

Data Qualifier	Definition
U	The analyte was analyzed for but not detected.
J	The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.
J+	The analyte was positively identified, and the result is likely to be biased high.
J-	The analyte was positively identified, and the result is likely to be biased low.
UJ	The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.
R	The data are rejected as a result of major problems with quality assurance/quality control parameters.

Appendix B

Management Plan for Investigation-Derived Waste

B-1.0 INTRODUCTION

This appendix describes how investigation-derived waste (IDW) generated during the Lower Water/Indio Canyons Aggregate Area investigation will be managed. IDW may include, but is not limited to, drill cuttings, excavated media, contact waste, decontamination fluids, immunoassay test kit waste, and all other waste that has potentially come into contact with contaminants.

B-2.0 IDW

Area of contamination request(s) may be submitted for approval to the New Mexico Environment Department (NMED) for sites at which excavation and/or drilling is planned.

All IDW generated during investigation activities will be managed in accordance with applicable standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy (DOE) orders, and Los Alamos National Laboratory Laboratory (LANL or the Laboratory) requirements. The LANL SOP applicable to the characterization and management of IDW is EP-DIR-SOP-10021, Characterization and Management of Environmental Programs Waste, available at http://permalink.lanl.gov/object/tr?what=info:lanl-repo/eprr/ERID-259199.

The most recent version of the Laboratory's Hazardous Waste Minimization Report will be implemented during the investigation to minimize waste generation. The report is updated annually as a requirement of the Laboratory's Hazardous Waste Facility Permit.

A waste characterization strategy form (WCSF) will be prepared and approved per requirements of EP-DIR-SOP-10021. The WCSF will provide detailed information on IDW characterization methods, management, containerization, and potential volumes. IDW characterization is completed through review of investigation data and/or documentation or by direct sampling. Waste characterization may include a review of historical information and process knowledge to identify whether listed hazardous waste may be present (i.e., due diligence reviews). If low levels of listed hazardous waste are identified, a "contained in" determination may be submitted for approval to NMED.

Wastes will be containerized and placed in clearly marked and appropriately constructed waste accumulation areas. If IDW is generated within the boundary of an area of potential contamination, it will be managed as nonhazardous within those boundaries in designated, properly constructed waste management areas. If hazardous, the IDW will be managed in accordance with hazardous waste requirements once it is removed from the area of contamination. If IDW is generated outside of area of contamination boundaries, the initial management of the waste will rely on the data from previous investigations and/or process knowledge. If the analytical data change the expected waste category, the waste will be managed in accumulation areas appropriate to the final waste determination. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the type of IDW and its classification. Container and storage requirements, as well as transportation and disposal requirements, will be detailed in the WCSF and approved before waste is generated. Table B-2.0-1 summarizes the estimated IDW waste streams, waste types and disposition.

The waste streams that are anticipated to be generated during work plan implementation are described below.

B-2.1 Drill Cuttings

This waste stream consists of soil and rock generated by the drilling of boreholes with the intent to sample. Drill cuttings include excess core not submitted for analysis and any returned samples sent for analysis. Drill cuttings will be containerized in 20-yd^3 rolloff containers, 55-gal. drums, B-12 containers, or other appropriate containers at the point of generation.

This waste stream will be characterized based either on direct sampling of the waste in each container or on the results from core samples collected during drilling. If directly sampled, the samples will be analyzed for the same analytical suites as identified for each site, and, if needed, toxicity characteristic metals. Other constituents may be analyzed as necessary to meet the waste acceptance criteria (WAC) for a receiving facility or if visual observations indicate that additional contaminants may be present. All wastes will be treated/disposed of at an authorized off-site facility appropriate for the waste classification.

B-2.2 Excavated Environmental Media

Layback and overburden spoils will consist of soil and rock removed from within or next to areas within the solid waste management unit (SWMU) to be excavated. The excavated material will be field-screened and examined for high explosives, radioactivity, and/or organic vapors during the excavation process. If the contamination is not detected during screening, the spoils will be stored either in rolloff bins, in other suitable containers, or on the ground surface with appropriate best management practices. If field screening indicates the potential for contamination, the layback and overburden spoils will be placed in rolloff bins or other suitable containers. The excavated material will remain within the boundary of the site, when possible, from which it was excavated.

Incremental samples of the spoils will be collected as the spoils are excavated or the media may be sampled in piles or containers. A minimum of one direct sample will be collected from each 50 yd^3 or each container of material excavated and will be submitted for laboratory analyses for the same analytical suites as identified for each site, and, if needed, toxicity characteristic metals. Other constituents may be analyzed as necessary to meet the WAC for a receiving facility. If the spoils are determined to be suitable for reuse (i.e., meet residential cleanup standards as determined by using NMED’s and DOE’s soil screening guidance), the Laboratory may use the soil to backfill the bottom of the excavations. If the spoils are not suitable for reuse, they will be treated/disposed of at an authorized facility appropriate for the waste regulatory classification. The Laboratory expects most of the excavated environmental media to be designated as nonhazardous, nonradioactive waste.

B-2.3 Excavated Manmade Debris

Excavated manmade debris may be generated at SWMU 15-009(g) if the septic tank is removed and not closed in place. To the extent possible, debris will be segregated as it is excavated. If present, the contents of the septic tank will be sampled and analyzed for target analyte list metals, cyanide, nitrate, perchlorate, pH, volatile organic compounds, semivolatile organic compounds, explosive compounds, gamma-emitting radionuclides, isotopic uranium, and, if needed, toxicity characteristic metals. If the septic tank is empty, swipe samples will be collected and analyzed for explosive compounds and gross-alpha, -beta, and –gamma radioactivity. The exact sampling method will be identified by qualified sampling personnel, and all decisions will be documented in the field activity notebook. Waste will be minimized, where practicable, through segregation of waste materials. Nonhazardous materials that can be shown to meet no detectable activity (NDA) for radionuclides or that can be decontaminated to meet NDA will be recycled, if practicable.

B-2.4 Contact Waste

The contact waste stream consists of potentially contaminated materials that “contacted” waste during sampling and excavation. This waste stream consists primarily of, but is not limited to, personal protective equipment such as gloves, decontamination wastes such as paper wipes, and disposable sampling supplies. Contact waste will be stored in containers and managed in accordance with the applicable Laboratory waste management requirements based on the waste characterization results.

Characterization of this waste stream will use acceptable knowledge (AK) based on data from the media with which it came into contact (e.g., drill cuttings, soil, sumps, etc.). The Laboratory expects most of the contact waste to be designated as nonhazardous, nonradioactive waste that will be disposed of at an authorized on-site or off-site facility.

B-2.5 Decontamination Fluids

Decontamination fluids consist of liquid wastes generated from decontamination of excavation, sampling, and drilling equipment. All sampling and measuring equipment, including but not limited to stainless-steel sampling tools and split-barrel or core samplers, will be decontaminated in accordance with EP-ERSS-SOP-5061, Field Decontamination of Equipment.

Consistent with waste minimization practices, the Laboratory uses dry decontamination methods to the greatest extent possible. If dry decontamination cannot be performed, liquid decontamination wastes will be collected in containers at the point of generation. The fluids will be characterized through AK of the waste materials, the level of contamination measured in the environmental media (e.g., the results of the associated drill cuttings), and, if necessary, direct sampling of the containerized waste. If directly sampled, the samples will be analyzed for the same analytical suites as identified for each site, and, if needed, toxicity characteristic metals and other analytes required by the receiving facility (i.e., total suspended solids, Microtox, chemical oxygen demand, oil and grease, pH, nitrates). The Laboratory expects most of these wastes to be nonhazardous liquid waste that will be sent to one of the Laboratory’s wastewater treatment facilities where the WAC allows the waste to be received.

B-2.6 Immunoassay Test Kit Wastes

Investigation samples will be field-screened for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and TNT (2,4,6-trinitrotoluene) using Strategic Diagnostics, Inc., ENSYS immunoassay test kits. Wastes generated from field screening include spent solvent (acetone), water, and soil-crushed tuff. These wastes will be containerized in closed 5-gal. buckets and stored within a satellite accumulation area or less-than-90-d hazardous waste storage area. The soil-tuff in the wastes will be characterized using data from the samples collected. The waste will be treated and disposed of at an authorized off-site hazardous or mixed-waste facility.

Table B-2.0-1
Summary of Estimated IDW Generation and Management

Waste Stream	Expected Waste Type	Expected Disposition
Drill Cuttings	Nonhazardous waste or low-level waste (LLW)	Treatment/disposal at an authorized off-site facility
Excavated Environmental Media	Nonhazardous waste or LLW	Reused as fill at the excavation location or treated/disposed of at an authorized on-site or off-site facility
Excavated Manmade Debris	Industrial waste, hazardous waste, LLW, or mixed LLW	Disposal at an approved off-site facility, recycled
Contact Waste	Nonhazardous waste or LLW	Disposal at an approved on-site or off-site facility
Decontamination Fluids	Nonhazardous waste or LLW	Treatment at an on-site wastewater treatment facility
Immunoassay Test Kit Wastes	Hazardous waste or mixed LLW	Treatment/disposal at approved off-site facility.

Appendix C

Site Photographs

Figure C-1 Area of Concern (AOC) 15-001 storage area, looking northeast

Figure C-2 Side of road cut west of AOC 15-004(h) looking east

Figure C-3 Drop inlet at Solid Waste Management Unit (SWMU) 15-014(l) south of building 15-185, looking east

Figure C-4 Location of former underground tank AOC C-15-011, south of building 15-185, looking north