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Documented Safety Analysis for Surveillance and Maintenance of Nuclear Environmental Sites at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY
EST. 1943

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Prepared by
Environmental Stewardship Division–Remediation Services

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CONTENTS

Appendixes

Figures

Tables

1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) prepared this documented safety analysis (DSA) for nuclear environmental sites (NES) in accordance with Chapter 10 of the Code of Federal Regulations Part 830 (10 CFR 830), Subpart B, "Safety Basis Requirements," and Section 204 of 10 CFR 830, "Documented Safety Analysis." Table 1-1 provides the name, potential release site (PRS) number, hazard category (HC) number, and a brief description for each NES. The Laboratory's Nuclear Waste Operations (NWO) Division is the steward for the NES on Laboratory property. None of the NES is active now or will serve as a disposal facility in the future. These sites have been inactive for years or decades and many of the activities described in this DSA have been taking place at the NES throughout that time. No significant deterioration of isolation systems is apparent and no significant worker injuries have been reported connected with activities on what have become the NES.

Table 1-1
Hazard Category and Description of NES

NES	Associated PRS	Brief Description of NES	Hazard Category (HC)
TA-21[a] MDA A	21-014	Subsurface tanks and pits associated with historical liquid and solid waste disposal	2
TA-21 MDA B	21-015	Undifferentiated subsurface areas associated with historical waste disposal	3
TA-21 MDA T	21-016(a)-99	Shafts and absorption beds associated with liquid wastes	2
TA-35 MDA W	35-001	Subsurface tanks used for disposal of sodium coolant from reactor experiments	3
TA-35 WWTP[b]	35-003(a)-99	Areas of residual contamination associated with leakage from, and removal of, components of former WWTP	3
TA-35 Pratt Canyon	35-003(d)-00	Areas of residual contamination associated with discharge from former WWTP	3
TA-49 MDA AB	49-001(a)-00	Three shaft areas (1, 2, and 4) associated with historical subcritical experiments involving nuclear materials	2
TA-50 MDA C	50-009	Complex of pits and shafts used for disposal of combustible and noncombustible debris and sludge-filled drums	2
TA-53 Resin Tank	53-006(b)-99	Subsurface tank that received contaminated ion-exchange resins from an accelerator facility	2
TA-54 MDA H	54-004	Shafts formerly used for disposal of classified waste	3

[a]TA = Technical area.
[b] WWTP = Wastewater treatment plant.

Eight of the NES comprise engineered and constructed disposal units with defined boundaries intended to isolate the waste inventory from the environment. Two of the NES (TA-35 WWTP and TA-35 Pratt Canyon) do not have defined disposal units. The inventory at TA-35 Pratt Canyon is contaminated soil and sediment from an outfall from operation of the TA-35 Waste Water Treatment Plant. Contaminated soil at TA-35 WWTP was caused by leakage from process equipment and remains after the decontamination and decommissioning of processing facilities on or near the current TA-35 WWTP site.

Until remediation and/or invasive characterization occurs, the Laboratory must continue surveillance and maintenance (S&M) activities to ensure that site contaminants do not migrate from their current location. A key surveillance activity that LANL has conducted for years is drilling to determine the nature and extent of contamination. LANL is required to continue performing such drilling by the New Mexico Environment Department (NMED) Consent Order (NMED 2004). Section XI of that Order requires the Laboratory and DOE to conduct, and report the results of, prescribed investigation activities in accordance with a negotiated schedule (Section XII). The activities include the characterization of the nature and extent of surface and subsurface contaminants at most NES because they are wholly or in part units regulated under hazardous waste regulations. Drilling at waste disposal areas like the NES is the only characterization method that facilitates direct evaluation of subsurface contaminant migration.

The purpose of this DSA is to ensure that workers, the public, and the environment are protected from the radiological, chemical, and other hazards associated with the NES. This DSA supports only those activities that are needed directly and indirectly to ensure that the sites are maintained in their current conditions. These activities will not intrude into defined waste disposal units such as shafts, pits, trenches, absorption beds, or tanks, which were constructed to isolate wastes from the environment.

Chapter 1 of this report provides the background and requirements for the DSA and describes the nuclear-site characteristics, locations, and site and area features. Sections of this chapter discuss general site characteristics and those that apply specifically to the NES. Chapter 2 presents a detailed description of the activities covered in this DSA. Chapter 3 presents the safety assessment for the NES. Appendix A identifies the barriers associated with preventing and/or mitigating each identified hazard/scenario for each of the five types of sites (as defined in section 3.4.1). Appendix B includes definitions for terms and acronyms used in this report and a metric conversion table. Technical safety requirements (TSRs) for the S&M activities in the DSA are described in “Technical Safety Requirements for Surveillance and Maintenance of Nuclear Environmental Sites at Los Alamos National Laboratory” (LANL November 2004).

1.1 Background

The US Department of Energy (DOE) administers, and the University of California operates, the Laboratory and the 32 technical areas (TAs) currently active within the Laboratory boundaries. Figure 1-1 shows the Laboratory and TA locations and the boundaries and locations of the NES. For more than sixty years, the Laboratory has been the location for experimental nuclear weapons and science programs. The NES are legacy sites associated with the disposal of materials related to these programs. On November 26, 2003, the DOE National Nuclear Security Administration (NNSA) concurred with the Laboratory’s initial hazard categorization of 11 PRS as hazard category (HC) 2 or 3 nuclear sites (Steele 2003). The initial categorization identified five HC-2 sites and six HC-3 sites. Ten of the NES are on Laboratory property, but the Bayo Canyon site is outside Laboratory boundaries. Because Bayo Canyon is not on LANL property and is beyond the control of LANL and the DOE, the Bayo site is not considered in this DSA, but is shown on Figure 1-1 for completeness.

The NES include material disposal areas (MDAs), an underground tank containing spent ion-exchange resins, a pair of underground tanks containing contaminated sodium, the area of a former wastewater treatment plant (WWTP), and the outfall associated with the WWTP. The inventory of nuclear materials at most of the NES is located at least 15 cm (6 in.) below the ground surface and is isolated from the atmospheric environment. An exception is TA-35 Pratt Canyon, where contamination is predominantly diffused in soil and some slight contamination may be at or near the ground surface. The subsurface inventory at some NES has not been characterized and is associated with a high level of uncertainty.

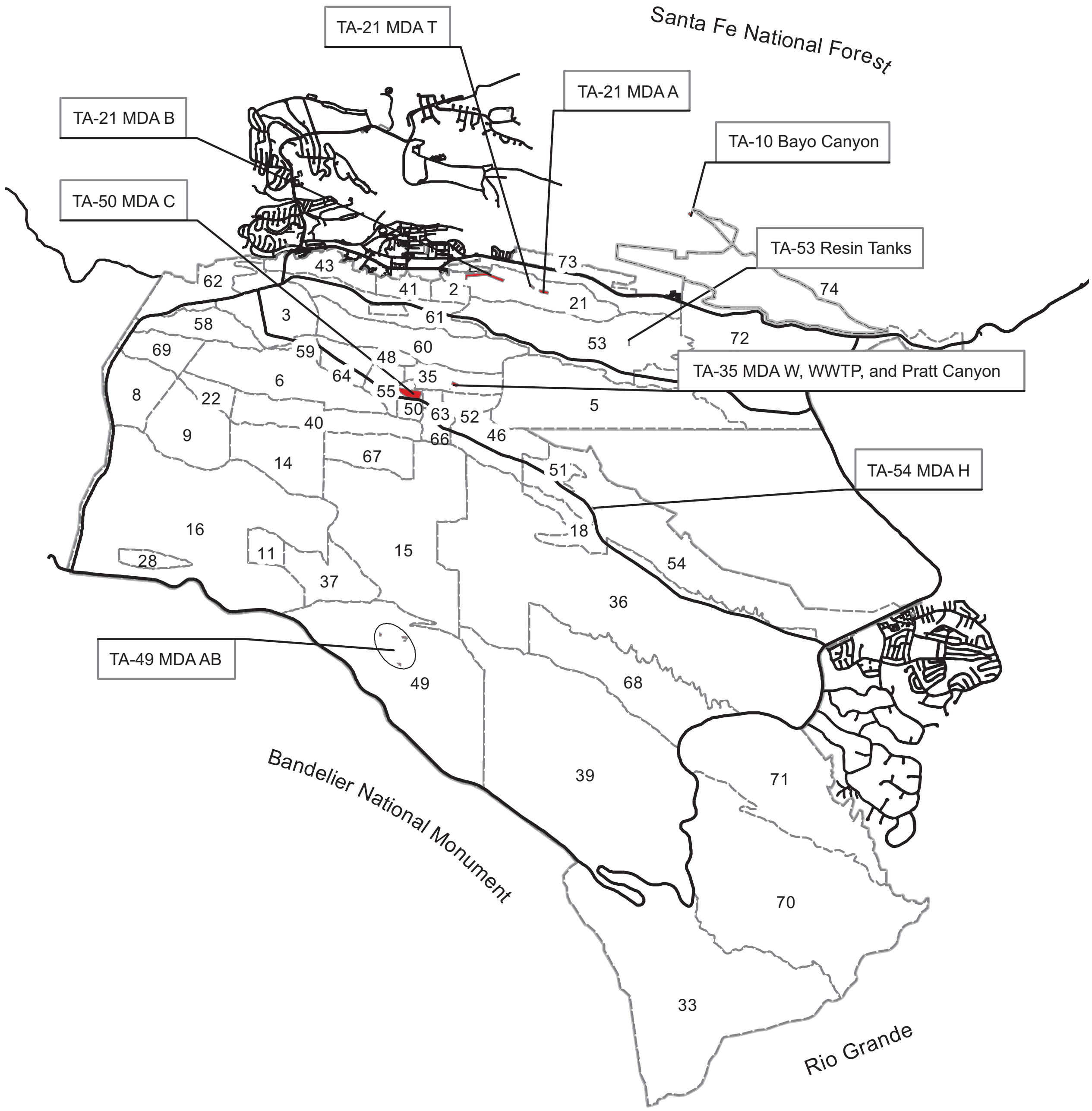

Figure 1-1. Locations of NES and Laboratory TAs

LANL analysts preparing this DSA became aware that the inventories used in the initial categorization for most NES did not account for radioactive decay after sampling or after the original dates of inventory calculation. For example, initial categorization inventories for some NES included plutonium-241, but not its progeny, americium-241, and for others included americium-241, but not its parent, plutonium-241. To correct this oversight, the analysts preparing this DSA revised inventories to reflect the ingrowth of americium-241, assuming 30 years of decay.

The analysts also updated the initial categorization inventories to include information or calculations that became available after the initial categorization. The site descriptions in section 1.6 present the initial categorization inventory and the inventory for use in the DSA.

1.2 Requirements

This DSA is compiled in accordance with the following code and standards:

- DOE Standard 1120-98, "Integration of Environment, Safety, and Health into Facility Disposition Activities, Volume 1 of 2: Technical Standard" (DOE 1998a)
- 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response"
- 10 CFR 830, "Nuclear Safety Management"

1.3 Approach

Because none of the S&M activities require working within a permanent structure, and because the activities associated with S&M of the NES present a low risk for a release to the public, the Laboratory concludes that the Safe Harbor described in 10 CFR 830 Subpart B, Appendix A, Table 2 for nuclear facility type 6 provides the appropriate methodology for this analysis. Accordingly, LANL prepared this DSA to comply with the methodology in DOE Standard 1120-98, "Integration of Environment, Safety, and Health into Facility Disposition Activities," and the provisions of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response," also referred to as Occupational Safety and Health Administration (OSHA) Standard 1910.120.

The requirements and guidance provided in 29 CFR 1910.120 and DOE Standard 1120-98 are essential to a DSA of the NES. DOE Standard 1120-98 applies to all phases of facility disposition, including long-term S&M (Chapter 1.1, "Applicability," DOE Standard 1120-98) (DOE 1998b). DOE Standard 1120-98 also acknowledges that as the activities at a nuclear facility change from operational to dispositional, environmental, safety, and health (ES&H) facility management challenges change significantly (Foreword to DOE Standard 1120-98) (DOE 1998c). Fundamentally, ES&H directives appropriate to operational activities are not necessarily appropriate to disposition activities such as long-term S&M. Preparing and implementing an analysis consistent with DOE Standard 1120-98 and 29 CFR 1910.120 ensures the evaluation and control of radiological and toxicological hazards to workers, the public, and the environment, and OSHA-type hazards (standard industrial hazards) for workers conducting S&M activities.

The implementation guide for developing DSAs (DOE 2003) dictates the use of "a graded approach such that the level of detail, analysis, and documentation will reflect the complexity and hazard associated with a particular facility of activity. Thus the DSA for a simple, low-hazard facility may be relatively short and qualitative in nature" (DOE 2003). The S&M of the NES appear to fall clearly under the category of "low-hazard facility" because of the passively safe and isolated nature of the buried inventory and the noninvasive character of the activities.

In applying a graded approach consistent with these low-hazard sites, LANL analysts conclude that a barrier analysis is the appropriate and adequate basis for the safety assessment in this DSA. The barrier analysis methodology enables safety analysts to determine physical and administrative barriers needed to ensure protection of workers, the public, and the environment. Safety analysts also use barrier analysis to evaluate hazards and identify the appropriate type, level, and number of hazard controls.

1.4 Laboratory Site Description

1.4.1 Location

The Laboratory and the residential and industrial areas associated with the town of Los Alamos (inclusive of the White Rock community) are located in Los Alamos County in north-central New Mexico, approximately 96.6 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe. The area surrounding the Laboratory, including portions of Los Alamos, Sandoval, Rio Arriba, and Santa Fe Counties, is largely undeveloped. Santa Fe National Forest, the Bureau of Land Management, Bandelier National Monument, the General Services Administration, and Los Alamos County own and/or manage large tracts of land north, west, and south of the Laboratory. Thirteen Native American Pueblos are located within an 80 km (50 mi) radius of the Laboratory. San Ildefonso Pueblo borders the Laboratory to the east.

1.4.2 Transportation and Access

1.4.2.1 Roads and Vehicular Access

Three state highways and the Los Alamos Airport allow vehicular access to the Laboratory and the town of Los Alamos. State Highway 502 enters Los Alamos from Pojoaque and areas to the southeast of Los Alamos and is the main access route for commuters from outlying communities. State Highways 4 and 501 enter Los Alamos from the Jemez Mountains to the west and southwest.

Traffic on State Highway 502 is moderate to heavy on workdays during the peak morning and evening commute. During off-hours and weekends, traffic is typically light to moderate on all three roads. The University of California has the authority, delegated by DOE, to limit access to DOE-controlled roads at the Laboratory during emergency situations and for transport of hazardous and radioactive materials (Bellows 1993).

1.4.2.2 Airports and Air Traffic

The Los Alamos Airport runway is located approximately 0.48 km (0.3 mi) north of MDA B adjacent to and north of State Highway 502. The airport consists of a single east-west runway and primarily serves the general public, with some occasional commercial or military traffic. Because of local atmospheric conditions and airspace restrictions, almost all air traffic enters from and exits to the east.

Los Alamos Airport has the capacity to handle 500 to 600 private flights and 200 to 300 commercial flights per month. Data obtained in 1997 for frequency of aircraft operations at the airport recorded approximately 4860 general-aviation and 1980 commercial takeoffs and an equal number of landings per year (Heindel 1998).

1.4.3 Population

The total population within 80 km (50 mi) of the Laboratory is about 224,000. Santa Fe is the largest city in the area, with a population of about 67,000. The Albuquerque metropolitan area, which is approximately 97 km (60 mi) to the south-southwest, has an estimated population of 670,000 (US Census Bureau 1997).

In 2002, Los Alamos County had a population of 18,305 individuals (US Census Bureau 2003). The Los Alamos community has an estimated population of 11,400 persons. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has approximately 6800 residents. A few permanent residents reside at the Bandelier National Monument, but during summer operational hours the population at the Monument can be as high as 1000.

Approximately 12,350 University of California and subcontractor employees work within Laboratory boundaries.

1.4.4 Climate

Los Alamos County has a semiarid, temperate mountain climate. “Los Alamos Climatology” (Bowen 1990) provides detailed discussion of the Los Alamos climate and includes frequency analyses of extreme climatologic events.

1.4.4.1 Wind Conditions

Los Alamos is considered a light-wind site, with surface winds at the Laboratory averaging 3.1 m/s (7 mph). Wind speeds are strongest from March through June and weakest in December and January. Wind gusts exceeding 80 km/hr (50 mph) are common during the spring. Wind distribution varies with location, height above ground, and time of day. The highest recorded wind gusts in recent history were 124 km/hr (77 mph) on November 15, 1998. No tornadoes have been reported to touch down in the Los Alamos area in recent history. However, a funnel cloud was reported near White Rock on August 23, 1983. In addition, numerous funnel clouds were reported near Santa Fe on August 24 and 25, 1987, and a tornado touched down in Albuquerque on September 20, 1985.

Five meteorological monitoring stations measure wind speed and direction around the Laboratory.

1.4.4.2 Temperature

Summer afternoon temperatures in Los Alamos County typically range between 20 and 25ºC (75 and 80ºF) and only infrequently reach 32ºC (100ºF). Nighttime temperatures typically range between 10 and 15ºC (35 and 50ºF) (Carter and Gardner 1995). Typical winter temperatures are between 1 and 10ºC (30 to 50ºF) in the daytime and between -10 and -3ºC (15ºF and 25ºF) at night. Winter nighttime temperatures occasionally drop to -17ºC (0ºF) or below (LANL 1992).

1.4.4.3 Precipitation

Annual average precipitation at Los Alamos is about 36 cm (14 in.), with about 36% occurring as brief, intense thunderstorms during July and August (Carter and Gardner 1995). Hail can be frequent and severe during the thunderstorms. Most hailstones have diameters of about 0.64 cm (0.25 in.). Snowfall is greatest from December through March, with heavy snowfall infrequent in other months. Annual snowfall averages about 1.30 m (51 in.). Variations in precipitation from year to year can be quite large, and annual precipitation extremes in Los Alamos range from 17 cm (6.8 in.) to 77 cm (30.3 in.). Daily rainfall extremes of 2.54 cm (1 in.) or greater occur in most years, and the estimated 100-year daily rainfall extreme is about 6.4 cm (2.5 in.). Precipitation generally increases westward toward the Jemez Mountains.

1.4.4.4 Lightning

Lightning associated with thunderstorms in Los Alamos can be frequent and dense. The National Oceanic and Atmospheric Administration provides a lightning-density map for the US on its web site. The density in the Los Alamos area shown on this map is four to eight strikes per km^2 per yr (National Weather Service Lightning Safety).

1.4.5 Atmospheric Dispersion

The terrain at Los Alamos is irregular and affects atmospheric turbulence and dispersion both favorably and unfavorably. Increased dispersion promotes greater dilution of contaminants released into the atmosphere. The complex terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical turbulence and dispersion. However, dispersion is greatly restricted within the area's canyons. Also, dispersion generally decreases at lower elevations, where the terrain becomes smoother and less covered in vegetation. The frequent clear skies and light winds cause good vertical daytime dispersion, especially during the warm season. Daytime heating during the summer can force strong vertical mixing to 900 to 1800 m (3000 to 6000 ft) above ground level (AGL). The generally light winds have a limited effect on the horizontal dilution of contaminants (Bowen 1990).

The clear skies and light winds have a negative effect on dispersion at night, causing strong, shallow surface inversions to form. These inversions can severely restrict near-surface vertical and horizontal dispersion. The inversions are especially strong during the winter. Shallow drainage winds can fill lower areas with cold air, thereby creating deeper inversions. A deeper inversion is common toward White Rock and the Rio Grande Valley on clear nights with light winds. Canyons also can limit dispersion by channeling airflow. A large-scale inversion during the winter can limit vertical mixing to under 3000 m (10,000 ft) above sea level (Bowen 1990).

Dispersion is generally greatest during the spring, when winds are strongest. However, deep vertical mixing is greatest during summer, when the atmosphere is unstable up to 1500 m (4875 ft) AGL or more. Low-level dispersion is generally the least during summer and autumn, when winds are light.

1.4.6 Geology

The 111 km^2- (43 mi^2) Laboratory site and the adjacent communities are situated on the Pajarito Plateau, a shelf approximately 16 to 24 km (10 to 15 mi) wide and 72 km (45 mi) long. The Pajarito Plateau consists of a series of east-trending finger-like mesas separated by deep canyons cut by streams. The mesa tops range in elevation from approximately 2400 m (7800 ft) on the flanks of the Jemez Mountains to about 1900 m (6200 ft) at their eastern termination above the Rio Grande Valley. The Laboratory is located at altitudes ranging from 1800 to 2500 m (6000 to 8000 ft) on the eastern slopes of the Jemez Mountains.

The Pajarito Plateau is formed of consolidated ash (tuff) from two major volcanic eruptions in the Jemez Mountains that took place about 1.61 and 1.22 million yr ago. These eruptions produced widespread, massive deposits known as the Otowi and Tshirege Members of the Bandelier Tuff. Smaller eruptions that occurred between the two major events produced an interbedded sequence of silica-rich (rhyolitic) tuffs and sediments that occur commonly, but not uniformly, between the Otowi and Tshirege Members.

Surface sediments across the Pajarito Plateau are composed of thin soils developed on the mesa top, alluvial (water-deposit) and colluvial (slope-deposit) residues on the mesa flanks, and alluvial deposition in the canyon bottoms. The sediments consist of coarse-grained colluvium on steep hill slopes and fine-grained materials on the flatter mesa tops. Alluvial deposits in the canyons are composed of loose (unconsolidated) fine and coarse sands of quartz, sanidine crystal fragments, and broken pumice fragments that are weathered and transported from the mesa top and sides. The slopes between the mesa tops and canyon bottoms often consist of rocky outcrops and patches of undeveloped colluvial soil. South-facing canyon walls are steep and sometimes have no soils, but north-facing walls generally have areas of very shallow, dark soils (DOE 1999).

1.4.7 Seismicity and Volcanism

Seismic source zones at Los Alamos include the Rio Grande Rift, the Jemez Volcanic Province, the Colorado Plateau Transition Zone, the Southern Rocky Mountains, and the Great Plains Provinces.

The Laboratory is situated near the western edge of and within the Rio Grande Rift, a tectonically, volcanically, and seismically active province in the western US. The instrumental and historical records of earthquakes in New Mexico extend back only about 100 yr.

The most recent volcanic activity within the Jemez volcanic field occurred about 50,000 to 60,000 yr ago. Studies have found more evidence for recurring seismic activity along the Pajarito Fault System than for recurring volcanic activity in the Jemez volcanic field (Reneau, Gardner, and Forman 1996; Olig et al. 1996). The three most significant and closest fault zones to the Laboratory are the Pajarito, Guaje Mountain, and Rendija Canyon Faults, which are accompanied by numerous smaller secondary faults. The larger faults are clearly expressed by surface offsets at some locations; their presence at other locations is inferred from geologic evidence (Wong et al. 1995).

The Woodward-Clyde study evaluated the seismic measurements recorded by the Laboratory from 1973 to 1992 (Wong et al. 1995). Only one well-located earthquake has occurred in the vicinity of the Laboratory or the three local faults. The maximum depth of seismic activity in the northern Rio Grande Rift is about 12 km (7.5 mi), which is consistent with elevated temperatures in the crust. Focal mechanisms show normal and strike-slip faulting generally on northerly striking planes. Consistent with the Rio Grande Rift zone, an approximately east-to-west extension characterizes the tectonic stress field.

The Pajarito Fault is thought to mark the currently active western boundary fault of the Española Basin (Carter and Gardner 1995). This fault forms the western boundary of the Pajarito Plateau and is easily visible above West Jemez Road as an east-facing escarpment about 91 m (300 ft) high. The Rendija Canyon and Guaje Mountain Faults are shorter than the Pajarito Fault. All three faults are geologically young and are capable of producing earthquakes.

The Pajarito Fault zone trends north along the western boundary of the Laboratory. The Rendija Canyon Fault zone is located 3.2 km (2 mi) east of the Pajarito Fault zone and trends north to south across the Laboratory. The Guaje Mountain Fault zone is located 1.6 to 2.4 km (1 to 1.5 mi) east of the Rendija Canyon Fault zone and also trends north to south. Maximum magnitudes for the random earthquakes within these provinces range from 6.0 to 6.5 Mw (Wong et al. 1995). Table 1-2 lists the approximate length, type, most recent movement, and maximum earthquake for each fault.

Table 1-2
Major Faults in the Laboratory Area

Name	Approximate Length (km/mi)	Type[a]	Most Recent Movement	Maximum Earthquake (Mw)[b]
Pajarito	26/16.3	Normal, east side down	100,000 to 200,000 yr ago, multiple in the past	6.9
Rendija Canyon	9.6/6	Normal, west side down	8000 to 9000 yr ago	6.5
Guaje Mountain	8/5	Normal, west side down	4000 to 6000 yr ago	6.5

[a] "Normal Fault" describes a steep to moderately steep fault for which the movement is downward for the rocks above the fault zone.
[b] "Mw" denotes the moment magnitude scale, which is physically based and calibrated to the Richter local magnitude scale at the lower values.

1.4.8 Hydrology

1.4.8.1 Surface Flow

Springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons on the Pajarito Plateau. Runoff from summer storms on the Pajarito Plateau reaches maximum discharge in less than 2 hr and generally lasts less than 24 hr (Devaurs and Purtymun 1985; Purtymun and Kennedy 1970). High-discharge rates can transport large masses of both suspended and bed sediments for long distances down the canyons. Spring snowmelt runoff occurs over several weeks to several months at a low discharge rate.

Surface flow in Pueblo Canyon is perennial in the form of effluent from the Los Alamos townsite. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year. Large-scale flooding is not common in New Mexico and has never been observed in Los Alamos. Most of Laboratory TAs are located on top of the finger mesas near drainage divides in areas that are not subject to flooding.

1.4.8.2 Groundwater

Groundwater in the Laboratory area occurs in shallow alluvial systems in canyons; in perched zones beneath some canyons and along the Jemez Mountains within the Bandelier Tuff, the Cerros del Rio Basalt, and the upper part of the Puye Formation; and in the regional aquifer. The regional aquifer is the only groundwater source that can serve as a municipal and industrial water supply. Eighteen deep aquifer wells, located in Otowi and Guaje Canyons and on the Pajarito Plateau, supply water to the Laboratory and the town of Los Alamos (inclusive of the White Rock community). The average saturated thickness of the aquifer penetrated by the Pajarito Field wells is 550 m (1800 ft). Regional aquifer waters date to a few thousand years to more than 40,000 yr, with the most recent waters in the western portions of the aquifer and the oldest in portions to the east.

The principal recharge to the main aquifer is from the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos. The integrity of the aquifer results from its confinement below ground; compromise from flooding, earthquakes, or volcanic eruption is unlikely. Water in the aquifer moves from the major recharge area east toward the Rio Grande, where the water discharges as seeps and springs in White Rock Canyon (Purtymun, Peters, and Owens 1980). The Rio Grande is the principal groundwater discharge for the regional aquifer, with annual discharge to an 18-km (11 mi) reach of the Rio Grande in White Rock Canyon of about 6.8 million m^3 (5500 acre-ft) (LANL 1995).

The aquifer extends to the south into Bandelier National Monument, where water movement trends more southerly than easterly. North of Frijoles Canyon, the aquifer surface is slightly above river level; south of the canyon, the aquifer surface is below river level (Purtymun, Peters, and Owens 1980).

1.5 Descriptions of Features Near NES

In addition to the general site characteristics described in the preceding sections, this DSA considers several specific site characteristics relative to safety and inventory isolation at the NES. These characteristics include facilities and potential energy sources near NES, NES locations relative to public receptors and nearby sites, access control of the NES, the proximity of NES to utilities and roads, NES vegetation relative to fuel-loading, and the potential for surface water to impact NES inventory. The following subsections discuss these characteristics of the NES.

1.5.1 Energy Sources and Facilities with Proximity to NES

Table 1-3 identifies the facilities and potential energy sources adjacent to each NES. Common energy sources include vehicular traffic and electric and natural gas utility lines. This table does not include any energy sources resulting from or related to activities performed within the boundaries of the NES.

Table 1-3
Adjacent Facilities and Potential Energy Sources outside NES Boundaries

NES	Adjacent Facilities and Potential Energy Sources outside NES Boundaries
TA-21 MDA A	Natural gas line (west boundary); empty diesel fuel tanks at steam plant (180 m/600 ft distant); water tower; live power/steam at power plant (~180 m/600 ft distant); MDA B and MDA T
TA-21 MDA B	Natural gas line (46 m/150 ft east); empty diesel fuel tanks at steam plant (180 m/600 ft distant); water tower; live power/steam at power plant (~180 m/600 ft distant); vehicular traffic; inactive radioactive waste line; buried county utilities (adjacent)
TA-21 MDA T	Empty diesel tank; natural gas (~46 m/150 ft distant); water tower; live power/steam at power plant; vehicular traffic; roads; electrical power
TA-35 MDA W	TAs 35, 52, 63; sewage lagoon near cliff face 3 to 4.6 m/10 to 15 ft distant; vehicular traffic; roads
TA-35 WWTP	Buried 13.2-kV power lines encased in concrete; natural gas lines; vehicular traffic at ground surface above lines
TA-35 Pratt Canyon	Buried 13.2-kV power lines encased in concrete; natural gas lines; vehicular traffic at ground surface above lines
TA-49 MDA AB	TA-49; Frijoles Mesa Site; helicopters; vehicles; planned detonations in and outside of TA-49; new 115-kV power line in progress
TA-50 MDA C	TAs 55, 63, 35; vehicular traffic; roads; electrical line; natural gas line (along fence)
TA-53 Resin Tank	TA-53 LANSCE[a] buildings; high-voltage, EMF[b], pressurized lines or volumes; beam line D (800 MeV); charged particles; high-radiation fields; magnetic field; compressed air; high and low electrical voltage in beam tunnel
TA-54 MDA H	MDA J, Area G, TA-54; vehicular traffic; roads

[a] LANSCE = Los Alamos Neutron Scattering Center.
[b] EMF = Electromagnetic field.

1.5.2 General Access and Proximity to Workers and the Public

All of the NES included in this DSA are located on LANL-controlled land at varying distances from residential or industrial areas outside Laboratory control. The MDA B NES, which is across DP Road from an occupied industrial area and 644 m (0.4 mi) from a residential area, is the NES closest to workers and residents. Table 1-4 provides descriptions of each NES, its location, and adjacent Laboratory TAs, sites, and structures. This table also identifies if the NES is located within a TA or operating facility boundary that is currently under control, requiring a LANL badge for entry. Boundary locations for each NES are provided in sections 1.5 and 1.6. As the Laboratory administrator, DOE has the option to completely restrict access to the Laboratory and to Laboratory TAs in the event of an emergency.

Table 1-4
NES Locations and Adjacent Sites

NES	Location	Within LANL-Controlled Area or Secure Boundary	Closest Public Receptor	Adjacent Properties/Sites
TA-21 MDA A	North-central portion of TA-21 south of access road between DP Canyon and Los Alamos Canyon	Yes	438 m North to NM 502	TA-21 PRS and buildings
TA-21 MDA B	Between DP Canyon and Los Alamos Canyon south of DP Road west of main TA-21 complex	Yes	~20 m North to DP Road	
TA-21 MDA T	North-central portion of TA-21 between DP Canyon and Los Alamos Canyon south of access road	Yes	335 m North to NM 520	
TA-35 MDA W	Southern edge of mesa between Mortandad Canyon and Ten-Site Canyon south of Pecos Drive and TA-35 Ten-Site buildings	Yes	1170 m NE to Truckroute	TAs 35, 52, 63; sewage lagoon
TA-35 WWTP	East central portion of mesa between Mortandad Canyon and Ten-Site Canyon, adjacent to eastern-most buildings at TA-35	Yes	1049 m NE to Truckroute	
TA-35 Pratt Canyon	Pratt Canyon south of Mortandad Canyon north of Ten-Site Canyon east of TA-35 mesa-top buildings	Yes	1049 m NE to Truckroute	
TA-49 MDA AB	On Frijoles Mesa between Ancho Canyon and Water Canyon	Yes	904 m SW on SR 4	TA-49 Frijoles Mesa Site
TA-50 MDA C	TA-50 above the end of Ten-Site Canyon between Mortandad Canyon and Two Mile Canyon north of Pajarito Road and south of Pecos Drive	Yes	1277 m NNW to Royal Crest Trailer Park	TAs 55, 63, 35
TA-53 Resin Tank	Between Sandia Canyon and Los Alamos Canyon north of La Mesita Road; north-central area of TA-53 complex; part of an exclusion area in TA-53	Yes	507 m SSW to Truckroute	TA-53 LANSCE buildings
TA-54 MDA H	North of Pajarito Canyon on Mesita del Buey north of Pajarito Road and south of Mesita del Buey Road south of primary TA-54 complex	Yes	526 m NNE to San Ildefonso land	MDA J, Area G, TA-54

1.5.3 Proximity to Roads and Utilities

Several of the NES are adjacent to major traffic routes through the Laboratory; others are isolated in locations, with limited vehicular access. Above- and/or below-ground utility lines and pipes, including electric power, natural gas, wastewater, water, and radioactive liquid waste (RLW) cross through or are adjacent to many of the NES. Utility maps updated and managed by the KBR, Shaw, LATA group (KSL) show the locations of utility lines, including those for natural gas, sewer, steam, electricity, and water that are nearby, adjacent to, beneath, or over the NES. Table 1-5 lists the roads near or adjacent to each NES. Table 1-6 lists and provides a brief description of utility lines associated with the NES.

Table 1-5
Roads Near and Adjacent to NES

NES	Near and Adjacent Roads
TA-21 MDA A	Adjacent open access road at termination of DP Road north of TA-21 complex; access currently not controlled; typically Laboratory traffic only
TA-21 MDA B	DP Road parallel to and directly north; public traffic
TA-21 MDA T	Adjacent open access road at termination of DP Road north of TA-21 complex; access currently not controlled; typically Laboratory traffic only
TA-35 MDA W	Nearest road within TA-35 complex approximately 20 to 30 m (66 to 100 ft) north, access restricted to Laboratory traffic only, controlled area
TA-35 WWTP	Adjacent TA-35 complex roads; light use; access restricted to Laboratory traffic only; controlled area
TA-35 Pratt Canyon	Unpaved access road through side bank of Pratt Canyon; seasonal use; limited physical access
TA-49 MDA AB	Unpaved roadways; access within TA-49 restricted to Laboratory traffic only
TA-50 MDA C	Pajarito Road along parts of southern boundary; heavy use; controlled access; Pecos Drive at TA-35 10 to 20 m (33 to 66 ft) northwest; access restricted to Laboratory traffic only
TA-53 Resin Tank	Many roadways within the TA-53 LANSCE complex; access restricted to Laboratory traffic only; controlled area
TA-54 MDA H	Pajarito Road 50 m (165 ft) southwest; heavy use; controlled access; Mesita del Buey Road 30 to 40 m (110 to 130 ft) north; restricted to Laboratory traffic only; controlled area

1.5.4 Vegetation

The Laboratory site and surrounding areas are generally forested and have high fuel loadings. Because of wildfire conditions in Los Alamos and at the Laboratory, vegetation at each NES is considered relative to wildfire fuel loading. Table 1-7 describes the fuel-loading conditions at each NES.

1.5.5 Surface Water Impact

Surface water has the potential to erode the cover from, infiltrate into, or destabilize former disposal units. Evaporation, transpiration, and infiltration generally deplete surface flow in the upper reaches of the canyons of the Pajarito Plateau before it can flow across the Laboratory and the NES. Some storm or snowmelt events provide sufficient runoff for short periods (days or weeks) to initiate flow across a NES (Devaurs and Purtymun 1985; Purtymun and Kennedy 1970). Table 1-8 summarizes the potential for surface water runoff to impact the NES. The potential impact to NES located on canyon or mesa-edge sites is high. At these locations, runoff could disturb inventory or covers associated with the NES. The potential for surface water runoff to impact other NES is low or moderate, depending upon site conditions and cover thickness.

Table 1-6
Utility Lines Near or Adjacent to NES

NES	Near or Adjacent Utilities
TA-21 MDA A	Natural gas line (with above-ground run) immediately west of site and adjacent to southwest; sewer line to Building TA-21-155 approximately 30 m (100 ft) east of boundary fence; steam line 30 m (100 ft) south
TA-21 MDA B	Natural gas line along western half to north of DP Road; sewer line near northwest and north of DP Road; presence of Los Alamos County water line to be determined
TA-21 MDA T	Natural gas lines near southeast; sewer line to Building TA-21-257; steam line near southwest adjacent to Building TA-21-228; steam line 30 m (100 ft) south; electric lines 30 to 60 m (100 to 200 ft) south
TA-35 MDA W	Sewer line 15 to 30 m (50 to 100 ft) north of site; natural gas lines to Buildings TA-35-110 and -114
TA-35 WWTP	Sewer and gas lines north to south across NES; electric lines to Buildings TA-35-29 and -53 adjacent north and south
TA-35 Pratt Canyon	Electric and sewer lines 30 to 90 m (100 to 300 ft) south of canyon at mesa top
TA-49 MDA AB	Electric line runs west to east between shaft areas 1 and 2 [15 to 45 m (50 to 150 ft) south] and 150 between sites 3 and 4 [150 to 300 m (500 to 1000 ft) north]
TA-50 MDA C	Electric and natural gas lines along south boundary adjacent to Pajarito Road, electric line near northeast corner
TA-53 Resin Tank	Electric line to Buildings TA-53-849 and -07 near west boundary; natural gas line to Buildings TA-53-03, -39, and -22 near east and south boundaries; sewer lines to various buildings east of site
TA-54 MDA H	Sewer line near southwest tip of site; electric lines along Pajarito Road, 50 m (164 ft) west

Table 1-7
NES Wildfire Fuel Loading

NES	Fuel Loading Description
TA-21 MDA A TA-21 MDA B TA-21 MDA T	Borders forested areas containing indigenous evergreen trees and wild vegetation; separated from large forested areas with high fuel loadings to the south by Los Alamos Canyon; separated from State Road 502 by a thinly forested canyon to the north. Separated from Jemez Mountains by urban Los Alamos townsite
TA-35 MDA W	Thinly forested near edge of canyon; 20 to 30 m (66 to 100 ft) south of multiple TA-35 buildings, canyon floor is heavily forested
TA-35 WWTP	Limited vegetation; adjacent to multiple TA-35 buildings
TA-35 Pratt Canyon	Moderate to heavy forestation in Pratt Canyon below TA-35
TA-49 MDA AB	Shaft area pads not forested but adjacent to moderate- to-heavy forestation and vegetation
TA-50 MDA C	Limited vegetation; adjacent to Pajarito Road, Pecos Drive, and multiple TA-35 buildings
TA-53 Resin Tank	Limited vegetation; adjacent to multiple TA-53 buildings
TA-54 MDA H	Thinly forested between Mesita del Buey Road and canyon edge

Table 1-8
Surface Water Impact Summary

NES	Surface Water Impact
TA-21 MDA A	Moderate
TA-21 MDA B	Moderate
TA-21 MDA T	Moderate[a]
TA-35 MDA W	High
TA-35 WWTP	Low
TA-35 Pratt Canyon	High
TA-49 MDA AB	Low
TA-50 MDA C	Moderate
TA-53 Resin Tank	Low
TA-54 MDA H	Low

[a] Moderate due to presence of above-ground water tank.

1.6 Descriptions of NES

The following sections describe important characteristics of each NES, including the relationship to PRS, boundaries, operational history, disposal methods employed, and the quantity, form, and other characteristics of radioactive and hazardous materials present. Also provided in these sections are site maps that show the NES locations in detail.

Table 1-9 provides summary descriptions of NES boundary and cover characteristics. Surface boundaries define the areas where personnel will conduct S&M activities.

1.6.1 TA-21 MDA A NES

The TA-21 MDA A NES is a 1.25-acre HC-2 site located 400 m (0.25 mi) east of the intersection of DP Road and the north perimeter road at TA-21. The NES boundary coincides with the boundary of PRS 21-014. A fence at TA-21 encloses the NES and its inventory, which is associated with the intermittent disposal of radioactively contaminated solid waste, debris from decontamination and decommissioning (D&D) activities, and radioactive liquids generated at TA-21.

From 1945 to 1949 and from 1969 to 1977, personnel at TA-21 discharged RLW to two 189,000-L (50,000 gal.), buried cylindrical steel tanks. Known as the General's Tanks, each is 3.7 m (12 ft) in diameter, and 19.1 m (62.8 ft) long, and rests approximately 5.2 m (17 ft) below grade. Tank cover consists of reinforced concrete caps 0.2 m (8 in.) thick, topped by 0.91 m (36 in.) of soil overburden. The tanks contain plutonium- and uranium-contaminated aqueous sediment.

Table 1-10 presents the initial categorization and DSA inventory estimates for the General's Tanks (LANL 2003). LANL analysts corrected unit conversions to calculate the DSA inventory and included values for ingrowth products that were omitted from the initial categorization. As a result, DSA estimates are larger for most radionuclides than initial categorization estimates. The DSA total inventory for the two tanks is 139 Ci, with 111 Ci in the western tank and 28 Ci in the eastern tank.

Table 1-9
NES Boundary and Cover Characteristics

NES	Boundary Description	Cover Characteristics
TA-21 MDA A	Fenced area coinciding with boundary of PRS 21-014 and encompassing soil- and concrete-covered areas adjacent to TA-21 access road.	Over pits: Estimated 0.15 to 0.30 m (6 to 12 in.) of slightly contaminated overburden Over tanks: 0.91 m (36 in.) overburden and 0.2 m (8 in.) reinforced concrete
TA-21 MDA B	Fenced area encompassing asphalt and soil-covered areas adjacent to DP Road (MDA B boundary).	Total site: Estimated 0.15 m (6 in.) overburden 75% of site: Estimated 0.10 to 0.15 m (4 to 6 in.) asphalt cover 25% of site: No asphalt cover; estimated additional 0.30 m (12 in.) overburden
TA-21 MDA T	Rectangular area encompassing subsurface absorption beds and shafts; fenced except for small portion of absorption bed at its west corner, which is under an access road.	Shafts: Topped with approximately 0.61 m (2 ft) concrete Entire site (includes shafts and absorption beds): 1.2 to 1.5 m (4 to 5 ft) crushed tuff and fill layer overburden
TA-35 MDA W	Rectangular area coinciding with MDA W concrete cap.	Concrete vault constructed of 0.2 m (8 in.) thick (nominally) walls and lid
TA-35 WWTP	Northwest-trending rectangle encompassing areas of radioactive soil contamination, including area at the head of Pratt Canyon not included in the Pratt Canyon NES.	Primarily subsurface soil contamination >0.60 to 0.91 m (>2 to 3 ft)
TA-35 Pratt Canyon	Soil contamination areas within the Pratt Canyon contaminant impact area; limited to the channel that received radioactive materials from the WWTP.	No engineered cover; commingling of uncontaminated soils with contaminated soils at surface
TA-49 MDA AB	Fenced areas around three covered shaft areas (1, 2, and 4).	Concrete pads or tuff cover over filled and sealed shafts
TA-50 MDA C	Fenced area encompassing soil covered areas between Pajarito Road and Pecos Drive. Boundary coincides with MDA C, except as described in Section 1.6.8. Current fence includes areas at the southwest corner of MDA C that are not part of the NES.	95% of site: Fill cover 0.15 to 2.44 m (0.5 to 8 ft) thick < 5% of site (north edge): Uncapped
TA-53 Resin Tank	Fenced area above tanks encompassing areas outside the resin tank, coincident with exclusion area above LANSCE beam line D.	Open access line to tank with metal cover – soil and pavement cover
TA-54 MDA H	Existing fenced area encompassing soil covered areas between Pajarito Road and Mesita del Buey, same boundary as MDA H.	0.91 m (3 ft) crushed tuff and 0.91 m (3 ft) concrete cap

Table 1-10
TA-21 MDA A Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-21 MDA A	MDA A West General's Tank	uranium-235	Not Included	1.1 E -03
		plutonium-238	Not Specified	2.5 Ee-01
		plutonium -239	Not Specified	4.3 E+01
		plutonium -241	Not Specified	6.3 E+01
		americium-241	Not Specified	4.8 E +00
TA-21 MDA A	MDA A East General's Tank	uranium-235	Not Included	3.1 E-04
		plutonium-238	Not Specified	1.6 E-02
		plutonium-239	Not Specified	1.1 E+01
		plutonium-241	Not Specified	1.6E+01
		americium-241	Not Specified	1.2E+00
TA-21 MDA A	MDA A Total (includes both General's Tanks)	uranium-235	Not Included	1.4E-03
		plutonium-238	1.17E-02	2.66E-01
		plutonium-239	6.96E+02	5.43E+01
		plutonium-241	5.53E-01	7.89E+01
		americium-241	1.47E+00	6.07E+00
TA-21 MDA A[a]	MDA A Pit Disposal Areas			

[a] Discussed in paragraph following table.

Personnel at TA-21 disposed of combustible and noncombustible solid wastes and debris in three pits, two 5.5 m (18 ft) wide, 3.8 m (12.5 ft) long, and 3.8 m (12.5 ft) deep located in the eastern portion of the NES and one 52 m (172 ft) long, 41 m (134 ft) wide, and 7 m (22 ft) deep located in the site's central area. Solid wastes disposed to the eastern pits contained a variety of radionuclides and hazardous chemicals. Wastes disposed to the central pit consisted of plutonium-, uranium- and americium-contaminated D&D-related building debris.

An estimated 0.15 to 0.3 m (6 to 12 in.) of slightly contaminated soil overburden covers the disposal pits, none of which are currently active. LANL analysts were unable to locate early records for the pits or records providing sufficient detail for estimating their radioactive inventory. Assuming contamination of the building debris to be limited to residual matter on building surfaces demolished during D&D, analysts believe the inventory in the central pit to be much less than in the General's Tanks. The TA-21 MDA A NES is shown in Figure 1-2.

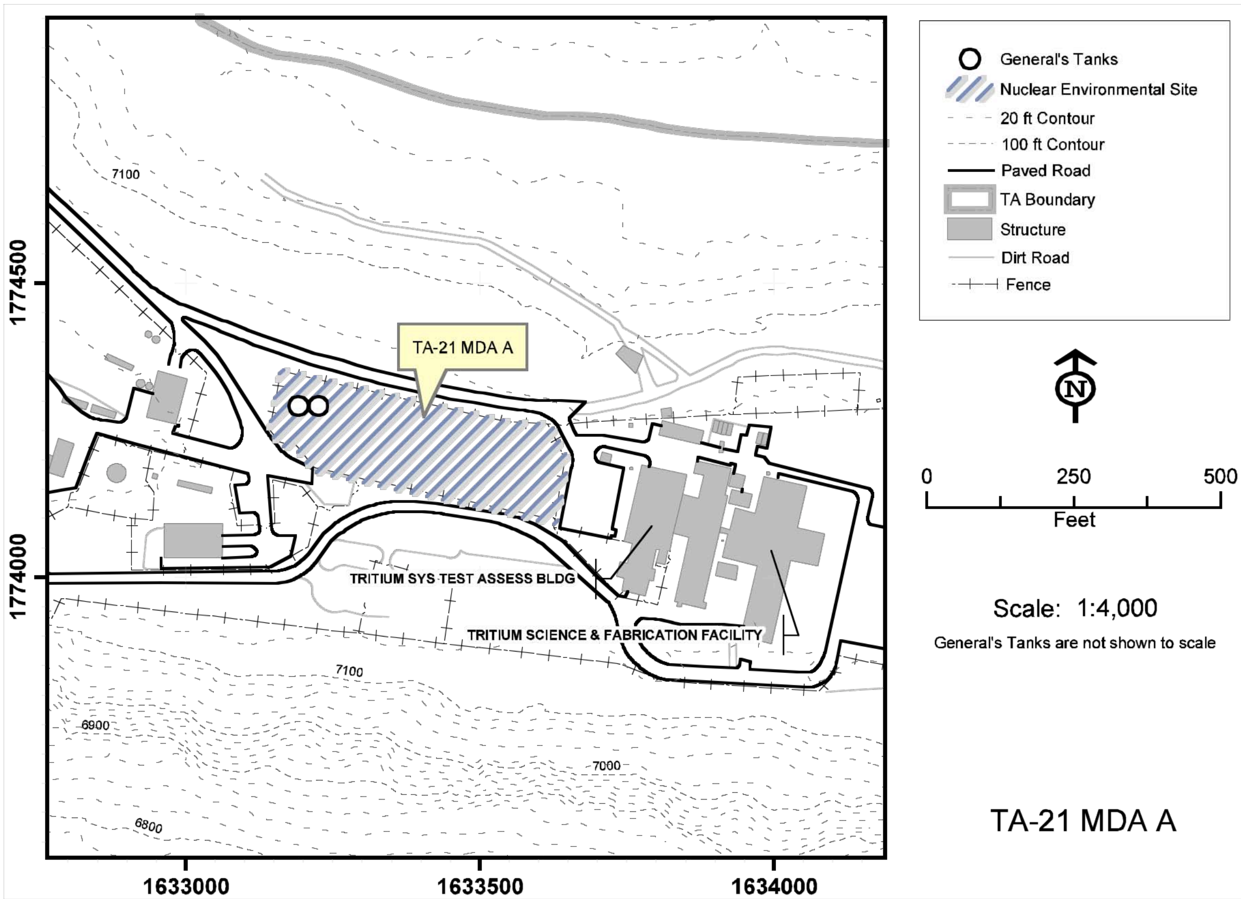

Figure 1-2. TA-21 MDA A NES location

1.6.2 TA-21 MDA T NES

The TA-21 MDA T NES is an HC-2 site located 320 m (0.20 mi) east of the intersection of DP Road and the north perimeter road of TA-21. This NES is a portion of consolidated PRS 21-016(a)-99, which comprises former PRS 21-007, 21-010(a, b, c, d, e, f, g, h), 21-011(a), 21-011(c, d, e, f, g, i, j), 21-016(a, b, c), 21-001, 21-011(h), 21-028(a), and areas of concern (AOCs) C-21-009, and C-21-012. The NES is a northwest-trending rectangle with a boundary that encompasses shafts and absorption beds of the former PRS 21-016(c) and 21-016(a). A fence encloses the NES and immediately surrounding areas. One small area of at the west corner of the NES is under an access road and is not enclosed within the fence.

Former PRS 21-016(a) consists of four inactive absorption beds (beds 1, 2, 3, and 4). Operational between 1945 and 1967, the beds were excavated trenches approximately 43 m (140 ft) long, 6 m (20 ft) wide, 1.2 m (4 ft) deep, filled with about 0.6 m (2 ft) of crumbled, clean tuff, covered with 0.3 m (1 ft) of gravel, and topped with 0.3 m (1 ft) of sand. RLW was discharged to the pits near their bases. The purpose of the tuff fill, gravel, and sand was to facilitate absorption of liquid waste and minimize migration away from the site. The absorption beds received untreated waste from TA-21 uranium- and plutonium-processing laboratories and the filter building (Building TA-21-12). During later grading and work on the site, personnel placed an additional 1.8 m (6 ft) of crushed tuff over the absorption beds.

The tuff- and fill-covered inventory of the beds is approximately 9.8 Ci. Results of historical sampling of the beds indicates that the majority of the radioactive inventory is under nearly 3 m (10 ft) of cobbles, gravel, and crushed tuff at the interface between the absorption layer and the bed bottoms.

Former PRS 21-016(c) consists of 62 asphalt-lined disposal shafts located between absorption beds 2 and 4. The shafts are 1.8 or 2.4 m (6 or 8 ft) in diameter and 4.6 to 21 m (15 to 69 ft) deep. Between 1968 and 1983, Laboratory personnel used the shafts for disposal of RLW mixed with cement. Shaft covers consist of concrete layers approximately 0.6 m (2 ft) thick and layers of crushed tuff and fill approximately 1.2 to 1.5 m (4 to 5 ft) thick. The inventory values used for categorization and subsequent analyses in the DSA are presented in Table 1-11.

Table 1-11
TA-21 MDA T Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-21 MDA T	Disposal shafts	uranium-233	6.90E+00	6.90E+00
		plutonium-238	3.13E+01	3.13E+01
		plutonium-239	1.51E+02	1.51E+02
		americium-241	3.74E+03	3.74E+03
		plutonium-241	Not Included	3.74E+04
TA-21 MDA T	Absorption beds	plutonium (undifferentiated)	Not Included	9.8 E+00

The absorption beds were not included for inventory in the initial categorization, but are included in the NES boundary and in the DSA. Analysts prepared the DSA inventories to include radioactive ingrowth products not considered in the initial categorization.

This NES is shown in Figure 1-3.

1.6.3 TA-21 MDA B NES

The western edge of TA-21 MDA B, an HC-3 NES, is located 488 m (1600 ft) east of the intersection of DP Road and Trinity Drive. The northern, fenced boundary of the NES is within a short distance of DP Road. The boundary of this NES coincides with the boundary of PRS 21-015 and is fenced.

The TA-21 MDA B NES is an inactive 24,400-m^2- (6.03-acre) disposal site. It was the first common disposal area for radioactive waste generated at the Laboratory and operated from 1945 until 1948. Radioactively contaminated paper, rags, rubber gloves, glassware, and small metal apparatus contained in cardboard boxes made up about 90% of the volume of waste disposed to TA-21 MDA B. Hazardous chemicals, waste products from a water boiler, wood from temporary storage cabinets, and at least one truck contaminated with fission products from the Trinity test made up the remainder. Radionuclide inventory in the TA-21 MDA B NES potentially comprises radioisotopes of plutonium, polonium, uranium, americium, curium, actinium, lanthanum, and possibly strontium. Organic chemical inventory potentially comprises perchlorates, ethers, solvents, and corrosive gases.

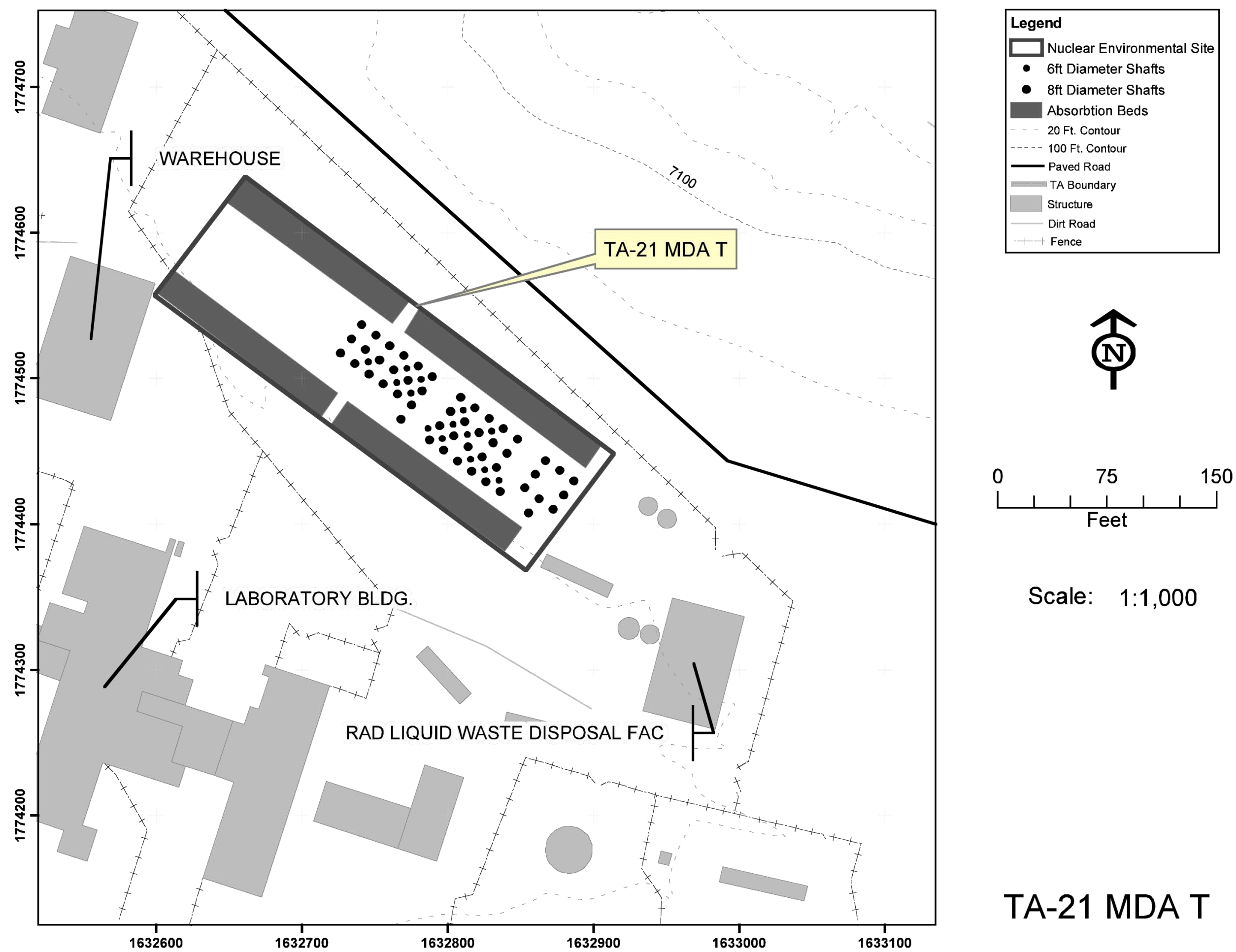

Figure 1-3. TA-21 MDA T NES location

Historical documents and records indicate the presence of at least five burial pits at TA-21 MDA B. With the exception of the hazardous-materials pit, which documents describe as a trench 12 m (40 ft) long, 0.6 m (2 ft) wide, and 0.9 m (3 ft) deep, documents describe the pits as 91 m (300 ft) long, 4.6 m (15 ft) wide, and 3.7 m (12 ft) deep. Cover at the NES consists of asphalt and soil overburden. The estimated asphalt coverage is 0.1 to 0.15 m (4 to 6 in.) over 75% of the site. Estimated soil overburden is 0.15 m (6 in.) in the asphalted area and 0.45 m (18 in.) in the nonasphalted area. Because of the variability of the cover layer, the safety analysis in Chapter 3 places a low value on cover as a barrier for TA-21 MDA B.

Initial categorization of TA-21 MDA B used the inventory reported in a 1971 memorandum from Meyer (Meyer 1971). According to the Meyer inventory, the maximum plutonium-239 inventory in MDA B is 100 g. As shown in Table 1-12, the DSA and initial categorization inventories are the same.

Table 1-12
TA-21 MDA B Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-21 MDA B	Undifferentiated disposal area for LANL waste	strontium-90	2.85E-01	2.85E-01
		cesium-134	5.49E-03	5.49E-03
		thorium-228	1.82E-01	1.82E-01
		plutonium-239	6.22E+00	6.22E+00

Inventory at TA-21 MDA B exists in slit trenches and pits separated by undisturbed bed rock and covered with fill and/or asphalt, as previously described. The material in the trenches includes combustible and noncombustible items. Figure 1-4 shows the location of TA-21 MDA B.

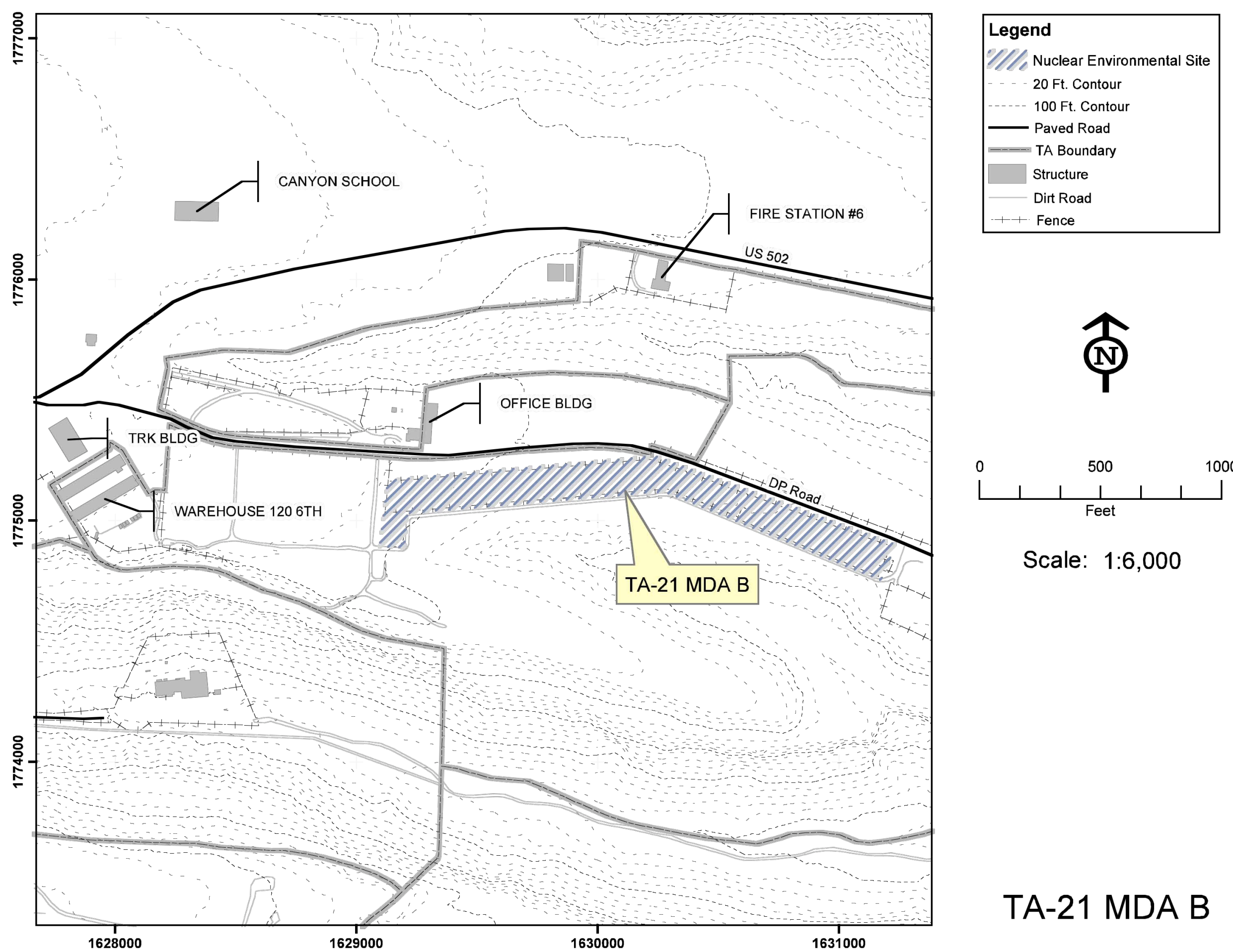

Figure 1-4. TA-21 MDA B NES location

1.6.4 TA-35 MDA W NES

The TA-35 MDA W NES (an HC-3 site) is located on the east end of Ten-Site Mesa, south of Middle Mortandad Canyon, and due south of Building TA-35-02. The rectangular boundary of the NES is the same as the MDA W boundary, which coincides with former PRS 35-001 and is not fenced.

This NES includes two vertically emplaced tanks formerly used for the disposal of sodium coolant from the Los Alamos Molten Plutonium Reactor Experiment 1 (LAMPRE-1) sodium-cooled research reactor, which operated at TA-35 from approximately 1960 to 1964. The tanks are stainless steel tubes approximately 37 m (120 ft) long, installed in shafts 38 m (125 ft) deep, and lined with an 8-in.- (0.2-m-) diameter carbon steel casing. Approximately 1 m (3.3 ft) of undisturbed tuff separates the two tanks. After experiments were complete, the two tanks were filled about half full with elemental sodium and were topped with nitrogen gas. The DSA analysts are unable to confirm whether the inert nitrogen blanket still exists. A concrete vault embedded in tuff encloses the upper ends of the sodium tanks and associated piping. The vault is constructed of 0.2-m- (8-in.-) thick (nominally) concrete walls and lid.

The predominant radionuclide of concern in the sodium is plutonium-239, which may have been introduced from the breach of one or two fuel elements during the operational life of LAMPRE-1 (Warren 1974; Harper 1981). Based on a review of available documentation, analysts concluded that the maximum radioactive material available from the rupture of two fuel elements is approximately 21 Ci of plutonium-239 and 4.7 Ci of plutonium-240 and that much of this quantity may have been retained in the reactor components prior to decommissioning in 1981 and not disposed with sodium in 1964. Table 1-13 shows the initial categorization and DSA inventory for the TA-35 MDA W NES.

Table 1-13
TA-35 MDA W Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-35 MDA W	Sodium Coolant Storage Tanks	plutonium-239	2.1 E+01	2.1 E+01
		plutonium-240	4.7 E+00	4.7 E+00

Inventory distribution in the tanks is unknown, including whether one tank has more inventory than the other or whether radioactive inventory is significant in either. Figure 1-5 shows the location of TA-35 MDA W and the locations of the other two TA-35 NES.

1.6.5 TA-35 WWTP NES

The TA-35 WWTP, an HC-3 NES, comprises areas within and outside of consolidated PRS 35-003(a)-99. Parts of former PRS 35-003(a, b, c, e, f, g, h, m, n, o, p) are included. This NES boundary also includes the head of Pratt Canyon, an area associated with consolidated PRS 35-003(d)-00. This NES is located on the east end of Ten-Site Mesa. The NES is a rectangle that trends approximately west-northwest.

The WWTP operated from 1951 until 1963, treating waste that originated from the radiochemistry laboratories. It consisted of an array of underground waste lines, storage tanks, and chemical treatment precipitation tanks. The RLW were acidic and included barium-140, lanthanum-140, strontium-89, strontium-90, and yttrium-90. The buildings, piping, tanks, and other process equipment were removed during several decontamination, decommissioning, and remediation efforts in the late 1980s and 1990s.

Residual soil contamination from accidental or long-term releases from process equipment contains the radioactive inventory that resulted in the HC-3 designation.

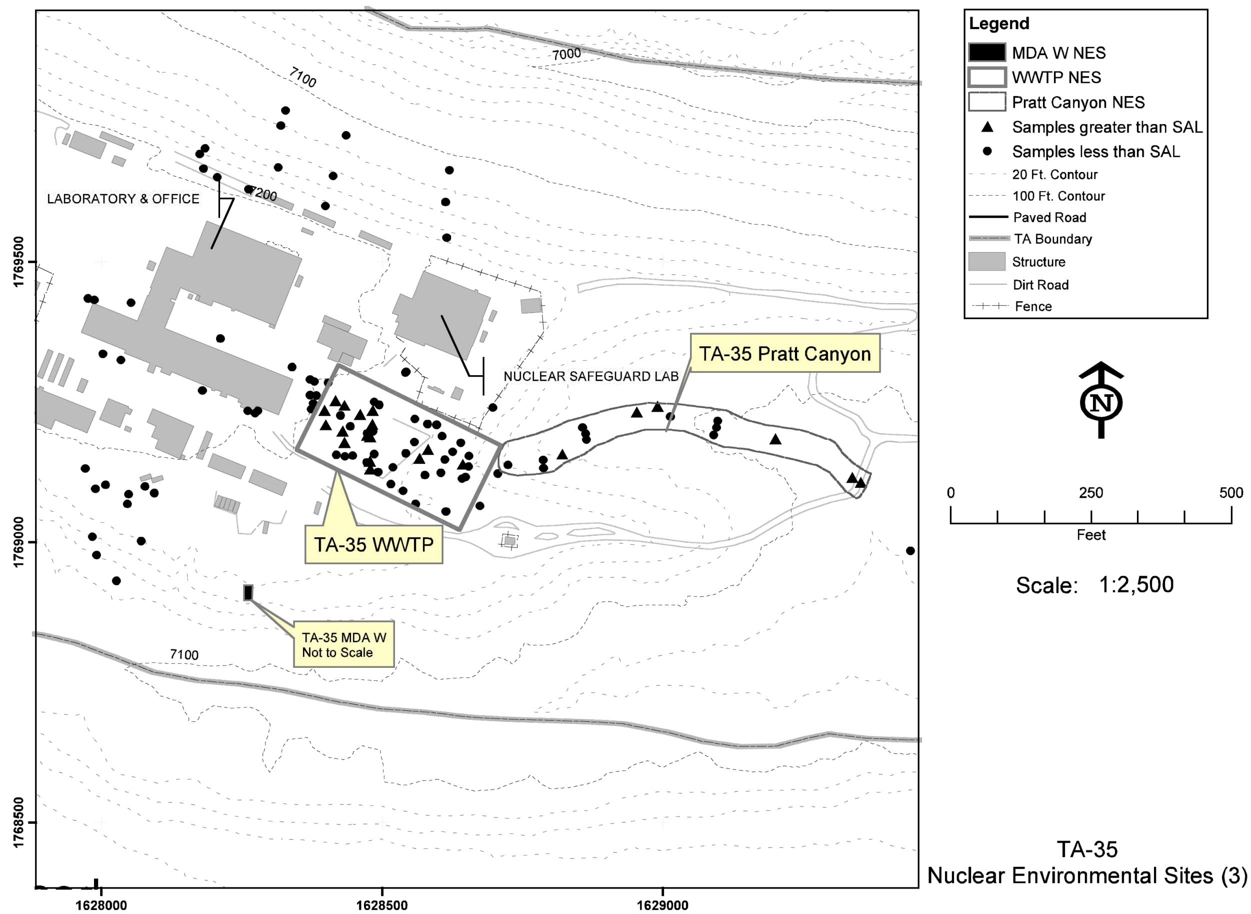

Figure 1-5. TA-35 MDA W, WWTP, and Pratt Canyon NES Locations

One apparent primary source of the contamination was former PRS 35-003(m), the site of a 3785-L (1000 gal.) underground sludge tank that was removed in August 1981. During the removal, measurements of the soil surrounding the tank showed up to 46,000 dpm/g (primarily Sr-90 and Cs-137). Soil from around the tank was excavated laterally until activity was not detected above background and below the tank to bedrock – 10 ft (3 m) below ground surface. At this depth, fractures in the rock measured by radiation field screening instruments had activity levels as high as 5000 pCi/g gross beta. The excavation was backfilled with clean soil material and paved over with asphalt to prevent release of contaminants to the environment.

Former PRS 35-003(o) was the site of a manhole that was removed in 1985. Following removal, 15 soil samples were collected that contained up to 7,145 pCi/g of beta activity. Because further excavation may have compromised the integrity of the excavation walls, the area was backfilled and paved over with asphalt. Additional soil contamination may exist from leakage from other underground piping and storage structures.

The radioactive inventory used for the TA-35 WWTP for this DSA is the same as the inventory used for initial categorization. Table 1-14 shows both inventories. The inventory at the TA-35 WWTP is widely distributed through subsurface soils and rock and covered with clean fill and an asphalt cap.

Table 1-14
TA-35 WWTP Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-35 WWTP	Residual soil and rock contamination following removal of components of former WWTP	tritium (H-3)	3.52E-01	3.5E-01
		cobalt-60	4.19E-02	4.2E-02
		strontium-90	7.31E+01	7.3E+01
		cesium-137	1.88E-01	1.9E-01
		europium-152	3.24E-02	3.2E-02
		uranium-234	6.25E-01	6.3E-01
		uranium-235	7.20E-02	7.2E-02
		uranium-238	3.55E+00	3.6E+00
		plutonium-238	5.64E-03	5.6E-03
		plutonium-239	2.37E-02	2.4E-02

Figure 1-5 shows the location of the TA-35 WWTP NES and the other NES located at TA-35.

1.6.6 TA-35 Pratt Canyon NES

TA-35 Pratt Canyon, an HC-3 NES, is located on the east end of Ten-Site Mesa (Figure 1-5). Initial categorization of this NES included the entire consolidated unit 35-003(d)-00, which comprised former PRS 35-003(d), 35-003(l), 35-003(q), and 35-003(r). However, only part [former PRS 35-003(r)] of the consolidated unit contains inventory associated with the outfall from the WWTP at TA-35. Former solid waste management unit (SWMU) 35-003(r) is the site of the canyon disposal area for liquid sludge effluent associated with the holding tanks of the former WWTP [former 35-003(d)]. This PRS is located in Pratt Canyon and extends from the head of Pratt Canyon at the eastern edge of Ten-Site Mesa to the confluence of Pratt and Ten-Site Canyons. Pratt Canyon is contaminated primarily by strontium-90, cesium-137, and plutonium-239. Residual contamination from this outfall is dispersed in isolated sedimentary pockets and interspersed with predominantly clean material that was deposited after the WWTP ceased operations.

Additional information has been used to refine inventory totals associated with this PRS. These are described in detail by Katzman (Katzman May 2004; Katzman June 2004) and the results are presented in Table 1-15 under the “DSA Inventory” entries. Katzman included all radionuclides for which there were sampling data. Plutonium-241 was not analyzed in the soil samples but was back-calculated based on rate of ingrowth of its progeny, americium-241.

This DSA uses the inventory calculated by Katzman, which is much less than the initial categorization inventory. The initial categorization assessment was very conservative in that it assumed that discrete sampling points represented large volumes of sediment and not localized contamination. Katzman’s analysis involved a realistic but still conservative assessment and the calculation of contaminated sediment volumes. The inventory totals as calculated by Katzman and presented in this DSA are a small fraction of the HC-3 levels.

Table 1-15
TA-35 Pratt Canyon Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-35 Pratt Canyon	Sediment contaminated with discharges of the WWTP	tritium (H-3)	4.71E+00	1.0E-04
		cobalt-60	3.93E-01	4.0E-04
		strontium-90	1.26E+02	1.7E-01
		cesium-137	2.67E+01	3.3E-02
		europium-152	4.87E-01	1.0E-04
		thorium-228	9.60E+00	9.6E-03
		uranium-234	2.95E+00	2.4E-03
		uranium-235	1.66E-01	2.0E-04
		uranium-238	3.89E+00	2.4E-03
		plutonium-238	1.13E-01	1.0E-04
		plutonium-239	1.85E+00	1.7E-03
		americium-241	4.40E-01	5.0E-04
		plutonium-241	Not Included	5.0E-05

Only PRS 35-003(r) is included in the refined inventory analysis. The small amount of residual contamination associated with other PRS in the consolidated unit is at the head of Pratt Canyon and is included in the inventory for the TA-35 WWTP NES and discussed in the preceding section.

1.6.7 TA-49 MDA AB NES

The TA-49 MDA AB NES is an HC-2 site located on Frijoles Mesa between Ancho and Water Canyon and is part of SWMU 49-001(a)-00. Specifically, the NES comprises shaft areas 1, 2, and 4, which are part of former PRS 49-001(a), 49-001(b), 49-001(c), 49-001(d), 49-001(f), and the intervening area. The boundary of the NES encloses all three shaft areas (1, 2, and 4). All three areas are enclosed within one fence (Figure 1-6).

Areas 1, 2, and 4 were the location of underground tests from late 1959 through mid-1961 involving high explosives (HE) and radioactive and special nuclear materials (SNM), including plutonium-239 and uranium-235. The tests were conducted in underground shafts [typically 1.8 m (6 ft) in diameter] drilled into the tuff. Containment shots conducted in some of the shafts used HE to characterize the tuff fracturing that resulted from underground explosions. Data from the HE shot experiments were used to design experiments using radioactive materials, to prevent releases of radioactivity, and to determine where to drill new shafts for radioactive tests to avoid encountering contamination from used shafts. Because HE is fully consumed in a normal test and because the HE used in all of the experiments is known to have detonated, no significant amount of HE is thought to remain in the subsurface. All shafts were filled with sand and crushed tuff. Shafts that contained SNM were routinely capped with concrete.

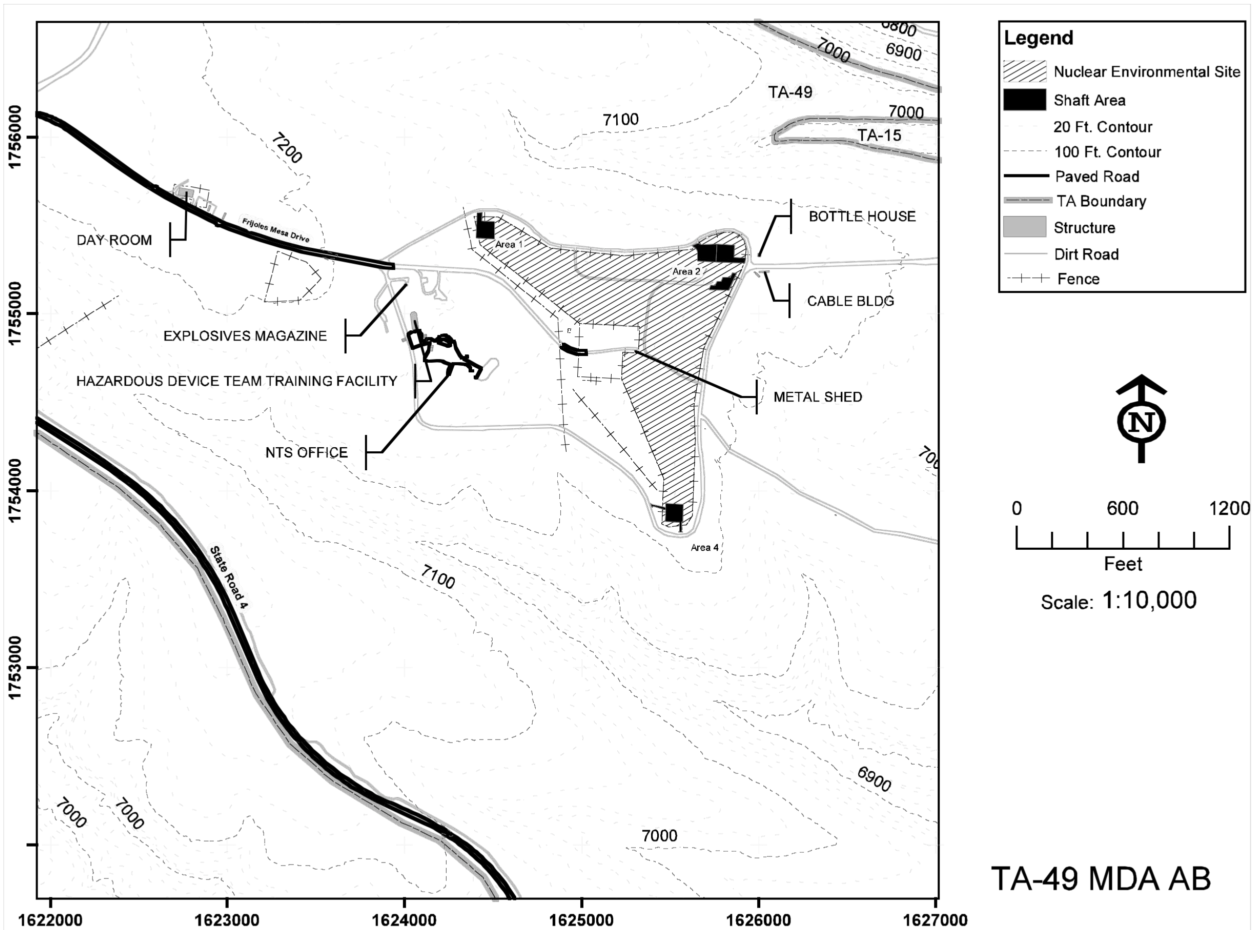

Figure 1-6. TA-49 MDA AB NES location

Prominent physical features of the NES are described in the following bulleted text. Inventories are not provided for each shaft area because that information must be treated as sensitive and is not required for the safety analysis. Table 1-16 presents the combined inventory of shaft areas 1, 2, and 4. The inventory used in the DSA incorporates radioactive ingrowth products and nonradioactive hazardous elements not considered in the initial categorization.

- Former PRS 49-001(a), known as shaft area 1, has a surface area of approximately 30.5 x 30.5 m (100 x 100 ft) and was designed to contain a maximum of 25 shafts on a uniform 1.5 x 1.5 m (5 x 5 ft) grid [7.6 m (25 ft) shaft spacing]. Of the 23 shafts drilled, 16 were used for radioactive materials experiments and had depths up to 25 m (81 ft).
- Former PRS 49-001(b), known as shaft area 2, has a surface area of approximately 30.5 x 30.5 m (100 x 100 ft) and was designed to contain a maximum of 25 shafts on a uniform 1.5 x 1.5 m (5 x 5 ft) grid [7.6 m (25 ft) shaft spacing]. Of the 22 shafts drilled, 16 were used for radioactive materials experiments and had depths up to 24 m (78 ft) [most up to 17.4 m (57 ft.)].

- Former PRS 49-001(c), known as shaft area 2A, is adjacent to the west side of shaft area 2 [PRS 49-001(b)], and occupies a surface area approximately 30.5 m (100 ft) long and 9.1 m (30 ft) wide. Six experimental shafts were installed in a single row at 7.6 m (25 ft) intervals in this area. Four shafts in shaft area 2A were used for experiments involving radioactive materials.
- Former PRS 49-001(d), known as shaft area 2B, is south of shaft area 2 and occupies a surface area of approximately 61 m (200 ft) long and 30.5 m (100 ft) wide. Shafts at shaft area 2B were aligned on a staggered grid with 11 shafts installed and another 15 proposed but not drilled. Six shafts were used for experiments with radioactive materials.
- Former PRS 49-001(f), known as shaft area 4, is approximately 30.5 m (100 ft) wide and 38.1 m (125 ft) long at the surface. This area was designed to contain 25 shafts on a uniform 1.5 m^2 (5 ft^2) grid. Eighteen experimental shafts were drilled at this site. One shaft 17.7 m (58 ft) deep was used for a containment shot. Thirteen shafts were used for experiments involving radioactive materials.

Table 1-16
TA-49 MDA AB Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci, except as indicated)
TA-49 MDA AB[a]	Three shaft areas that were used for subcritical experiments involving nuclear materials.	uranium-235	2.0 E -01	2.0 E -01
		uranium-238	4.47 E -02	5.7 E -02
		plutonium-239	2.4 E +03	2.4 E +03
		plutonium-240	5.54 E +02	5.1 E +02
		plutonium-241	2.33 E +04	2.5 E +03
		americium-241	Not Included	5.3 E +02
		beryllium	Nonradiological	1.1 E 04 (g)
		lead	Nonradiological	9.0 E 07 (g)

[a] Shaft area 1, 2, and 4 combined inventory.

Figure 1-6 shows the location of TA-49 MDA AB.

1.6.8 TA-50 MDA C NES

The TA-50 MDA C NES is located north of and along Pajarito Road and due south of Building TA-50-1. It includes most of PRS 50-009 (MDA C). The boundary of MDA C is used to define the boundary of the HC-2 NES except along its southeast border. In that area, a section of MDA C that contains no disposal units has been excluded from the defined NES. Although a fence has been proposed for that section of the MDA C, currently only the outer margin of MDA C is fenced. That fence also encloses the section of MDA C that is not considered to be part of the NES. The MDA is inactive.

MDA C was established in May 1948 and served as the main Laboratory disposal facility for approximately 20 yr. The site covers about 48,600 m^2 (12 acres). The inventory at TA-50 MDA C is distributed among 108 shafts and 7 pits formerly used for burial of hazardous chemicals, uncontaminated classified materials, and radioactive materials.

The pits received combustible and noncombustible debris. Drummed sludge waste was also placed in the pits. Periodically, as wastes accumulated, layers of clean fill would be placed on top of waste in the pits, resulting in significant quantities of fill material interspersed with waste. The entire area has been covered and re-seeded.

Pits 1 through 5 are located in the eastern half of MDA C. Pits 1 through 4 are approximately 186 m (610 ft) long, 12.2 m (40 ft) wide, and 7.6 m (25 ft) deep. Pit 5 is 33.5 m (110 ft) wide, 215 m (705 ft) long, and 5.5 m (18 ft) deep. Pit 6 is 30.5 m (100 ft) wide, 54 m (505 ft) long, and 7.6 m (25 ft) deep. Pit 7 was the chemical pit and is 55 m (180 ft) long, 7.6 m (25 ft) wide, and 3.7 m (12 ft) deep. The shafts are 0.6 to 0.9 m (2 to 3 ft) in diameter, 3 to 7.6 m (10 to 25 ft) in depth, and are generally placed on 2.3 m (7.5 ft) centers. Some shafts are lined with concrete. One shaft was specifically used for high-activity strontium-90 waste disposal. Shafts between pits 4 and 5 received high-activity waste from Ten-Site. Waste in sealed metal containers was placed into these shafts. After each placement of a container, a layer of clean fill or concrete was placed into the shaft.

The radionuclide inventories used for initial categorization formed the basis for the DSA inventory. Both inventories are shown in Table 1-17. The DSA inventory includes consideration of radioactive ingrowth products that were not incorporated in the initial categorization. Figure 1-7 shows the location of TA-50 MDA C.

Table 1-17
TA-50 MDA C Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-50 MDA C	Complex of pits and shafts that were main Lab disposal area from late 1940s to late 1960s.	tritium (H-3)	2.00E+04	2.0E+04
		sodium-22	5.80E-01	5.8E-01
		cobalt-60	2.40E+00	2.4E+00
		strontium-90	2.10E+01	2.1E+01
		radium-226	1.00E+00	1.0E+00
		uranium-233	5.0E+00	5.0E+00
		Total Uranium	2.50E+01	2.5E+01
		plutonium-238	2.60E+01	2.6E+01
		americium-241	1.45E+02	1.5E+02
		plutonium-241	Not Included	1.5E+03

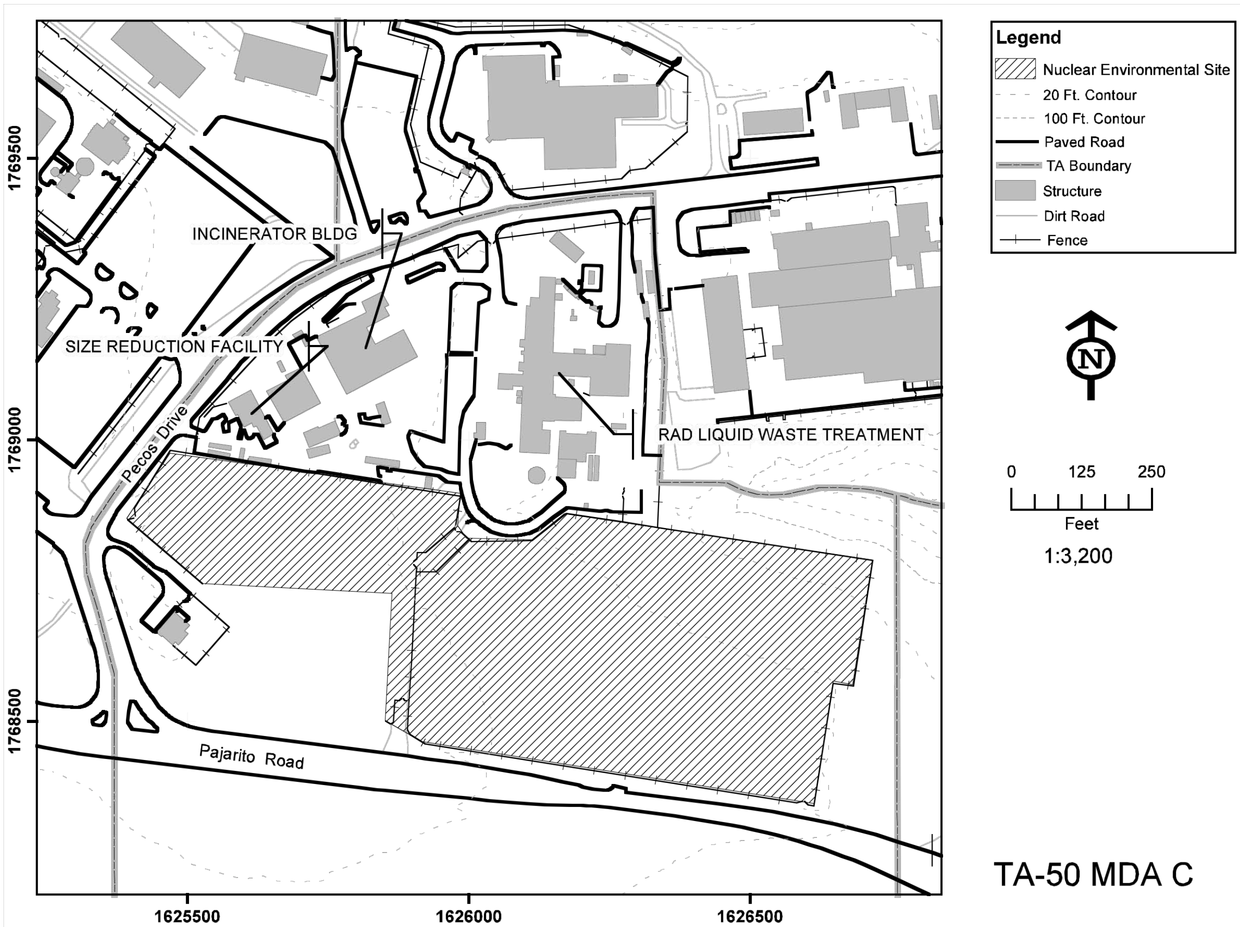

Figure 1-7. TA-50 MDA C NES location

1.6.9 TA-53 Resin Tank NES

This HC-2 NES comprises one of three inactive underground tanks associated with the former RLW system at TA-53. It is located north of the main TA-53 access road, south of Building TA-53-3, and almost directly above the Los Alamos Neutron Scattering Center (LANSCE) accelerator beam line D. The two tanks not comprised by the NES were emptied and rinsed in the early 1980s. The tank included in the NES is former PRS 53-006(a), known as structure TA-53-59. This NES is shown in Figure 1-8. The NES boundary coincides with a fenced exclusion zone that ensures access control above the beam line.

Structure TA-53-59 was used to store spent ion-exchange resin from the LANSCE accelerator facility from 1972 until the early 1980s. This steel tank is 0.7 m (28 in.) in diameter, 19.8 m (65 ft) long, and has a capacity of approximately 522 L (138 gal.). It was installed vertically with the top of the tank 4.6 m (15 ft) below grade. This tank is south of Building TA-53-3, approximately 4.6 m (15 ft) northeast of former PRS 53-006(b) and 53-006(c). The spent ion-exchange resins were generated from the operation of the water purification system located in Building TA-53-3M. Resins were flushed into the tank from this area approximately semi-annually through a buried 0.1 m (4 in.) drain line and allowed to settle.

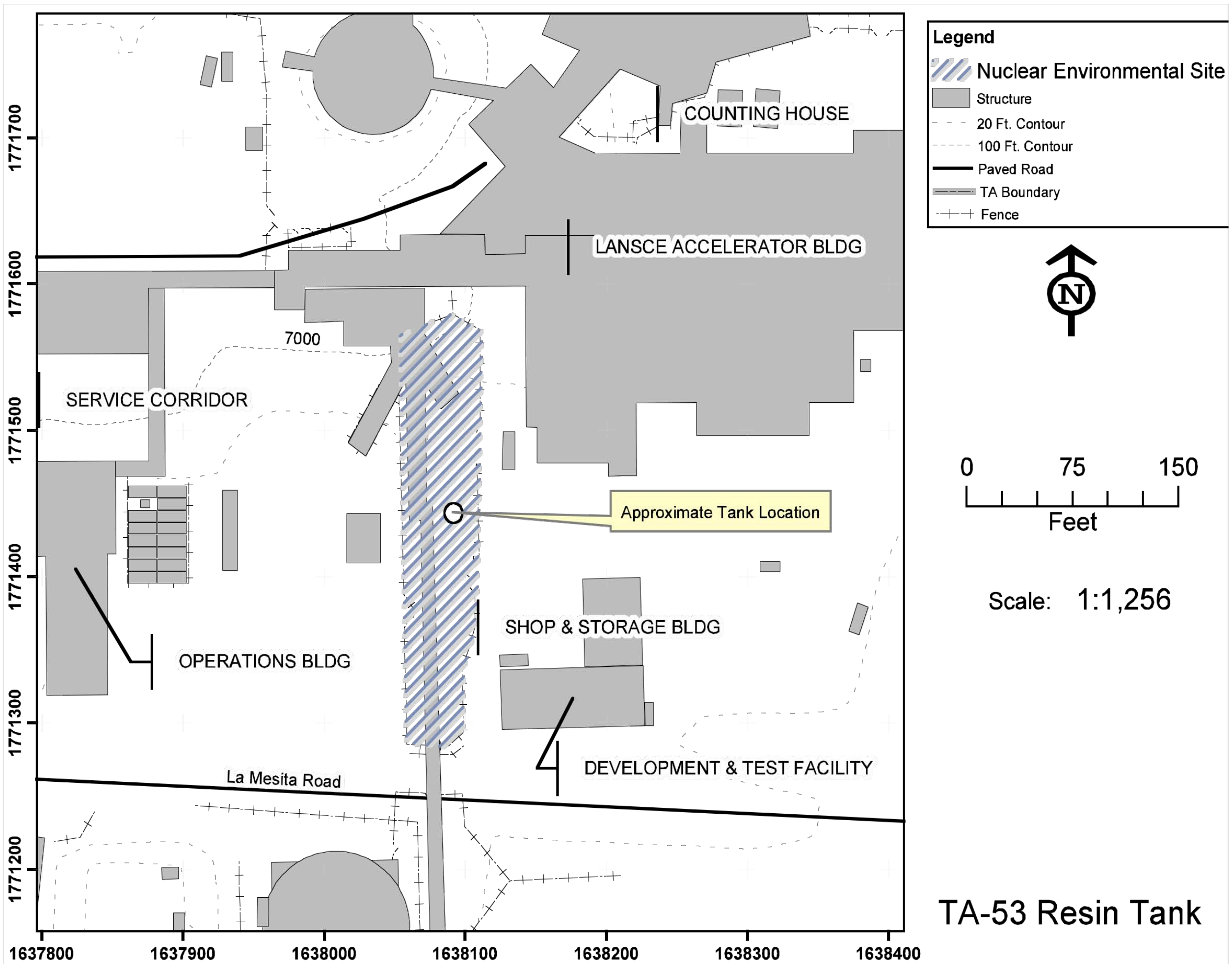

Figure 1-8. TA-53 Resin Tank NES location

This site was determined to be HC-2 because insufficient information was available at the time of initial categorization to quantify the inventory in the resin tank. HC-2 is the default categorization for NES for which insufficient information is available for initial inventory categorization.

1.6.10 TA-54 MDA H NES

TA-54 MDA H, an HC-3 NES, is located on Mesita del Buey. The NES boundary coincides with the boundary of PRS 54-004 and is enclosed by the fence around MDA H.

The NES contains nine inactive shafts that were used for disposal of Laboratory classified waste, such as weapon-component mock-up shapes (mainly depleted uranium), detonators, fuel elements, and papers. Some items were contaminated with tritium, residual plutonium, and HE. Shaft 9 received hazardous waste. Each shaft is 1.8 m (6 ft) in diameter and 18.3 m (60 ft) deep. The shafts were capped when waste came to within 1.8 m (6 ft) of the surface. Shafts 1 through 8 are capped with 0.91 m (3 ft) of crushed tuff above the waste and 0.91 m (3 ft) of concrete to the surface. A layer of concrete 1.8 m (6 ft) thick caps shaft 9. The surface area of MDA H has been re-seeded.

Table 1-18 presents the inventories used for initial categorization and safety analysis of TA-54 MDA H. Figure 1-9 shows the location of this NES.

Table 1-18
TA-54 MDA H Inventory

NES	Brief Description of Site	Radionuclide	Initial Categorization (Ci)	DSA Inventory (Ci)
TA-54 MDA H	Disposal area of 9 shafts for classified waste. All shafts capped with crushed tuff and/or concrete.	tritium (H-3)	2.40E+02	2.4E+02
		uranium-234	2.60E+01	2.6E+01
		uranium -235	1.36E+01	1.4E+01
		uranium -236	5.70E-01	5.7E-01
		uranium -238	3.50E+01	3.5E+01
		plutonium-238	2.50E-02	2.5E-02
		plutonium -240	1.60E-03	1.6E-03
		plutonium -241	5.00E-05	5.0E-05
		americium-241	Not included	5.0E-06

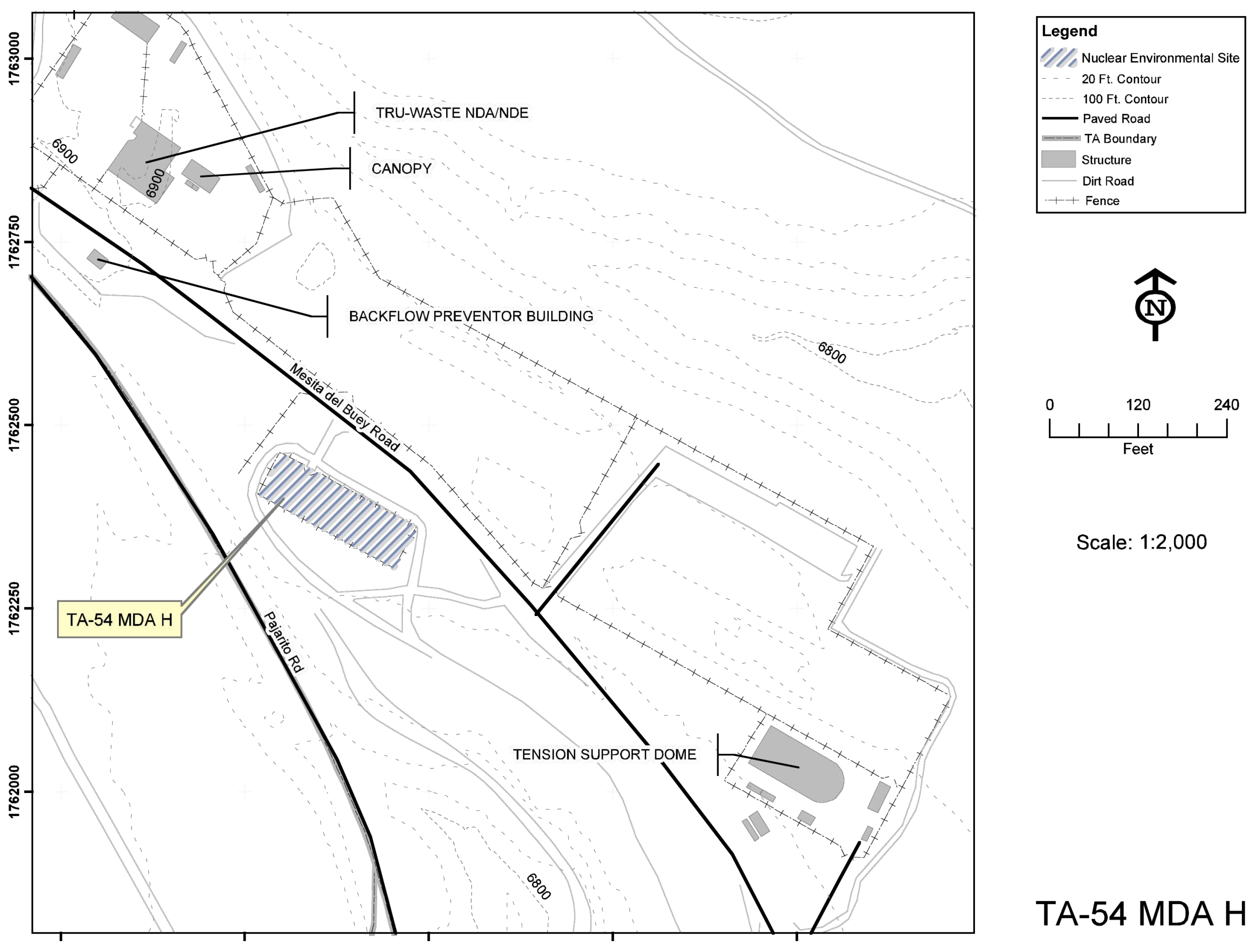

Figure 1-9. TA 54 MDA H location

2.0 ACTIVITIES AND TASKS

2.1 Introduction

This chapter describes comprehensively the broad set of DSA S&M activities and tasks needed to ensure the retention of fundamental conditions at the NES. The descriptions are part of the basis for analyzing hazards and, along with other information presented in this DSA, provide sufficient detail for developing the appropriate type, level, and number of controls. In conducting S&M activities, the intent is to maintain current NES waste-isolation characteristics, assess changes in the physical setting at the NES that could materially affect waste-isolation characteristics, and evaluate the presence and magnitude of contaminant migration at the NES. The DSA S&M activities are described in section 2.2. These activities do not include remediation or intrusive characterization activities or any activities that will intrude into the disposal units.

Completing each S&M activity requires performing tasks, following processes, and using equipment. Some tasks are unique to a certain activity, but most tasks will be needed to complete many of the activities. The DSA separates the description of activities from the description of tasks to eliminate the redundancy that would occur if each task were described for multiple activities. Tasks that are unique to an activity are described within that activity. Section 2.3 presents detailed descriptions of the actions, processes, and equipment that apply to more than one activity. Table 2-1 lists the tasks and the S&M activities to which they may apply. However, because the Laboratory recognizes that tasks may apply to activities in addition to those indicated in Table 2-1, the table is presented as a guide only. The safety assessment and controls were developed under the assumption that all tasks apply to all activities at all NES.

2.2 Description of Activities

S&M activities are defined broadly as operations required for evaluating and maintaining characteristics important to site safety or waste isolation. These activities include site maintenance, access maintenance and control, drilling, soil and sediment sampling, biota sampling, air sampling, penetrating radiation monitoring, water sampling, vapor and soil moisture sampling, geophysical and radiological survey, surface or geologic mapping, and visual inspection. Tasks and equipment common to most of these activities are described in section 2.3. The following sections describe specific activities and activity-specific task and equipment requirements.

2.2.1 Site Maintenance

Site maintenance requires vegetation and erosion control on and near NES to limit combustible materials, ease access, facilitate visual inspection, and prevent or mitigate natural phenomena events or other natural causes from having adverse effects on site characteristics. Small repairs and enhancements to the cover are also included under site maintenance.

2.2.1.1 Vegetation Control

Vegetation at many NES requires maintenance. This activity involves tasks such as mowing, clearing brush, removing debris, and removing trees to maintain site surface characteristics and to limit combustible materials. Maintenance involves cutting or removing vegetation at the surface. If trees must be removed, they will be cut and the stump will be ground down to grade level (if necessary). This activity can also entail establishing new vegetation to stabilize surfaces.

Table 2-1
General Relationship of Tasks to Activities

	TASKS	ACTIVITIES								
		Site Maintenance	Access Maintenance and Control	Drilling	Soil and Sediment Sampling	Biota Sampling	Air Sampling and Penetrating Radiation Monitoring	Water Sampling	Vapor and Soil Moisture Sampling	Survey, Mapping, and Visual Inspection
Non Ground -Disturbing	Access and Staging	X	X	X	X	X	X	X	X	X
	Installation and Maintenance of Access Routes		X	X						
	Surface Leveling or Grading	X	X	X			X			
	Vegetation Control	X	X	X	X	X	X			
	Placing Sand Bags, Hay Bales, Wattles etc.	X		X						
	Equipment Calibration, Repair, Maintenance			X				X		
	Structure Repair or Maintenance			X			X	X		
	Sample Media Collection				X	X	X	X		
	Welding and Cutting			X				X		
	Waste Management	X	X	X	X	X		X		
Ground -Disturbing	Installation and Maintenance of Fencing and Signage		X	X						
	Erosion Control	X		X						
	Cover Maintenance	X								
	Installation of samplers						X	X		
	Installation of Concrete or other Pad			X			X			
	Installation of Bollards			X						
	Marking Areas and Locations		X	X					X	X
	Emplacing Structures			X						

2.2.1.2 Erosion Control and Cap/Cover Maintenance

At some NES, site maintenance includes maintaining the surface and near-surface soil, overburden, and cap layers that isolate the NES contents from the near-surface environment. Site maintenance of an NES also can include implementing and maintaining erosion controls and water diversions to prevent surface water from transferring potential radiological and chemical contamination at the surface into or away from the NES or from eroding cover materials. Maintenance may also include cover augmentation or other small repairs in response to erosion or biological actions, such as burrows. This task would involve light site preparation and addition and compaction of clean fill material in areas where the cover is thin or as a preventive measure to ensure the cover is not thinned by erosion.

2.2.2 Access Maintenance and Control

This activity involves access and staging activities and the installation/maintenance of fencing and signage. Roads, parking and storage areas, and walkways at NES may require repair and upkeep. If access routes are needed, they will be constructed solely by the addition of new material rather than the removal of existing material. New construction involves tasks such as surface preparation, gravel or other material emplacement, and compaction. Maintenance tasks include surface grading (of new material only); filling potholes and other areas that require minor repair; and the maintenance of drainages, road barriers, and rights of way. Removal of snow, mud, and other debris is needed to keep access areas clear and can entail the use of graders, front-end loaders, bobcats, or other heavy equipment.

The installation or repair of fencing and signage facilitates access control. Building and repairing fences and installing signage can involve minor site preparation, such as light scraping and removal of vegetation, and can include digging holes, placing concrete, setting posts, and using a “come along” or other suitable light equipment to stretch fencing materials. Maintenance activities include visual inspection, replacement of damaged or poorly visible signage, and repair of fencing and posts.

2.2.3 Drilling

The NMED Consent Order requires the Laboratory to perform certain activities to characterize the extent of subsurface contaminants. At subsurface waste disposal areas, drilling (vertical and slant) is the only characterization method that facilitates direct evaluation of contaminant migration from contaminant disposal locations. Almost all of the investigations will involve vertical drilling within or near the NES to evaluate the potential migration from individual disposal units (trenches, pits, or shafts) to the rock between or outside of designated disposal areas. In a very few cases, slant drilling (also referred to as angle drilling) is used to drill under MDA to assess vertical migration of contaminants below disposal areas. During angle drilling, down-hole geodetic instruments or other appropriate methods are used to determine that the depth and trajectory of the bit are as planned to ensure that waste disposal units are not breached.

Boreholes are typically 4 to 8 in. in diameter although augers up to 12 in. in diameter may be used. Depth of holes typically ranges from 10 to several hundred feet. Drilling will likely be accomplished either by hollow-stem auger drill or an air rotary rig. Both methods deliver cuttings to the surface where they can be monitored for radioactive or hazardous contamination and placed in sealed containers. During drilling with a hollow-stem auger, the cuttings are transferred physically upward by a corkscrew that is along the outside of the stem. At the surface, the cuttings are retained and can be surveyed and/or sampled for radiological or hazardous material content and for matrix identification. The water content within the tuff keeps the fines moist and limits the potential for them to become airborne as they leave the hole. In an air-rotary rig, the cuttings are brought to the surface using compressed air. The use of compressed air means that the entire system is enclosed. As the cuttings reach the surface, they are diverted into a dust suppression system. Cyclones are used to separate the cuttings from finer materials and all materials are collected.

Monitoring is performed of cuttings as they are brought to the surface or soon after to evaluate their radioactivity or hazardous material content and their matrix type. Additionally, the vicinity and personnel may be monitored to assess potential exposure conditions. Air, radiation, or hazardous chemical monitoring or sampling may be used, depending on the hazards that could be expected.

During drilling, cores are brought constantly to the surface. Depending on the substrate, the cores are brought up enclosed in a barrel and are in finite lengths, usually between 5 and 10’. The cores are evaluated for radioactivity and hazardous material content before the barrel is opened.

The tasks, equipment, and materials required to perform drilling at or near NES depend upon site conditions, duration of activity, depth of boring, amount and type of sampling, and the need for monitoring devices.

The logistical support for drilling activity can vary from a small truck-mounted drill rig and minimal support equipment to a very large drill rig and extensive support equipment, including many vehicles, large mud and water tanks, compressors, pumps, small cranes, and large quantities of materials such as drill casing, drill pipe, well casing, and the raw materials needed for drilling activities. Installation of a monitoring well or wells or other monitoring device(s) can be necessary. In addition, drilling can require the construction and maintenance of a road or base pad (see section 2.2.2) to provide access and room for equipment, materials, and temporary support structures and can necessitate the placement of erosion control devices (see section 2.2.1.2). If an existing source for electrical or other power is unavailable or unusable, a temporary power source may have to be installed.

The following subsections present four tasks that are common to angle and vertical drilling. A description of tasks unique to angle drilling follows the descriptions of the common tasks.

2.2.3.1 Pre-Drilling Tasks

In addition to establishing necessary access roads, erosion control devices, and/or electrical or other power sources, pre-drilling tasks generally involve marking the location, placing the drill rig over the location in readiness for actual drilling, raising the drill rig mast, stabilizing the drill rig with down-riggers or jacks, placing plastic sheeting under the drill rig, and transporting to and staging at the site any accessory materials and equipment required for the operation. Drilling tasks of extended duration can entail the placement of temporary office trailers, toilets, large generators, storage units, and tanks near the drilling location to support the personnel and activities involved. Fences and other access controls can be required (see section 2.2.2). Drilling tasks that involve the use of fluids can require excavating and lining a mud pit. (Note: Mud pits, if required, will not be located on the NES.) Depending on the type of drilling, the following accessory equipment may also be required: mud mixing equipment and tanks, large air compressors, cyclones, air filtration apparatus, conductor casing, drill casing, well casing, drill pipe, and pallets with bags or 5-gallon buckets containing mixing materials such as cement, bentonite, and sand. Pre-drilling tasks can require the use of large flatbed trucks, forklifts, and small cranes.

Other tasks will be required before drilling commences to ensure that the drill rigs are located and positioned correctly such that drilling does not intrude into the disposal units. These tasks may include compiling and reviewing historical construction records, disposal records and logbooks, previous geophysical or location surveys; and performing new surveys as needed. These tasks will be implemented on a site-specific basis as needed to ensure that the location of drill rigs relative to buried inventory is established.

2.2.3.2 Drilling Tasks

Drilling tasks vary, depending on the method of drilling employed. All drilling methods use some form of rotating equipment and/or drill rods and involve repeatedly adding and removing sections of drill rod, pipe, casing, augers, or other drilling apparatus to and from the borehole. Cables, running lines, running blocks, and moving jaws and other moving parts, many operated hydraulically, are part of any drilling operation. The addition or removal of casing can require welding and cutting equipment. Larger sections of casing or drill rod can be moved into place by using lifting lines or winch lines on the drill rig or by hand. Breaking down or adding to the drill string or casing usually involves using a variety of hand tools or chains, including large pipe winches, adjustable winches, or specialty winches, or swinging arms with specialty attachments. During large drilling operations stacks or racks of casing and drill rod may be moved around on a daily basis. If air or mud drilling is employed, pumping apparatus and mixing tanks and numerous hoses may be used to transfer fluids. After a borehole is drilled, but before the well is installed, down-hole geophysical logging may be done. Logging instruments can include a neutron or gamma radiation source. These standard industrial radioactive sources may be lowered into and retrieved from the borehole by a winch line.

During drilling, a variety of monitoring techniques will be used to evaluate ambient air conditions and to evaluate radiological and hazardous material content of exhumed material. The tasks are accomplished with small, portable equipment. Area air samplers may require a small portable power supply.

2.2.3.3 Well-Installation Tasks

During well installation, down-hole well construction requires handling and pouring bags or buckets of materials, including grout and cement. Installing well casing requires using a winch line to lower the casing into the borehole. The surface completion of the well involves using a variety of hand and power tools to cut and weld a protective steel casing and to place the casing in cement. Well installation can also require installation of a permanent cement pad with protective bollards. Installation of down-hole pumping or sampling apparatus requires lifting sections of pipe or attached instruments and lowering them carefully into the borehole. Sampling or monitoring devices can require installing electrical or other power supply equipment.

2.2.3.4 Post-Drilling and Demobilization Tasks

After a well has been drilled and is no longer needed, the cuttings, which have been screened and found to be nonradioactive, are mixed with bentonite or other stabilizing agent as needed, and are put back down the hole. This filled borehole is then capped at the surface to prevent inadvertent intrusion and to ensure it does not serve as a conduit to carry fluids deep underground near areas of potential contamination.

Post-drilling tasks involve demobilizing all equipment and materials used for drilling and well installation, removing any temporary support structures, and restoring and cleaning up the site. Demobilization and structure removal can require the use of cranes, forklifts, bobcats, flatbed trucks and other heavy equipment. Site clean up can be accomplished by using simple hand tools, such as shovels and rakes, and by loading equipment and materials onto trucks by hand. Site restoration can involve implementing erosion control measures, placing straw, seed, and fertilizer over the affected area, and removing temporary fencing and signage. Mud pits excavated during drilling activities must be filled and the excavation site contoured to pre-excavation conditions.

2.2.3.5 Additional Angle Drilling Tasks

Setting up the drill rig and drill mast are more involved tasks in angle drilling than in vertical drilling. In angle drilling, the stability of the drill rig is paramount. To maintain stability and the proper drilling angle, extra measures can be employed, including using large wooden pads, blocks, braces, or tie down apparatus on the drill rig. During actual drilling, the drilling angle can require modifying the techniques used for adding sections of drilling rod, drill casing, or other drilling apparatus. The techniques used to install well casing or down-hole monitoring devices for angle drilling can require the same modifications.

2.2.4 Soil and Sediment Sampling

Soil and sediment samples are collected within NES from shallow holes excavated by using a small hand-held scoop or a hand-operated auger. Characteristics inherent to these tools limit the depth of excavation. No power equipment is used to perform soil and sediment sampling activities. Portable radiation-measuring equipment may be used to conduct surface contamination surveys to identify sampling locations.

Surface soil sample depths range from 0 to 30 cm (0 to 12 in.). Soil sampling requires removing small amounts of local vegetation, gravel, or other surface debris; other minor surface preparation; and entails the collection of samples with small scoops or spades. Generally, sample preparation involves placing several scoops of soil into a stainless steel bowl, homogenizing the soil by mixing and breaking it up as much as possible, and then placing the homogenized soil in containers.

Sediment sampling is similar to surface soil sampling, with the exception that it can require collecting samples from wet, difficult-to-access drainage channels and performing activities in areas to which vehicles have little or no direct access.

2.2.5 Biota Sampling

Most biota sampling within NES boundaries involves the collection of vegetation samples. Additional activities are collecting live species and tree core samples. Site preparation requirements for biota sampling are light and may include removing gravel or other debris from ground surfaces. Sample materials are collected by using hand tools such as small scoops, spades, or shears. Live species are collected by using traps. Biota sample materials are placed in containers and packaged.

2.2.6 Air Sampling and Penetrating Radiation Monitoring

Fixed or portable equipment is used to collect air samples and to evaluate the ambient radiation field. Activities for this task include installing new sampling equipment, maintaining existing sampling equipment, and collecting sample media from the sampling equipment. Operational inspections are conducted to stop and start equipment, perform calibrations, and visually inspect components inside the sampling equipment. Maintenance activities, including routine repair and/or component change-out, require accessing the area where the equipment is located, using power or hand tools, and disconnecting equipment from power sources. System rewiring involves using a variety of hand tools to connect and disconnect (cut) electric wiring. Maintaining and repairing mechanical components and power systems, including motors, bearings, pumps, and electronics, are performed either on site or the systems or components are removed for maintenance and repair off site. Maintenance activities involve minimal site preparation such as clearing brush.

Installing new stations requires the tasks listed in the preceding paragraph and additional site preparation activities such as clearing and leveling the surface and digging holes for stabilization posts. If required, leveling will be performed by bringing in and compacting new fill material. Cover material will not be removed to accomplish the leveling. Installation may involve digging holes, placing cement, setting posts, and undertaking light construction, such as installing small, prefabricated structures.

Portable air sampling equipment is also used to support activities within NES boundaries. This equipment may include personal air samplers; high-volume, electric-powered samplers; or intermediate-volume air samplers, usually powered by a generator. In general, this type of sampling equipment requires set up prior to initiating sampling. Such set up may require light site preparation.

2.2.7 Water Sampling

NES surveillance can require collecting water samples from flowing or impounded surface water, subsurface monitoring wells, or precipitation gages. The collection of groundwater samples from monitoring wells within NES is conducted periodically and requires maintaining existing groundwater monitoring wells to support groundwater-sampling activities. Monitoring wells are capped when not in use. Wells that are no longer needed are properly abandoned, capped, and sealed. The integrity of aboveground wellheads is checked during routine sampling activities and maintenance. A wellhead usually has a concrete base, a metal or PVC casing protrusion, and a metal cover. Sometimes these features have locks. Maintenance and repair may involve patching concrete or using a cutting torch to replace a cap. A bollard can be installed to ensure that vehicles cannot run over the well. Routine inspection and mechanical maintenance/repair are required for power systems, motors, and other mechanical water-sampling equipment. Standard operating procedures prescribe the frequency for checking equipment for samples and for changing equipment filters. Rain gauges may need to be checked. Runoff samplers, which are triggered automatically to collect samples during a runoff event, will need to be visited to collect the sample.

Sampling water from wells involves using a variety of different pumps and, depending on the depth to water and the size of pump, lowering them into the well either by hand or by mechanical means. An electrical generator, air compressor, or a battery supplies the power to run the pump. Sampling deeper wells can require using a specialty rig equipped with piping and winches or lifting lines for lowering and retrieving a pump. The sampling of wells that have dedicated pumps involves supplying power to the pump and using secondary hoses, tubing, piping, or accessory fittings and valves attached to the wellhead. Some dedicated well-sampling systems are highly specialized and may require using special, system-specific sample containers, power systems, and mechanical devices. As part of the Laboratory's environmental monitoring program, water samples may be collected from drainages, pools, streams, or rain gauges.

2.2.8 Vapor and Soil Moisture Sampling

The surveillance of NES can require using soil moisture and vapor sampling to assess subsurface characteristics. Vapor sampling is typically used to assess the migration of tritium, volatile organic compounds, or other predominantly gaseous materials through the subsurface. Soil and vapor sampling tasks involve placing monitoring tubes, canisters, or probes into the soil by hand. Vapor sampling additionally involves collecting soil gas from interstitial pore spaces, either actively (directly into evacuated chambers) or passively (onto sampling media such as activated charcoal or silica gel). The sampling media are transferred to an off-site analytical laboratory for processing. Soil-moisture sampling can entail collecting data from wells on subsurface moisture content. This task requires lowering an instrument with a neutron source into a well to measure soil moisture content. Vapor sampling may involve using small pumps and vacuum chambers to facilitate removal of vapor from the subsurface.

2.2.9 Survey, Mapping, and Visual Inspection

Surveys (including general, radiological, and geophysical), geological mapping, and visual inspection are fundamental to understanding physical, radiological, or security-related aspects of the NES and their surroundings or of activities at the NES. All surveys involve marking locations and areas as described in section 2.3.2.6.

2.2.9.1 General Surveying

A surveyor and assistant or qualified individual trained in the use of a Global Positioning System usually conduct general surveying. Some surveying equipment (e.g., tripod, survey rod) slightly intrudes into the subsurface to provide a firm base for instruments when in use. The depth of penetration in typical local soils is less than 7.6 cm (3 in.). Personnel use pin flags, flagging, and wooden or metal stakes to mark locations and may pound stakes 0.3 m (1 ft) or deeper into the subsurface for use as temporary markers, benchmarks, or turning points. General surveying can require installing permanent benchmarks by using a hand- or battery-operated rock drill to make a small hole in bedrock and cementing the benchmark in the drilled hole. To provide a clean line of sight for instrument readings, personnel may use small saws, axes, or clippers to clear brush and thin branches in areas of vegetation.

2.2.9.2 Radiological Survey and Radioactive- and Hazardous-Materials Monitoring

Refining an understanding of surface and near-surface radionuclide distribution can involve periodic surface radiological survey to obtain background or baseline data pertinent to the NES and to worker safety. Radiation surveys might also entail the evaluation of radioactive materials deposition from adjacent facility operations or from an accidental release. Materials exhumed during drilling will be evaluated as needed for radiological and hazardous materials, depending on the location of the operations and possible materials that could be encountered. Survey equipment includes a wide array of devices that are generally small, hand-held self-contained units. To properly conduct a survey, personnel may require access to radioactive storage areas; waste lagoons; areas downwind of stack release points or exhaust vents; areas near storm, septic, sanitary, or drainage systems; and areas where runoff may collect. These areas may be within or outside of NES boundaries. Survey personnel may have to work in areas of dense vegetation or rough terrain and along parking lots and roadways near traffic.

2.2.9.3 Geophysical Survey

Geophysical survey using ground-penetrating radar, electrical resistivity, or other physically nonintrusive methods may be performed in or near an NES to acquire geophysical data. The kinds of geophysical instruments used to perform these surveys vary, but most are carried by hand, strapped on the user's body, or built into a small-wheeled carriage that is pushed by hand across the ground surface. Ground-penetrating radar equipment may be transported and used on a smooth-bottomed sled. Field personnel conducting surveys may have to traverse rough terrain, brushy areas, or dense vegetation while packing equipment and instruments. Reference points are established by pounding wooden stakes in the ground or by pin-flagging. Some types of surveys may involve placing lines or wires on the ground surface to form a grid or other pattern used to establish reference areas.

Surface radiological surveys are inherently nonintrusive, but may require marking important locations or reference points by placing pin flags and/or wooden stakes into the ground surface. Personnel typically use hand-held instruments to conduct surveys, but may use vehicle-mounted detection systems as well. Surveys can also involve setting up small collection devices (i.e., charcoal canisters or vapor traps) to collect data at the surface. Personnel either place these devices directly on the ground or mount them on stands or tripods that may intrude a few centimeters into the surface.

2.2.9.4 Geologic Mapping

Geologic mapping may be used to assess and document current geologic status at an NES and the effects of erosion or geologic events on NES surface characteristics. Mapping includes general surveying, geologic mapping, and visual observation. Periodically performing mapping and location surveys provides information about changes to older features and structures. Personnel use this information to coordinate sampling activities, identify sampling locations, and verify the accuracy of previously gathered information.

Personnel conduct geologic mapping to identify soils, sub-surface formations, and faults, and to spot newly formed sedimentary deposits or erosion features, usually at road cuts, in stream channels, along natural outcroppings of bedrock, and at other locations where subsurface or other important features are visible and can be inspected at the surface. Geologic mapping involves minimally intrusive activities, such as using a spade or scoop to dig and scrape at the surface, a geologic hammer to break away small bedrock samples for in-field hand analysis, or a hand auger to obtain borings of limited extent. Ground penetration is usually no more than 0.3 m (1 ft). Small pin flags, flagging, or other markers may be used to mark important features or locations.

2.2.9.5 Visual Inspections Including Safety Inspections and Security Patrols

Activities to assess NES security and physical surface characteristics include patrolling and visually observing the NES and performing other assessments that use information gathered by visual observation. Personnel perform inspections and security patrols regularly throughout the Laboratory and in areas within or near NES. Personnel also perform security or other visual inspections in response to nonroutine natural phenomena, such as heavy rains and lightning, and to events such as traffic accidents or reported unusual or suspicious activities. Inspections may also be performed as a part of the routine assessment of conditions and activities at the NES. Information gathered during inspections and patrols is used to evaluate NES features and surface expressions, assess changes in the physical attributes of NES, and assess physical damage such as corrosion, erosion, collapse, settlement, or animal burrowing. Visual inspections also include inspecting existing structures and fences to determine their integrity.

The personnel who perform inspections and patrols work in and are exposed to a variety of environments throughout the Laboratory. Assigned inspection and patrol tasks and duties can require walking and driving off roads and in unfamiliar terrain. Inspection activities can also require performing surveillance by aircraft, in accordance with restricted airspace regulations, to observe and record physical conditions.

2.3 Description of Tasks

Tasks are actions and processes that are needed to complete the activities described in section 2.2. The DSA groups such tasks into two broad categories: (1) tasks that do not disturb the ground surface and (2) tasks that disturb the ground surface. These categories help provide the framework for the description, safety assessment, and development of controls.

2.3.1 Tasks that Do Not Disturb the Ground Surface

Tasks that do not disturb the ground surface are separated from those that do because that distinction is important in the subsequent safety assessment and development of appropriate controls. This category of tasks includes accessing the NES by foot or vehicle; staging vehicles or equipment on the NES; installing/maintaining access routes; surface leveling/grading of new material; clearing brush and mowing; clearing debris; tree-stump grinding, placing items such as sand bags, hay bales, and wattles; filling and/or repairing potholes; calibrating, repairing, and maintaining equipment; maintaining and repairing structures; collecting sample media; welding/cutting; and managing waste.

2.3.1.1 Access and Staging

To perform S&M activities, personnel must be able to enter and traverse the site. Most activities require motorized vehicle access, including access by car, truck, or all-terrain vehicle (ATV). The choice of vehicle type depends on the amount of equipment that must be carried, the nature of the access route, and the distance to be covered. Personnel use vehicles to access the site and travel on internal roads or paths to reach site destinations. Some vehicles are left on site (staged) for use during activities that last more than one day.

Some activities, such as ground or biota surveys, require traversing the site on foot. Personnel performing these activities gain access to the site by vehicle and then walk between site-sampling and survey locations. Traversing the site on foot can involve moving over rough terrain and can bring personnel into direct contact with vegetation, insects, reptiles, mammals, and pathogens typical of Northern New Mexico.

2.3.1.2 Installation and Maintenance of Access Routes

S&M activities can require installing or maintaining roads, parking areas, staging areas, or walkways within NES boundaries. Maintenance of the access routes and installed parking and staging areas includes grading, patching, and the removal of snow and other debris. Grading actions are limited to newly introduced material.

Installation tasks require sand, gravel, or other material suitable for fill and for the construction of road and surface bases; equipment such as trucks, transport vehicles, concrete or asphalt mixers, and pumping apparatus; hand tools to support barrier placement; and heavy construction equipment, including excavators, graders, compactors, backhoes, and other large industrial, mechanized equipment. These tasks can also require using oxy-acetylene cutting torches and welding units, arc welding units, electric or pneumatic drills, saws and jackhammers, generators and compressors, and trenching equipment.

2.3.1.3 Surface Leveling or Grading

Surfaces require preparation to make them ready for tasks such as repairing and maintaining roads, installing sampling equipment, drilling, and cover enhancements. In general, surface leveling or grading involves removing debris and using appropriate equipment to make the site level and clean. To ensure that the barrier characteristics of the covers over disposal areas are not lessened, S&M activities will not involve removal of fill or cover materials from NES. As a result, for activities requiring a level surface, this task will entail the addition/compaction and final leveling of new materials only. Equipment requirements vary from shovels and apparatus for light-digging to graders and other large industrial equipment for leveling and grading large areas of newly introduced fill materials.

2.3.1.4 Mowing and Clearing Brush and Debris

Clearing brush and mowing involves cutting or trimming grass by hand or by using a mower, trimming trees and removing trimmed debris, cutting and removing brush, and removing trees at the surface (not removing roots). Personnel performing these tasks use a variety of equipment, which can include miscellaneous hand tools and cutters, chain saws, tractors with fixed or adjustable cutting attachments, weed-line or blade trimmers, push mowers, tractors with fixed or adjustable (hydraulic) mower decks, and trucks and transport vehicles, including cherry picker hydraulic lifts.

Clearing debris is required to perform activities and tasks such as access and site/surface maintenance, erosion control, and site preparation before setting up a monitoring station or a drill rig. Personnel clearing debris use small hand- or power-operated tools for light clearing and larger, industrial machinery, such as graders, front-end loaders, or bobcats for removing heavier or more extensive debris.

2.3.1.5 Tree Stump Removal

Personnel can grind tree stumps down to grade level to eliminate interference with other activities, such as mowing. Digging, pulling, or pushing tree stumps from the ground is not included in this DSA because of the potential for these tasks to bring contaminated material to the surface.

2.3.1.6 Equipment Calibration, Repair, Maintenance

Calibrating, repairing, and performing maintenance tasks for power systems, motors, bearings, pumps, and electronics involve removing systems or components. Personnel perform these tasks on and off the NES. Small hand and power tools, cleaning agents, and electrical testing equipment are necessary for the calibration, repair, and maintenance of sampling equipment. Maintenance and repair of a wellhead can require using hand and power tools and cutting and welding equipment. Removing down-hole pumps for repair or replacement requires using a special pump-pulling rig to extract the pump and associated piping. The same rig must be used to install the new or repaired pump. Both activities—pump installation and removal—involve using winch lines to repeatedly lift sections of pipe.

2.3.1.7 Structure Repair or Maintenance

Structures placed or built on site to support activities or tasks require maintenance and repair for surfaces such as panels (for example by painting, resurfacing, or replacing) and structural elements such as wall studs or roof rafters. Personnel performing these tasks use small hand and power tools and use lifts, hoists, and cranes to remove and place larger items.

2.3.1.8 Sample Media Collection

Sample collection methods vary, depending on the medium being sampled. Methods may require using portable AC- or DC-powered sampling equipment, placing sampling equipment components and electronics, and using charcoal tubes, Tenax/CMS tubes, and Tedlar bags. Performing sampling activities involves driving trucks, transport vehicles, and ATVs, and working with small quantities of sample preservatives such as nitric and hydrochloric acid. Radiological and industrial hygiene survey equipment, sampling trailers, sample containers, and sample transport containers (coolers) also are needed to support the collection of sample media.

Air sampling usually involves periodically retrieving air sampling filters and replacing them with new sample filters. Equipment is limited to small hand and power tools, but a generator and/or portable AC- or DC-powered sampling equipment may also be required.

Water sampling techniques include simple methods such as dipping a sample container into the media or using the container to collect precipitation, as well as methods that extract water samples by using small peristaltic pumps or hand-suction pumps with hoses and tubing. Small, portable generators supply power to the peristaltic pumps. Ropes, poles, and other devices are attached to sampling containers to lower them into drainages, pools, or streams. Samples collected in this manner are transferred from the sampling container to individual sample containers for transport to a laboratory for analysis. Small quantities of nitric or hydrochloric acid or other chemical preservatives are added to containers for water samples that require preservation for transport or shipping

2.3.1.9 Welding and Cutting

Welding or cutting tasks support many other tasks and activities and may be performed throughout the NES. Welding equipment includes oxy-acetylene and electrical tools. Cutting equipment includes oxy-acetylene, hand-operated, electrical (arc), and power tools.

2.3.1.10 Waste Management

Activities at NES generate fluid and solid wastes, including used sampling paraphernalia and personal protective equipment. In compliance with standard waste management practices, personnel place waste materials into appropriate containers and store the containers on site pending waste determination. After waste determination, personnel follow approved waste management procedures to dispose of the waste. Waste disposal may require using appropriate heavy equipment, flatbed trucks, or other specialty vehicles to transport containers of various sizes and weights off site.

2.3.2 Tasks that Disturb the Ground Surface

Some tasks required for S&M activities will disturb the ground surface, but none intrude into the waste. In most cases, ground-disturbing tasks are limited to those that involve marking locations or providing anchors for erosion control and other purposes. These tasks may require driving small stakes or rebar into the ground. Tasks and activities likely to be ground-disturbing are installing or repairing fencing and/or signage, installing sampling equipment, installing concrete and other pads, installing bollards, marking locations and areas, digging shallow holes by hand or auger, repairing damage from burrowing animals, erecting prefabricated structures, performing light construction, setting up drill rigs, and drilling. Tasks that disturb the ground surface have some of the same requirements as tasks that do not involve ground disturbance. For example, each ground-disturbing task described in section 2.3.2 requires performing some of the nondisturbing access and staging tasks described in section 2.3.1.1.

2.3.2.1 Installation and Maintenance of Fencing and Signage

Several activities require installing and maintaining fencing and signage. Personnel performing these tasks may use trucks and transport vehicles with mounted hydraulic lifts and pole drivers to install posts and lift materials; vehicle-mounted, power, or manual augers to excavate post holes; hand tools to support post and fence placement; cutting torches to cut fencing or signage materials; radiological and industrial-hygiene survey equipment; oxy-acetylene or arc welding units; and electric or pneumatic cutting drills and saws.

Maintenance tasks include visually inspecting fences and posts, performing needed repairs, and replacing damaged or poorly visible signage. Personnel who perform maintenance tasks use the same tools as those who perform installation tasks.

2.3.2.2 Erosion Control

This task involves grading and other surface preparation of erosion control zones on NES. The process can include adding fill material, repairing surfaces and replacing soils associated with erosion control devices, placing hay bales or straw as barriers, placing gabions and sand bags, installing or placing silt fences and rip-rap, installing concrete culverts and drainages, driving posts and anchors for erosion controls, and repairing and maintaining the aforementioned items.

Equipment used to perform these activities can include trucks and transport vehicles, including mounted hydraulic lifts and pole drivers, vehicle-mounted augers to excavate post holes and anchor footings, powered hand-held augers to excavate post holes and anchor footings, concrete mixers and pumping equipment, hand tools to support barrier placement, and diesel-powered construction equipment such as excavators, graders, and backhoes.

2.3.2.3 Cover Maintenance

The cover at some NES could be damaged or thinned through action of wind or water erosion, by burrowing of animals, physical impact from equipment used on site, or other causes. During visual inspections, surveys, or other evaluations it may become apparent that the cover has been damaged or is becoming too thin to meet its functional requirement. In this case, appropriate measures will need to be taken to protect or re-establish acceptable conditions. Addition and compaction of clean materials to the cover as well as other measures to deter burrowing or repair damage caused by burrowing animals are likely at some of the NES.

2.3.2.4 Installation of Samplers

Installation of permanent or temporary air or water samplers generally requires site preparation, including debris removal, light grading to level the area, digging holes, pouring concrete, setting posts, and, for some samplers, installing a pad for the sampler to sit on. Some installations use samplers on skids, and the skids have to be anchored to the ground, generally by stakes. Necessary equipment includes small hand and power tools and site-preparation equipment as described in section 2.2.1.

Installation of samplers that require protection from the elements can necessitate installing small prefabricated structures or light construction as described in section 2.3.2.7 below.

2.3.2.5 Installation of Concrete or Other Pads

Activities can require pads to support the installation of samplers and to provide a stable surface for drilling or other operations. Pad material is concrete, asphalt, or another suitable material. Sites can require preparation before pad installation, as described in the sections for surface leveling or grading and debris removal. Although preparation for pad installation does not involve leveling or removing existing material, installing pads may require placing anchors into the surface, and, therefore, can involve ground disturbance.

Equipment includes small hand and power tools, concrete and asphalt mixers, and site preparation equipment as described in section 2.2.1.

2.3.2.6 Installation of Bollards

Activities can require installing bollards to protect air monitoring and sampling stations, water monitoring wells, wellheads, and drilling or other sensitive equipment. Installation typically requires auguring or hand-digging a hole, emplacing the bollard, and filling the area around the base of the bollard with concrete or tamped dirt.

2.3.2.7 Marking Areas and Locations

Pin flags, flagging, wooden or metal stakes, or other suitable methods are used to mark locations. Stakes can be pounded into the subsurface to 0.3 m (1 ft) or deeper to provide temporary markers, benchmarks, or turning points. Permanent benchmarks may be installed by using a manual or small, battery-operated drill and by making a small hole in bedrock and then cementing the benchmark in the hole. If no bedrock or other solid structure is available, installing a benchmark may require pounding long, metal rods up to 6.1 m (20 ft) into the ground.

2.3.2.8 Emplacing Structures

Activities can require enclosing drilling, air monitoring, or other equipment that requires protection from the elements or for other reasons. Enclosures for equipment are light, prefabricated structures transported intact to the site for installation, or transported in sections or pieces for assembly at the site. Although structure installation does do not require permanent footers, it may require anchors such as stakes.

Assembling the structures involves using small hand and power tools. Installing anchors may minimally penetrate the ground surface. Before installing the structures, personnel may perform surface preparation tasks such as debris removal and grading or leveling as described in previous sections.

Table 2-1 summarizes the general relationship between tasks and activities. The DSA is based on the assumption that any and all tasks may apply to any and all activities at any and all NES.

3.0 SAFETY ASSESSMENT

3.1 Introduction

Inventory disposed of in NES must be evaluated to assess its potential for dispersal and to describe the controls needed to ensure that the waste is contained safely within disposal units. The worker, public, and environmental impacts associated with S&M of these sites must also be evaluated and controlled. In some NES, the inventory is in the form of radiological contamination dispersed in a soil matrix whereas the inventory of others is residual radiological material in disposal units such as tanks, pits, trenches, or shafts.

The LANL concluded that the barrier analysis methodology is the most appropriate hazard analysis methodology for the type of work that is planned and for the configuration of the NES.

In this barrier analysis, disposal sites are reviewed qualitatively to identify potential hazards to workers, the public, or the environment from the activities and tasks described in the preceding chapter and from external forces that could impact the isolation of the waste. Qualitative analysis was performed to identify physical and administrative barriers that mitigate these hazards.

The barriers described form the control sets that are implemented through the TSRs. For each barrier, qualitative expectations are established to guide implementation. These expectations form the basis for the development of implementing programs and procedures, which will specifically define the acceptance criteria for each of the controls. These acceptance criteria will be incorporated into the NES Surveillance and Maintenance Program described below. Details of the barrier analysis are provided below.

3.2 Barrier Analysis Methodology

The first step in performing the barrier analysis for the NES is the determination of the hazard category (HC) of nuclear materials using the categorization methodology described in DOE Standard 1027-92, Change Notice 1 (DOE 1997). The hazard category helps identify material-related hazards and subsequent development of controls. Nuclear materials are categorized in DOE Standard 1027-92 in one of four categories (DOE 1997). Hazard categories 2 and 3 apply to the NES and are described in the following paragraphs.

HC-2 is defined for each radionuclide in DOE Standard 1027-92, Attachment A, Table A.1, "Thresholds for Radionuclides" (DOE 1997). If fissile material above the limits defined by DOE Standard 1027-92 is being maintained in an NES, then the NES is considered HC-2. HC-2 nuclear materials are contained in some NES at the Laboratory; therefore, NES S&M activities at HC-2 NES are designated as HC-2.

HC-3 is also defined for each radioisotope in DOE Standard 1027-92, Attachment A, Table A.1, "Thresholds for Radionuclides" (DOE 1997). This category applies to several of the NES.

The hazard categorization for each NES is presented in Table 3-1.

Note: All sites are considered in detail in this analysis, regardless of whether they are HC-2 or 3. In fact, because of differences in disposal type, disposal depth and configuration, and waste form, certain HC-3 sites may pose greater hazards and consequently greater challenges for control development than some HC-2 sites.

Table 3-1
NES Hazard Categorization

NES	Hazard Categorization
TA-21 MDA A	2
TA-21 MDA T	2
TA-49 MDA AB	2
TA-50MDA C	2
TA-53 Resin Tank	2
TA-21 MDA B	3
TA-35 MDA W	3
TA-35 WWTP	3
TA-35 Pratt Canyon	3
TA-54 MDA H	3

The second step in the barrier analysis is to conduct an evaluation of the hazards that could be encountered during the NES S&M phase. Based on these hazards, a set of barriers is derived that can be used to minimize the potential for events that could impact the health and safety of the public, the onsite workers, and the environment. The OSHA-type hazards (standard industrial hazards) are not addressed specifically for workers conducting S&M activities as these hazards are sufficiently covered by OSHA regulations and other codes and are encompassed under the Safety Management Programs described under Barrier #2. The hazard types and material/ energy sources considered in the analysis and major derived barriers are summarized in Table 3-2. The “Affected NES” are grouped in this table according to 5 basic disposal types as defined in section 3.4.1. Appendix A provides a breakdown of barriers associated with preventing and/or mitigating each identified hazard/scenario for each of the five groups of sites.

Table 3-2
Barrier Analysis Summary

Hazard Type	Material/Energy Source	Major Barriers	Affected NES
Nuclear Material/ Hazardous Material	Radioactive materials in soil, water, sediment and debris; Hazardous materials such as lead, beryllium, solvents, etc.	Inventory Isolation System, NES S&M Program, Integrated Work Management (IWM) Program, Radiation Protection Program, Qualification and Training Program, Emergency Preparedness Program	General’s Tanks, Sodium Tanks, TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas Contaminated Soil
Kinetic Energy	Crane loads, drilling rigs and components, vehicles, forklifts, vibration, projectiles from mowers, shrapnel or debris from explosives firing	Inventory Isolation System, NES S&M Program, IWM, Radiation Protection Program, Qualification and Training Program, Maintenance Program, Emergency Preparedness Program	Disposal Areas Contaminated Soil
Potential Energy	Elevated work surfaces, lifts, scaffolds, ladders, stacked material, heavy masses over weak ground areas	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Emergency Preparedness Program	Generals Tanks (MDA A), Sodium Tanks (MDA W), TA-53 Resin Tank Disposal Areas
Combustibles/ Flammables	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/solvents	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Emergency Preparedness Program, Fire Protection Program, Hazardous Material and Waste Management Program	Disposal Areas Contaminated Soil
Electrical	Portable electrical equipment, Power generating and distribution equipment	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Maintenance Program, Emergency Preparedness Program, Fire Protection Program	Disposal Areas Contaminated Soil
Thermal	Electrical equipment, vehicle/engine exhaust or heat, welding equipment	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Maintenance Program, Emergency Preparedness Program, Fire Protection Program	Disposal Areas Contaminated Soil
Pyrophoric Material	Actinides and other waste constituents	Inventory Isolation System, NES S&M Program, IWM, Emergency Preparedness Program, Fire Protection Program	Sodium Tanks (MDA W) Covered Shafts Covered Disposal Areas Disposal Areas

Table 3-2 (continued)

Hazard Type	Material/Energy Source	Major Barriers	Affected NES
Spontaneous Combustion	Fuels for vehicles, generators, etc., acids, solvents, sodium/water reaction	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Maintenance Program, Emergency Preparedness Program, Fire Protection Program	Sodium Tanks (MDA W) Disposal Areas Contaminated Soil
Open Flame	Welding equipment	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Maintenance Program, Emergency Preparedness Program, Fire Protection Program	Disposal Areas Contaminated Soil
Chemical Reaction	Agitation/friction of dry resins	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Emergency Preparedness Program, Fire Protection Program	TA-53 Resin Tank
Explosive	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates	Inventory Isolation Program, NES S&M Program, IWM, Qualification and Training Program, Emergency Preparedness Program, Fire Protection Program	Generals Tanks (MDA A), Sodium Tanks (MDA W), TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas
Pressure	Air system, gas cylinders	Not Applicable	None
Internal Flooding Sources	Domestic water, water trucks/tanks	Inventory Isolation System, NES S&M Program, IWM, Qualification and Training Program, Maintenance, Emergency Preparedness Program, Fire Protection Program	Sodium Tanks (TA-35 MDA W)
Criticality	Fissile materials	Inventory Isolation System, NES S&M Program, IWM, Nuclear Criticality Program, Emergency Preparedness Program	General's Tanks, Sodium Tanks, TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas
Ionizing Radiation	Waste constituent, contamination, radioactive sources, accelerator beams or radio-activated materials	Inventory Isolation System, NES S&M Program, IWM, Radiation Protection Program, Qualification and Training Program, Emergency Preparedness Program	General's Tanks, Sodium Tanks, TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas Contaminated Soil

Table 3-2 (continued)

Hazard Type	Material/Energy Source	Major Barriers	Affected NES
Penetration of Containment	Installation, drilling, or other tasks/activities associated with surveillance and maintenance	Inventory Isolation System, NES S&M Program, IWM, Radiation Protection Program, Qualification and Training Program, Emergency Preparedness Program, Fire Protection Program	General's Tanks, Sodium Tanks, TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas Contaminated Soil
External and Natural Phenomena Events	Aircraft impact, lightning, earthquakes, high winds, heavy rains/flooding	Inventory Isolation System, NES S&M Program, Qualification and Training Program, Emergency Preparedness Program, Fire Protection Program	General's Tanks, Sodium Tanks, TA-53 Resin Tank Covered Shafts Covered Disposal Areas Disposal Areas Contaminated Soil

3.3 Importance of Waste Form

The physical form of the contained waste may compound or mitigate the associated hazard. The hazard is increased if the material is easily dispersible. Of primary concern are materials that are in a physical form that presents the potential for inhalation. Of second highest concern are those materials that are in soluble form. The least dispersible form is a solid. Material in a solid form requires significant energy input (e.g., explosion) to be readily dispersible. A physical form and its impact on the potential for release of hazardous material at NES vary according to site and disposal type. Waste form varies widely among the disposal sites but is, for all but two sites, a significant contributor to the prevention or mitigation of the release and dispersal of hazardous material. However, at NES MDA W and the TA-53 Resin Tank, the material form could conceivably increase the potential for dispersion of the inventory in some instances. A discussion on waste form for each of the NES is provided below.

TA-21 MDA A (General's Tanks) – The radioactive waste in the General's Tanks is in the form of contaminated sediment or aqueous sludge. In the event of containment breach, the form of the material would provide a very effective passive mitigation to limit the rate and quantity of material that would be released. Furthermore, because aqueous materials are not significantly dispersible in air or respirable, they could not contribute significantly to an inhalation dose pathway.

Waste form in these tanks is a moderately high-value contributor toward minimizing the potential for nuclear material release. Limits on activities, personnel training, vehicle and equipment maintenance, and drilling controls will ensure that additional water or other materials are not introduced that could reduce the barrier effectiveness of the waste form.

Shafts at TA-21 MDA T – These shafts are separated from other shafts for discussion because the waste disposed here was mixed with cement during disposal. The resultant mix is either hardened in concrete or an extremely viscous, partially cemented sludge. In either case, the material form provides an effective passive barrier that makes it extremely difficult to release this material from the shafts and renders the material nondispersible and nonrespirable in the event of a release.

Shafts at TA-49 MDA AB and Absorption Beds at TA-21 MDA T – These are combined for discussion because, based on the evidence available, the radioactive materials in each disposal area are predominantly embedded into or absorbed within the bedrock. High-energy activities at TA-49 MDA AB propelled the majority of the nuclear material into cracks and fissures, effectively embedding the material directly into a solid substrate. The design of TA-21 MDA T was intended to result in the radioactive material being absorbed into layers of tuff fill at the base of the absorption beds. Sampling of the beds indicated that the majority of the materials are in a clay layer at the interface of the absorption layers and the bedrock at the base of the excavation. Regardless of whether the radioactive material is absorbed within crushed tuff, held within a clay layer on bedrock, or absorbed into the bedrock itself, the material form combined with its location render it essentially nondispersible.

Disposal Areas (pits, trenches, and shafts at TA-21 MDA A, TA-21 MDA B, TA-50 MDA C, and TA-54 MDA H) – Much variability and uncertainty exists regarding the forms of wastes deposited in undifferentiated disposal areas of this group. The variability and uncertainty are partly related to the disposal to these areas of widely varied waste streams from across the Laboratory and also to the incomplete records that accompanied waste disposal throughout much of the Laboratory's early history. Although much of the waste may be in a nondispersible form and interburied with clean materials, uncertainty and variability require that a lower value be placed on the waste form as a contributor to the minimization of the nuclear and hazardous material release potential at these sites.

Contaminated Soil (TA-35 WWTP and TA-35 Pratt Canyon) – The distinction between the disposal characteristics and waste form is blurred at this site. Because there are no disposal units at these NES, the radioactive materials are primarily in the form of particles adsorbed onto or absorbed within tuff soils or sediments derived from the mesas and Jemez Mountains. The particles at the TA-35 WWTP are dispersible by nature, but are buried.

TA-35 MDA W and TA-53 Resin Tank – The radioactive materials in the TA-35 MDA W tanks are mixed with sodium metal. In some circumstances (extreme dryness), the mix might reduce the potential for release of the radioactivity if the tanks were breached. However, sodium reacts with water and burns. If the containment were breached in the presence of water, the sodium could burn and provide both a release mechanism and energy to disperse radioactive materials. The resin in the TA-53 Resin Tank could explode and burn if agitated, providing the potential both for breach of containment and for energy to disperse contamination.

3.4 Barriers

The primary method for reducing the risk to the public, the workers, and the environment from the release of nuclear or hazardous materials is to maintain integrity of the physical barrier (Barrier #1) provided by the Inventory Isolation System. This is accomplished by minimizing intrusions/disturbances to this passive barrier, monitoring its status over time through surveillance and evaluation to ensure that unacceptable degradation does not occur, and repairing or enhancing the cover or cap if it becomes necessary to ensure that the important isolation characteristics of the barrier remain intact. Other barriers include safety management programs, which are supportive programs that complement direct S&M activities for maintaining Inventory Isolation System integrity. As controls for NES activities, and to prevent the degradation of physical barriers, multiple administrative barriers are implemented to minimize the potential for nuclear material to become involved in an accident, for nuclear material release to the public receptor and environment, and for worker accidents.

The following sections provide detailed descriptions and analyses of the barriers identified to mitigate the hazards encountered during the NES S&M phase.

3.4.1 Barrier 1 – Inventory Isolation System

The Inventory Isolation System, which comprises primary containers, configuration of burial, depth at which hazardous materials are buried, and the thickness and characteristics of the cover material, is the primary passive barrier to the release of nuclear or hazardous materials and to the interaction of disposal sites with external forces or other potential release mechanisms. The Inventory Isolation System is a TSR design feature. Although the configuration of the elements in the Inventory Isolation System varies among the NES, two basic configuration types are identified. Figures 3-1 and 3-2 illustrate conceptually the configuration types that characterize the Inventory Isolation System for the NES.

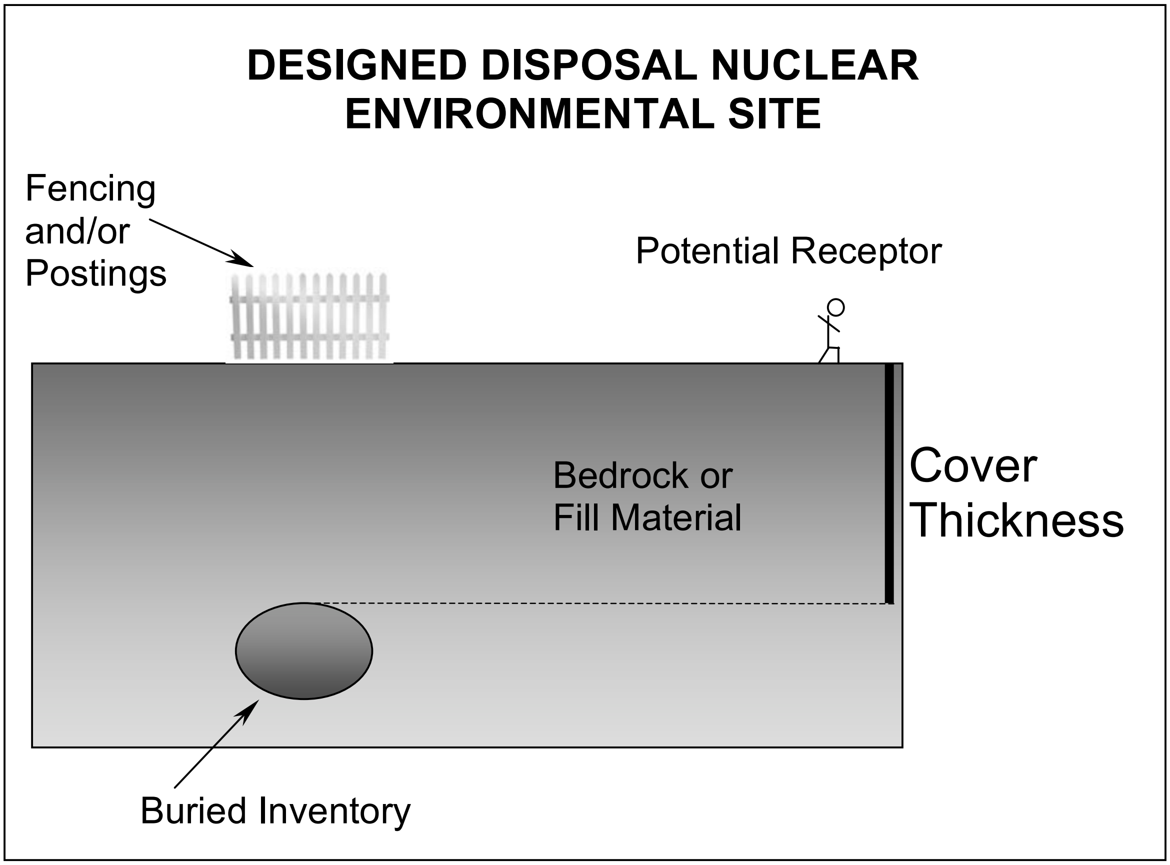

Figure 3-1. Generalized, conceptual, and cross-sectional depiction of burial and inventory isolation in a designed-disposal NES

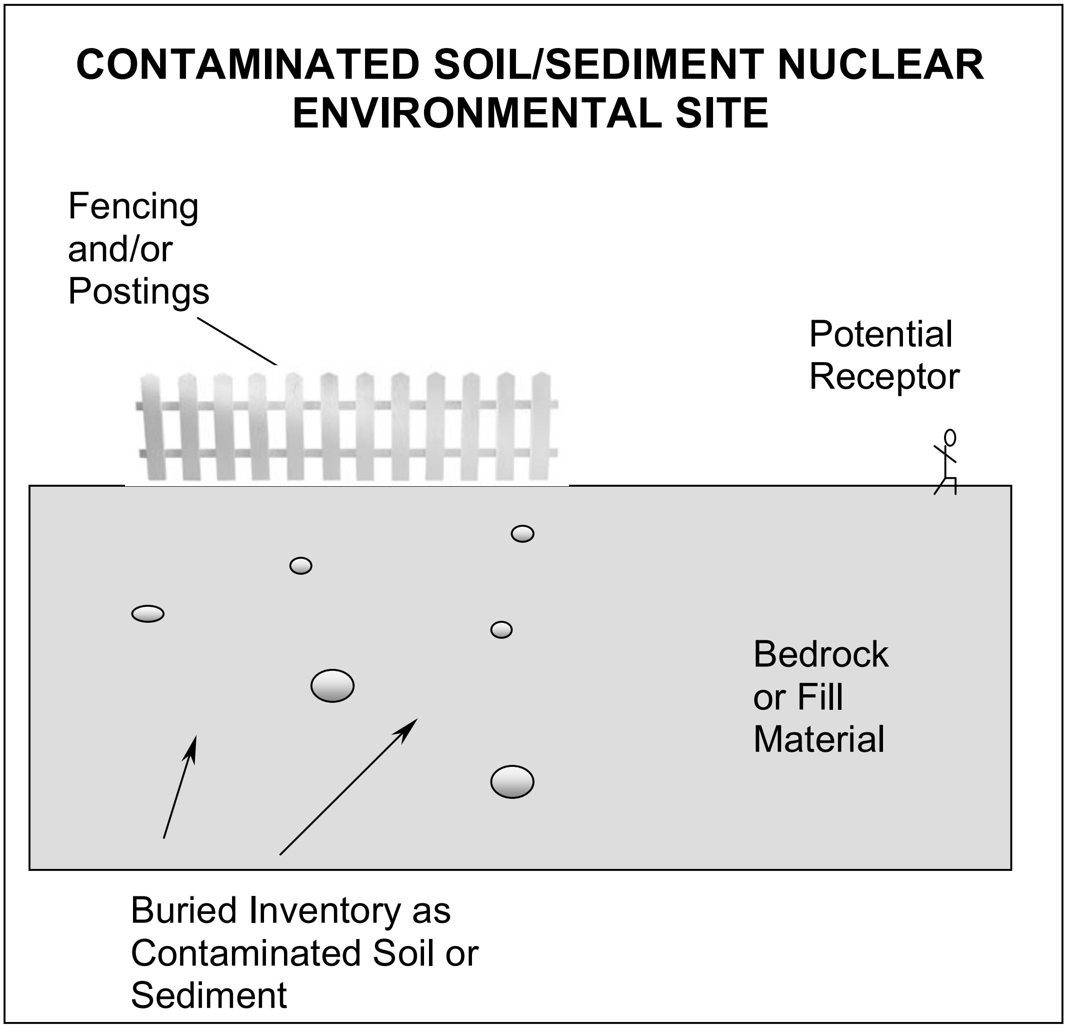

Figure 3-2. Generalized, conceptual, and cross-sectional depiction of NES with contaminated soil/sediment

The function of the Inventory Isolation System is to provide passive protection to the wastes from external forces, including those associated with activities planned for the NES. These passive features are important to prevent or mitigate the release of hazardous materials if some aspect of containment is disturbed. Covers, caps, and overburden can also prevent some worker accidents, such as vehicles or workers falling into pits or shafts.

To provide a physical buffer between external forces and contaminated material, the depth and configuration of burial are the prime elements of this barrier in ensuring waste isolation. The thickness and material of the cap or cover are also important, especially with respect to DSA activities, excluding drilling. To maintain depth of burial and to prevent the degradation of covers and caps from their current condition, programs need to ensure that material is not removed from the tops or sides of the disposal units and that the caps, covers, and the general disposal area are examined and evaluated periodically.

The prime elements of the Inventory Isolation System (Barrier #1) are identified below. The applicability of these elements to prevent or mitigate hazards is shown in the tables in Appendix A.

1. ***Primary Containment Vessels*** – Primary containers help make sure that the inventory remains in its location and form and can help ensure protection of the inventory from intrusion by activities or outside forces.

2. ***Configuration of Burial*** – The configuration of buried inventory affects its vulnerability to activities and outside forces and also can mitigate the amount of material that could be released if containment were breached. For example, pencil tanks (long and thin), with their long axis oriented vertically, offer much less surface area for potential inadvertent intrusion through drilling or other activities. And, if they were breached at one spot, because of their geometry, very little of the inventory would likely be affected.

3. ***Burial Depth*** – Depth of burial provides protection of the waste from surface activities and other external forces. It also limits the amount of direct radiation exposure a receptor on the surface could experience because of the self shielding provided by the buried inventory and clean interspersed fill material.

4. ***Inventory Distribution*** – Distribution (rather than concentration) of the inventory, primarily serves as a barrier to the release and distribution of concentrated radiological material or hazardous chemicals. In sites where the inventory is spread throughout large soil or sediment volumes, the amount of material that could be released by any single event is extremely small. Likewise, where inventory is distributed throughout pits, trenches, and shafts, it is extremely unlikely that any single event or action could affect more than a tiny fraction of the inventory.

5. ***Thickness and Characteristics of Cover Material and Caps*** – The prime function of cover materials and caps is to ensure that the inventory is not affected by actions or events at the surface. Thicker cover and caps provide more protection than thinner cover/caps made of the same material. Caps of concrete provide greater protection than asphalt caps which are more robust than packed-earth caps. Consideration of the characteristics of thickness and material allow assessment of the relative importance of these features to protect against the suite of hazards at the different sites.

By design, the activities in this DSA are intended to minimize ground disturbance. Limiting activities in this way lessens the need for complex programmatic controls to ensure that cover material and caps are not disturbed. For example, rather than include grading and other potential activities that would require significant controls to ensure that the barrier function of caps and covers was not impacted, the DSA states that surface leveling required by activities such as site preparation, access construction, or monitoring station installation be completed by bringing additional material on-site rather than grading the existing surface.

With the exception of drilling, the activities under this DSA that do disturb the surface are limited to actions such as placing pin flags, driving small area-location stakes, surface sampling and shallow hand-augering, and putting in fence posts (as needed for access control). Limitations on potentially ground-disturbing activities are intended to ensure that material is not removed from the tops or sides of the disposal units.

The S&M program (described below) includes surveillance that will be applied on a site-specific basis, depending on the importance of the cap/cover as a barrier and the condition and thickness of the cap/cover at present. This program ensures that caps, covers, and the general disposal area are examined and evaluated periodically to ascertain that the overall waste-isolation capabilities are intact.

The functional requirement of covers, caps, and overburden is to provide a protective physical barrier for the inventory on all sides. Surface-breaking activities are controlled to minimize damage to cover materials. To ensure that cover materials are not reduced in thickness below that required to perform the functional requirement, periodic inspections will be performed to evaluate the condition of all cover material, describe any significant changes, and correct the situation by augmenting the cover if necessary. At sites where cover material is thin, no ground-disturbing activities (except drilling) are allowed under this DSA.

Disposal methods vary throughout the NES but fundamental similarities with respect to cover, configuration, and depth of burial among a number of the sites allow grouping for analysis and determination of value as a barrier. Sites with unique characteristics are discussed alone. Several of the sites have distinct disposal elements that fall within more than one group. The groups are as follows:

- General's Tanks (TA-21 MDA A), Sodium Tanks (TA-35 MDA W), and TA-53 Resin Tank
- Covered Shafts (TA-49 MDA AB, TA-50 MDA C, TA-54 MDA H, and TA-21 MDA T)
- Covered Disposal Areas (pits/trenches at TA-50 MDA C and absorption beds at TA-21 MDA T)
- Disposal Areas (pits and trenches at TA-21 MDA A and TA-21 MDA B)
- Contaminated Soil at TA-35 WWTP and TA-35 Pratt Canyon

The characteristics of each as related to its functional importance as a barrier are discussed and summarized below.

3.4.1.1 TA-21 MDA A (General's Tanks), TA-35 MDA W, and TA-53 Resin Tank

TA-21 MDA A (General's Tanks) – The two horizontal, cylindrical steel tanks serve as the primary containment for radioactive waste in aqueous sludge/sediment. No indication of leakage from the tanks has been observed; however, because of their age, their ability to remain leak-proof if subjected to significant force is questionable. The bottoms of the tanks rest approximately 5.2 m (17 ft) below grade. The tanks are covered by a 0.2-m- (8-in.-) thick reinforced concrete cap, and by 0.9 m (3 ft) of clean material as overburden over the concrete cap. The cap and overburden shield the tank from external forces and, in the event of a tank rupture, the concrete (fractured or intact) and overburden would limit the rate and quantity of material released. The combination of steel tanks, concrete cap, and significant overburden is an important and effective passive barrier to prevent or mitigate release of radioactive material.

TA-35 MDA-W – This NES is unique primarily because of the geometry of waste containers. The two stainless steel tubes are 37 m (120 ft) long and oriented vertically within shafts lined with carbon steel casing and separated by about 1 m of undisturbed tuff bedrock. The upper ends of the two pencil tanks and associated casings are covered by a concrete vault embedded in the tuff. The vault is constructed of 0.2-m- (8-in.-) thick (nominally) walls and lid. This burial method and cover have been an extremely effective waste-isolation method, but the location of the tanks may negate the containment function of these tanks in some instances. Because the tanks are located near the edge of a canyon, the effective distance from ground surface to the tanks is not as great as it would be if they were buried in a completely flat area, and the tanks may be susceptible to events that destabilize the canyon slope.

TA-53 Resin Tank – Overall configuration of this tank is similar to the tanks described above (buried and covered steel tank) but the waste form, as described above, indicates that this tank should be considered unique. The steel tank is oriented with the long axis vertical and the top of the tank almost 5 m (16.4 ft) below grade. Clean fill and an asphalt cap are above the tank. The tank is well removed from the edge of the canyon. The combination of steel tanks, asphalt cap, and significant overburden form an important and effective physical barrier to any release of material.

Group Summary – The tanks all have primary containment vessels and all are buried with significant cover material and a cap. These elements combine to create an effective barrier. Activities at the surface are unlikely to affect these disposal units. Programs to maintain depth of burial and overall site integrity will be sufficient to ensure that these units are not breached from surface activities. Drilling controls implemented through the NES S&M Program described below will address the potential for underground penetration of containment.

3.4.1.2 Covered Disposal Areas (pits and trenches at TA-50 MDA C and absorption beds at TA-21 MDA T)

The dimensions of the disposal pits and trenches vary, but in all cases the majority of the waste is well below the surface and the waste is covered by a layer of uncontaminated material. The burial geometry and presence of cover material are significant because external forces would have to act through the surrounding rock or through the cover material to affect and disperse the inventory. The absorption beds are similar to the pits and trenches in that the contaminated material is well below grade. The absorption beds are covered by more overburden than the pits and trenches [approximately 3 m (10 ft) of crushed tuff, sand, and other clean fill material].

Group Summary – The cover at MDA C is sufficient to isolate the waste from activities or phenomena acting at the surface. However, small, isolated areas of the cover are less than 30 cm (12 in.) thick and surveillance needs to ensure that these areas do not get thinner and that new material is added if necessary to maintain thickness. Contaminants in the absorption beds are so deeply buried that surface activities will not affect them and surveillance is not needed beyond evaluating overall site integrity and ensuring that the surface is not eroded significantly. Drilling controls will address the potential for underground penetration of containment.

3.4.1.3 Covered Shafts (TA-49 MDA AB, TA-54 MDA H, and TA-21 MDA T)

The geometry of shafts, long with respect to diameter, means that the majority of the waste is contained well below the surface and separated by bedrock from other waste disposal units. Even more than in pit/trench burial, the depth of the waste provides isolation from external forces and dispersal mechanisms. Because of the nature of historical activities at MDA AB, the radioactive material at the NES is confined to the lowermost areas of deep shafts and is covered by clean sand, crushed tuff, and other materials up to the existing surface.

All shafts are covered. Although the cover provides isolation to the waste, it isolates a smaller fraction of the waste than is isolated in a pit or trench and is therefore a less important barrier.

Group Summary – The shaft caps require a surveillance program to ensure that the caps are not being affected by DSA activities or other forces near the surface. Drilling controls will address the potential for underground penetration of containment.

3.4.1.4 Disposal Areas (pits and trenches at TA-21 MDA A and TA-21 MDA B)

As with the covered disposal areas, most of the waste is contained well below the surface and separated from other waste disposal by areas of bedrock. TA-21 MDA A and B each have cover material above the waste, but the covers are thin, inconsistent in thickness, and may be slightly contaminated in some locations. The covers provide some barrier to the release of material, but for the sake of conservatism in this DSA, analysts consider these covers to be of minor importance as a preventive or mitigative passive barrier. As described above, the waste configuration (trench/pit) does afford passive protection to the waste.

Group Summary – Because the covers are somewhat thin and discontinuous on these MDAs, a robust surveillance program will be required in addition to the programs to limit activities. Based on the findings of the surveillance, additional cover material may be needed to increase the thickness of the cover.

3.4.1.5 Contaminated Soil (TA-35 WWTP and TA-35 Pratt Canyon)

These sites have no structural primary containment or any defined disposal units. Rather, they comprise radioactive constituents dispersed throughout tuff-derived soils. In the TA-35 Pratt Canyon NES, the contamination is dispersed in sediments in what was the active sedimentary channel during WWTP discharge to Pratt Canyon. Some radioactive material has been taken up in the vegetation above the soil contamination.

Group Summary – In all sites, most of the radioactive inventory is below the surface and dispersed throughout a large volume of soil or sediment. Because of this distribution and depth of burial, a very small fraction of the inventory is available for dispersal from any event. Small quantities of contaminated material at the surface could be dispersed by activities or events.

3.4.2 Barrier 2 – LANL Safety Management Programs

Numerous site safety management programs act as additional barriers to a release of nuclear or hazardous materials by directly or indirectly supporting the Barrier #1 and are TSR administrative controls. These site-wide programs and their relation to NES S&M activities are summarized in this section. The first program in the list below is the NES S&M Program, which is specifically intended to apply to the NES. The Unreviewed Safety Question (USQ) program will evaluate potential actions that could affect the safety of the NES. The other safety management programs listed below are Lab-wide programs, elements of which apply toward ensuring the safety of workers, the public, and the environment.

NES Surveillance and Maintenance Program – A NES S&M program is necessary to maintain current NES waste-isolation characteristics, evaluate changes in the physical setting at the NES that could significantly affect waste-isolation characteristics, and evaluate the presence and magnitude of contaminant migration at the NES. Moreover, NES S&M is the primary program for ensuring that the Inventory Isolation System design feature is not altered or modified such that the potential for release of materials that could impact the public, worker, or environment is increased. The NES S&M program uses a series of S&M activities as the primary controls for preserving Inventory Isolation System integrity. This program will ensure that the minimum functional requirements of the design feature are met. The NES S&M Program consists of the following elements. With the exception of element #1, which will be applied at all sites uniformly, the other elements will be implemented on a site-specific basis based on site-specific conditions:

1. Prohibition of the addition of HAZARDOUS MATERIALS to the NES by S&M activities. This prohibition is intended to preclude any permanent additions to the radiological or hazardous inventory of the NES. However, it is important to differentiate the NES inventory that comprises the radiological and hazardous chemicals that were disposed of when the NES was an active disposal facility from the potentially hazardous materials that are needed to support S&M activities and will be on site temporarily. These radiological or hazardous chemicals that may be used temporarily on site are exempted from the prohibition. Exceptions to the prohibition include the temporary use of radioactive sealed-sources for calibration or measurement in support of S&M activities and other chemicals and material in quantities less than 40 CFR 302, "Designation, Reportable Quantities, and Notification Limits." Hydraulic fluids, fuels, lubricants, and other substances that are needed for operation of vehicles or equipment on site, but will be there only as long as the vehicles or equipment are in use are excluded as well.

2. Vegetation maintenance – Routine trimming, mowing, and other control or removal of shrubbery, trees, and other plant life onsite that could build up and contribute to the propagation of a fire. Stumps cannot be removed by pulling, pushing, or digging them out of the ground. Rather, they can be ground down to grade level.

3. Erosion control and cover maintenance measures – Provides for installation of systems to control the amount and location of runoff and infiltration near and on NES and for the maintenance of cover layer, shaft caps, especially after accidents, natural phenomena, or other natural events that affect the integrity of the cap or cover. Maintenance may include cover augmentation or other small repairs in response to erosion or biological actions, such as burrows. In the event of soil erosion or damage to a cover cap from external forces, the cover cap will be restored to a condition that meets its intended function.

4. Access control and maintenance measures – Unauthorized workers and members of the public are not allowed access to the NES locations; access to each site will be controlled as needed by fencing and posting. In addition to site-specific fencing and posting, a Laboratory-wide system such as a graphic information system (GIS) will be enabled to ensure that line managers and workers are made aware of the presence and location of the NES. These and other measures will notify the appropriate line manager to ensure that proper training and work control is in place. Maintenance of access control includes installation and repair of fencing and signage; upkeep, repair, and construction of roads, parking areas, storage areas, and walkways; removal of snow, mud, and other debris. Any construction must be accomplished without removing material from the cover of any disposal unit.

5. Drilling controls – Drilling activities at the NES will be conducted using approved procedures. Several key elements ensure that drilling does not intrude into disposal units, mitigate the consequences if an intrusion occurs inadvertently, and ensure that the entire drilling program is well controlled and run safely.

   a) Pre-drilling location evaluation – It is critical that at the start of drilling, the exact location of proposed shafts relative to disposal units is determined to ensure that the disposal units are not disturbed. Methods to ensure this will be site specific and will depend on the availability and reliability of construction records, ground surveys, geophysical surveys, disposal surveys and other documents or studies that can be used to identify the boundaries of the disposal units. Where records or earlier surveys are lacking or unreliable, new evaluations including ground and

geophysical surveys may need to be performed. If the disposal unit boundaries cannot be determined with a high degree of certainty, the distance between drilling and disposal units may need to be greater than if the unit boundaries are very well defined and well characterized.
b) Location evaluation during drilling – Methods are available that can pinpoint the location of the drill bit during drilling. During angle drilling, these will be used as needed to ensure that drilling is occurring where it is intended to and is kept at a conservatively safe distance from a disposal unit. Almost all the drilling will be vertical holes, which, after identifying the initial drill location, has very little chance of intersecting the inventory in a waste disposal unit. A very few holes may require angle drilling in order to characterize potential contaminant migration below disposal units. During angle drilling, down-hole geodetic instruments or appropriate alternative methods are used as needed to characterize the depth and trajectory of the drill bit to ensure that drilling is proceeding according to plan.

c) Monitoring and measurements of work environment and vicinity during drilling – These measurements allow evaluation of conditions to ensure worker safety and to limit any potential releases to the environment, thus protecting the public and the environment. Dust levels may be monitored to evaluate general working conditions. Increases in dust levels can be an indicator of problems in the drilling that need to be rectified and can be used to indirectly assess radionuclide air concentrations. Personal Protective Equipment (PPE) and area monitoring for radiological or hazardous materials will be specified in work control documents such as Radiation Work Permits (RWP) and Integrated Work Documents (IWD) as appropriate for the hazards that could be encountered during drilling.

d) Monitoring and measurements of exhumed material and prevention of contamination movement – Exhumed material (including cuttings and core) is evaluated for radioactive and hazardous chemicals and to determine the nature of the material matrix immediately after the material is brought to the surface. The general process for core evaluation is that the core is laid on a flat surface where a survey is performed for chemicals of concern and radioactive materials before the barrel is opened.

Radioactive and hazardous material limits will be established for exhumed material. If these limits are exceeded, if the matrix is not tuff, native soils, or sediments, or if unexpected conditions develop, drilling will be stopped in a safe condition and the situation will be stabilized. Evaluation will be initiated to determine the appropriate actions that need to be taken. Evaluation to determine if the inventory in a disposal unit has been breached will include an evaluation of the radioactive and hazardous material content and an analysis of the matrix material to determine if its form is consistent with original waste or, instead, the matrix is contaminated soil, rock, fractures, or voids. If the matrix is consistent with disposed waste, it is a positive indication that a waste disposal unit has been breached.

If evaluation concludes that inventory in a disposal unit was not breached, drilling can continue and exhumed material will be managed commensurate with the levels of radioactive or hazardous constituents.

If a disposal unit has been breached, drilling in that hole will be terminated permanently and the hole will be stabilized. Exhumed material will be handled according to the Radioactive and Hazardous Waste Management Program (described below under the Safety Management Programs) and a thorough evaluation will be conducted to determine why a disposal unit was breached.

The incremental advancement of the bit and recovery of cuttings, a process inherent in rotary drilling, minimizes the potential of contamination being carried down hole. During rotary drilling auger flights or drill casings are added as the borehole is advanced. The increments are usually no more than 5 ft. Across each interval, core is collected through the center of the drill. Each core is brought to the surface for inspection and screened for radioactivity before the borehole is advanced. This screening provides an opportunity to determine if contaminated materials have been encountered and to assess the risk associated with continuing to greater depths. During rotary drilling, cuttings are lifted by auger flights or drill fluids (air, foam, or mud) to the surface. The drill cuttings must be removed for further borehole advancement. Therefore, the methods of drilling inherently limit the rate of downward progress and the delivery of materials to the surface. These drilling methods provide check points that limit the potential for downward migration of contaminants and ensure that minimal contaminated material can be brought to the surface before it is recognized as such and appropriate measures taken.

In addition to the precautions taken during drilling to prevent contamination from being transported down hole, the method of finishing the well also ensures that it will not become a conduit for contamination movement. After a well has been drilled and is no longer needed, the cuttings, which have been screened and found to be nonradioactive, are mixed with bentonite or other stabilizing agent and put back down the hole. This filled borehole is then capped at the surface to prevent inadvertent intrusion and to ensure it does not serve as a conduit to carry fluids underground, near areas of potential contamination.

e) *Control the rate of material removal* – The size of the borehole and rate of drilling will be controlled to ensure that material will be removed at such a rate as to allow continuous or near continuous evaluation of exhumed material and to minimize the amount of contaminated material that could potentially reach the surface.

f) *Dust control* – Dust from drilling operations will be controlled to minimize hazards to worker, public and the environmental.

6. Sampling and survey measures - Radiological and chemical surveys to ensure that materials have not migrated or been released
7. Geological mapping - Includes general surveying, geologic mapping, and visual observation techniques to assess and document current geologic status and the effects of erosion or geologic events on NES surface or subsurface characteristics
8. Visual inspections - Periodic physical inspection of the NES will be conducted to identify problematic conditions including vegetation, erosion, burrowing or other biological agents, or access control issues and general condition of the cover; inspections will ensure that the Inventory Isolation System barrier is in a condition that allows it to provide its intended function

Integrated Work Management Program – This program defines requirements and processes for doing work in a safe, secure, environmentally responsible manner. It defines the requirements for implementation of the five-step process associated with Integrated Safety Management (ISM) and Integrated Safeguards and Security Management (ISSM) and directly supports the LANL Environmental Management System at the activity level. The core functions of ISM and ISSM are to

- define the work;

- identify and analyze hazards;
- develop and implement controls;
- perform the work; and
- ensure performance.

While implementing the five-step ISM process, IWM emphasizes the following:

- Management and worker accountability;
- Applying the worker's knowledge and experience;
- Providing integrated, worker-friendly documentation that includes defined work tasks/steps that are linked to specific hazards and unambiguous controls;
- Identifying a single person-in-charge (PIC) for each work activity;
- Providing independent oversight and facility coordination;
- Formally validating, releasing, and closing out work activities; and
- Feedback and continuous improvement.

The most important aspects of this process are the direct involvement of workers in controlling the risks, and the accountability of responsible division leaders (RDL) and responsible line management (RLM) for safety, security, and environmental protection. To provide the required oversight, the RDL must be different than the RLM for each activity unless specifically approved by the RDL's Associate Director. As the level of risk posed by the hazards and work complexity increase, IWM requires a more rigorous process and documentation. For moderate- and high-hazard and complex activities, the work process, hazards, and controls must be documented in a Integrated Work Document (IWD). The IWD consists of four parts (for purposes of change control and records management, these four parts may be treated as separate documents):

- Activity-specific information;
- Work-area information;
- Validation and release information (followed by work execution); and
- Close-out information.

The NES Integrated Work Management program serves as a preventative barrier by ensuring that the correct controls are in place, and that the work and workers are authorized to do the work safely so that the integrity of the inventory isolation system is maintained and no increase risk to the workers, public, or environment is created. Additionally, this program ensures the use of a systematic, rigorous process to document, review, and approve changes to the barriers that are relied upon to protect the public, workers, and environment.

Unreviewed Safety Question Program – The USQ process facilitates the ability to make changes to support day-to-day operations. It also provides a mechanism for keeping the safety basis current by reviewing potential USQs, reporting USQs to DOE, and obtaining approval from DOE prior to taking any action that involves a USQ. The USQ process is required for:

a. All temporary or permanent physical changes at a facility
b. All temporary or permanent changes to procedures at a facility

c. All activities, operations, tests, or experiments that are new to a facility
d. Discoveries of potential inadequacies in the existing documented safety analysis

The USQ process not only applies to changes within the boundary of a NES, but also to changes outside the boundary, when those changes have the potential to affect the safety of the operations within the boundaries.

The NES USQ program ensures that changes to NES physical attributes, S&M activities and procedures, and modifications to components are analyzed against the DSA with respect to frequency, consequences, and safety margin to determine if the change falls within the existing safety envelope or if it requires approval through the USQ process. The NES USQ program thereby ensures that controls currently in place remain effective and any additional controls necessary to the safety basis of the NES are identified as necessary. The NES USQ program is in place as a preventative measure to preclude accidents from occurring by ensuring that physical changes and new activities are sufficiently safe and all necessary safety controls are in place for those, as yet, unidentified changes and activities that may occur in the future at the NES.

Nuclear Criticality Program – Worker health and safety at the NES is assured for S&M activities with a potential for nuclear criticality by addressing activities which may involve significant quantities of fissile materials to provide protection from the occurrence and consequences of a nuclear criticality accident. The NES Nuclear Criticality program ensures criticality safety through the following:

- Identification of the criticality hazards
- Evaluation of identified criticality hazards by the LANL Nuclear Criticality Safety Group (Environmental, Safety, and Health Division, ESH-6)
- Identification of control measures such as mass, geometry, volume, etc., to maintain subcriticality of NES S&M activities
- Documentation of established and/or revised criticality limits and controls for NES S&M activities
- Employee education and training on criticality limits and controls
- Maintenance of familiarity with all operations involving significant quantities of fissile material by the LANL Nuclear Criticality Safety Group staff
- Periodic review of NES fissile material limits by the operating groups, the LANL Nuclear Criticality Safety Group, and the LANL Nuclear Criticality Safety Committee
- Periodic review of operations by the Nuclear Criticality Safety Committee

The NES Nuclear Criticality program minimizes the likelihood of an inadvertent criticality by providing for criticality safety evaluations and the establishment of criticality safety limits.

Radiation Protection Program – The NES Radiation Protection program ensures that employees, contractors, subcontractors (for example, maintenance subcontractors), visiting scientists, DOE or Department of Defense personnel, members of the public, and any other personnel who perform work at the NES sites conduct their work such that radiation doses resulting from their work are kept as low as reasonably achievable (ALARA). The NES Radiation Protection program includes the following elements combined to accomplish the ALARA principle and ensure personnel health and safety:

- Areas with potential radiological hazards are identified and designated with postings

- Radioactive contamination is managed and controlled to minimize personnel exposure and limit inadvertent transfer beyond area boundaries.
- External and internal radiation doses to personnel are monitored and ensured not to exceed annual or lifetime limits
- Instrumentation used to make radiation measurements is calibrated and maintained to ensure accurate results
- Areas and activities requiring personal protective equipment are identified
- Personnel are given training in radiation protection
- All NES S&M activities are planned to ensure radiation protection measures are incorporated as needed to provide for efficient and safe conduct of work

The NES Radiation Protection program serves as a preventative barrier by minimizing personnel exposure to radiation and reducing the likelihood that overexposure will occur.

Quality Assurance Program – LANL's Institutional Quality Management Program (IQMP) assigns roles, responsibilities, authorities and accountabilities; defines policies and requirements; provides for the performance and assessment of work; and the identification and application of improvement initiatives.

Through the implementation of the IQMP, LANL:

- Enhances its formality of operations
- Reduces work related risk and hazards to the public and workers
- Improves responsibility and accountability for material, process, and product control
- Improves work control processes through the integration of quality and safety principles in a single work control process that uses consensus codes and standards
- Provides guidance for tailoring and simplifying the approach to meet requirements
- Institutionalizes the Integrated Safeguards and Security Management System (ISSM)
- Communicates an integrated corporate approach to business systems management
- Minimizes rework and improves efficiency and effectiveness in work productivity
- Provides the means to ensure continued ability to meet customer needs and institutional goals
- Increases facility availability to support national science and stockpile stewardship missions

The NES Quality Assurance program supports the LANL IQMP to achieve and improve quality through the identification of problems and recommendation and initiation of improvements at the NES. This program ensures that the NES S&M activities maintain quality requirements that address the needs of sampling, surveying, mapping, drilling, personnel, and other activities associated with NES. Specific sampling objectives and criteria will be identified in the NES S&M Program on a site-specific basis. The NES Quality Assurance program serves as a preventative barrier by holding the NES responsible for the performance and assessment of work by NES personnel and through identification of areas in need of improvement.

Abnormal Event Reporting Program – An abnormal event is a real-time event that adversely affects workers, the public, property, or the environment. Examples include, but are not limited to:

- Vehicle accident/incident resulting in damage to the vehicles involved and/or personnel injury

- Occupational injury/illness
- Fire/explosion
- Radiological or hazardous material spill
- Loss of process ventilation that results in a spread of radiological or hazardous contamination
- Natural phenomena (flooding, severe weather, forest fire)
- Procedural/regulatory violation (violations of DOT regulations)
- Property damage that is not security-related (damage that results in a claim against the Laboratory, damage caused by fire, contaminated personal clothing, DOE-recordable levels)

The NES Abnormal Event Reporting program ensures that injuries or illnesses, environmental incidents, radiological incidents, property damage, and any other reportable occurrences are reported according to the required method set forth by LANL. The NES Abnormal Event Reporting serves as a preventative barrier by ensuring that abnormal events occurring during NES S&M activities are analyzed and documented to facilitate the identification of causes, the implementation of corrective actions, and the dissemination of lessons learned to minimize potential for recurrence.

Qualification and Training Program – Specific training requirements have been established by LANL for all workers. Training and qualification of workers, based upon an identification of the knowledge, skills, and abilities required to independently perform work is an important mechanism used to control hazards. Required institutional, facility-specific, and job-specific training for performing their assigned jobs shall be provided to all workers.

The NES Qualification and Training program ensures that LANL's institutional training requirements are met and identifies NES-, job-, and task-specific training necessary for NES workers to complete their work safely and effectively, minimizing the potential for accidents resulting in the release of radiological material. Therefore, the NES Qualification and Training program is a preventative barrier.

Record-Keeping Program – Records include information created and received in the course of conducting LANL programs and business. Records management serves to promote the creation, capture, use, and transfer of records and knowledge. It also serves to preserve and protect the Laboratory's archival and historical documents and information. Further, the management of records reduces the legal risk to the Laboratory when approved retention schedules are implemented. LANL's records management program is designed to follow good business practices to ensure the protection of corporate information assets.

The NES Record-Keeping program supports LANL's records management program by ensuring that records created in the normal course of business are maintained and protected from unauthorized destruction or removal. The NES records important to safety during S&M activities include personnel records documenting radiation doses, documentation of identified hazards, and technical baseline documentation. The NES Record-Keeping program is a preventative barrier.

Configuration Management Program – Configuration management (CM) is an integrated management program that establishes consistency among design requirements, physical configuration, and facility documentation, and maintains this consistency throughout the life of the facility as changes occur. The CM program consists of CM functions associated with program management, design requirements, document control, change control, and assessments.

The program elements in the NES Configuration Management program ensure that changes to the technical baseline are properly identified, developed, assessed (technically reviewed and validated), approved, scheduled, implemented, and documented through the use of a formal process.

The NES Configuration Management program serves as a preventative barrier by ensuring the retention of the as-designed configuration of the physical barriers provided by the Inventory Isolation System. Additionally, this program ensures the use of a systematic, rigorous process to document, review, and approve changes to the barriers that are relied upon to protect the public, workers, and environment.

Vehicle and Equipment Maintenance Program – The following six elements form the core of an effective maintenance program at LANL:

- Inventory and grade (graded approach)
- Maintenance procedures
- Training and qualification
- Scheduling
- Equipment/system status
- Equipment history

This program ensures the identification and maintenance of equipment that has the potential to adversely affect public safety, worker safety, environmental protection, and programmatic mission at LANL.

The NES Vehicle and Equipment Maintenance program ensures the proper implementation of maintenance and work control requirements and primarily encompasses the maintenance of vehicles and equipment that may be in use near or on the NES. By ensuring that equipment is functionally properly reducing the likelihood of an accident initiated by faulty equipment, the NES Maintenance program serves as a preventative barrier.

Emergency Management Program – The “LANL Emergency Management Plan” (LANL February 2004) incorporates into one document a description of the entire process designed to plan for, respond to, and mitigate the potential consequences of an emergency. This plan, coupled with the Building Emergency Planning Program and site-specific emergency procedures, states the requirements, procedures, and information needed to ensure that any emergency at the Laboratory is mitigated as expeditiously and effectively as possible. Implementation of the LANL Emergency Management Plan establishes an emergency management program that

- assigns responsibilities
- guides in categorization and classification of an emergency
- states necessary notifications for emergency response personnel and the public
- outlines the assessment of Laboratory and off-site hazardous materials conditions during or following an emergency
- outlines an effective course of action to protect the public and Laboratory personnel in the event of an emergency
- addresses the implementation of protective actions
- guides mitigation of hazardous materials consequences
- outlines necessary training for emergency response personnel

Division leaders, program managers, office leaders, project leaders, facility managers, group leaders, and office leaders must plan for emergencies, provide the necessary emergency training to ensure that employees and the public are protected, and take the actions necessary to mitigate the emergency until relieved by authorized personnel. The Emergency Management and Response (EM&R) Group is responsible for assisting LANL managers in that effort by administering a comprehensive emergency management program.

The NES Emergency Management program serves as a mitigative barrier by ensuring NES personnel and emergency management organizations are ready to respond rapidly and correctly to accident situations such that the effects of the accident can be minimized. The program includes emergency procedures, activation of emergency organizations, assessment and protective actions, worker training to minimize exposure to radiological and hazardous materials, and recovery actions to minimize releases in the unlikely event that the inventory isolation system is breached. As such, this program is credited with minimizing public, worker, and environmental consequences from releases of radioactive or hazardous materials from the NES during an accident.

Fire Protection Program – This program minimizes the potential losses from the following fire-related events:

- Injury or loss of life
- A fire that causes an unacceptable on-site or off-site release of hazardous or radiological material
- Vital programs suffering unacceptable interruptions as a result of fire and related hazards
- Property losses from fire and related events exceeding defined limits established by LANL
- Critical processes, controls, and safety class systems being damaged as a result of fire and related events

The NES Fire Protection program serves as the overarching program for ensuring fire safety during NES S&M activities. The program has provisions for ensuring the implementation of NES-related fire protection activities such as worker fire prevention and safety training, combustible controls, fire watch, and fire extinguisher inspection, testing, and maintenance. The NES Fire Protection program serves as a preventative barrier to fires initiating at NES and minimizes the potential for a significant fire should one occur, thus serving as a mitigative barrier as well.

Calibration Program – LANL's Calibration Program is essential to programs that depend on accurate measurements. LANL is responsible for ensuring the stated accuracy of any measured data used for the following purposes:

- Monitoring or controlling safe conditions to prevent hazards to personnel or the environment
- Reports or publications
- Establishing specifications
- Acceptance testing of purchased items
- Final testing of products or services provided to customers within or outside the Laboratory
- Monitoring or controlling process parameters
- Evaluating or testing weapons material or systems
- Verifying the accuracy of measuring and test equipment

The NES Calibration program ensures the proper control, use, and calibration of tools and equipment necessary for NES S&M activities. The NES Calibration program particularly ensures the safety of workers and the public through the proper calibration of measuring and test equipment used to manage and control radiation doses to minimize personnel exposure and limit inadvertent transfer beyond area boundaries and is a preventative barrier.

Hazardous Materials Protection Program – This program ensures that chemical and hazardous material exposures to the workers and the public are minimized during NES S&M activities. Additionally, this program ensures that the effects of atmospheric releases of these substances are monitored and minimized. Worker health and safety at the Laboratory is assured for hazardous materials handling by addressing the generic health and safety considerations for handling hazardous materials in laboratories, facilities operations, and construction activities. It includes corrosives, carcinogens, combustibles, flammables, oxidizers, heavy metals, reactive and explosive chemicals, pesticide and herbicide application and use, toxins/proteins/enzymes, toxic substances, chemical exposures, controlled substances, chemical inventory, chemical storage, asbestos (worker and environmental protection), lead exposure, ventilation, and appropriate personal protective equipment.

The NES Hazardous Materials Protection program serves as a preventative barrier by ensuring that workers are educated about the hazardous materials they work with and are properly trained to ensure their safety during NES S&M activities involving hazardous materials. The NES Hazardous Materials Protection program adheres to OSHA requirements.

Radioactive and Hazardous Waste Management Program – The LANL waste management program has been established to manage waste and aid in meeting the requirements of DOE orders, federal and state regulations, and Laboratory permits

The NES Radioactive and Hazardous Waste Management program serves as a preventative barrier by ensuring the implementation of LANL waste management requirements for NES S&M activities. By implementing the waste management requirements, the NES further ensures the health and safety of workers and the public as well as minimal impact to the environment by reducing the potential for a release of radioactive or hazardous material as the result of improper handling, storage, or disposal of radioactive or hazardous waste.

3.5 Site Evaluations

The first step in implementing the NES S&M program involves the comprehensive inspection of all NES. The purpose of the inspections is to evaluate current conditions and to identify any existing deficiencies with respect to access control, cover and cap condition, erosion, vegetation, or other elements important to the current and long-term integrity of the physical barrier. For example, each NES will be evaluated to determine if the fencings or postings are adequate to ensure that unauthorized personnel cannot access the site and to identify the corrective measures needed if fencings/postings are found to be inadequate.

3.6 Barrier Analysis Summary

Two major barriers prevent the workers, public, and environment from being exposed to radiological or toxicological releases from the NES. The Inventory Isolation System is a physical barrier primarily dependent upon maintaining the depth, characteristics, and configuration of burial to protect the inventory from external forces. Waste form is a major contributor to inventory isolation for all but two of the NES. To ensure that the integrity of the Inventory Isolation System barrier is maintained, TSR administrative controls are required to limit activities in areas with thin covers and to perform activities that evaluate the cover viability and identify and correct areas of deficiency.

By either directly or indirectly supporting the Inventory Isolation System, the second barrier comprises the numerous site surveillance, maintenance, and safety management programs that act as additional barriers to a release of nuclear material. These programs also implement the OSHA industrial safety requirements to protect workers from standard industrial hazards.

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Appendix A

Hazard/Scenario-Barrier Matrices

Tables A-1 through A-5 provide a breakdown of barriers associated with preventing and/or mitigating each identified hazard/scenario for each of the following groups:

- General's Tanks (TA-21 MDA A), Sodium Tanks (TA-35 MDA W), and TA-53 Resin Tank
- Covered Shafts (TA-49 MDA AB, TA-54 MDA H, and TA-21 MDA T)
- Covered Disposal Areas (pits and trenches at TA-50 MDA C and absorption beds at TA-21 MDA T)
- Disposal Areas (pits and trenches at TA-21 MDA A and TA-21 MDA B)
- Contaminated Soil (TA-35 WWTP and TA-35 Pratt Canyon)

The hazards/scenarios were evaluated based upon their potential to cause a material release to the public, workers, and/or environment. Standard industrial hazards (SIH) associated with performing surveillance and maintenance tasks/activities were not evaluated but will be controlled according to 29 CFR 1910 as implemented through LANL's Safety Management Programs. Hazards were identified as "Not Applicable" if they were considered standard industrial hazards only and/or if they were unlikely to cause a material release. Hazards are identified as "As Applicable" if they only apply to some of the sites within the group or if there are insufficient data to conclude that the hazard does or doesn't apply.

The NES S&M Program may include one or more of the following elements depending upon the site and the identified hazard/scenario:

1. Prohibition of the addition of HAZARDOUS MATERIALS to NES by S&M activities beyond existing inventory (exceptions being temporary radioactive sealed-sources for calibration or measurement and chemical/toxic material in quantities less than 40 CFR 302, "Designation, Reportable Quantities, and Notification," limits used in support of S&M activities)
2. Vegetation maintenance
3. Erosion control measures
4. Access control and maintenance measures
5. Drilling controls
6. Sampling and survey measures
7. Geological mapping
8. Visual inspections

Elements will be implemented on a site-specific basis through the NES S&M Program except # 1, which applies to all sites all the time.

Table A-1
Hazard-Barrier Matrix for General's Tanks (TA-21 MDA A), Sodium Tanks (TA-35 MDA W), and TA-53 Resin Tank

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Nuclear Material/ Hazardous Material Scenario(s): Release of material	Radioactive materials in waste inventory	✓	✓	✓		✓	✓	✓			✓			✓				✓				
	Hazardous materials such as lead, beryllium, solvents, etc. **As Applicable**	✓	✓	✓		✓	✓	✓						✓				✓			✓	
Hazard Type: Kinetic Energy Scenario(s): Disturbance of surface material; worker injury (SIH)	Crane loads, drilling rigs and components **Not Applicable**																					
	Vehicles, forklifts **Not Applicable**																					
	Vibration **Not Applicable**																					
	Projectiles from mowers **Not Applicable**																					
	Shrapnel or debris from explosives firing **Not Applicable**																					

Note: Units in this group all have primary containment vessels and are buried with significant cover material and a cap; activities at the surface are unlikely to affect these disposal units.

Table A-1 (continued)

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Potential Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Elevated work surfaces, lifts, scaffolds, ladders **Not Applicable**																					
	Stacked material **Not Applicable**																					
	Heavy masses over weak ground areas **As Applicable**			✓		✓	✓	✓						✓				✓				
<u>Hazard Type:</u> Combustibles/ Flammables <u>Scenario(s):</u> Surface fire; worker injury	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/ solvents **Not Applicable**																					
<u>Hazard Type:</u> Electrical <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Portable electrical equipment **Not Applicable**																					
	Power generating and distribution equipment **Not Applicable**																					

Table A-1 (continued)

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Thermal Scenario(s): Surface fire (SIH); worker injury (SIH)	Electrical equipment **Not Applicable**																					
	Vehicle/engine exhaust or heat **Not Applicable**																					
	Welding equipment **Not Applicable**																					
Hazard Type: Pyrophoric Material Scenario(s): Underground fire	Actinides and other waste constituents **(TA-35 MDA W only)**	✓		✓		✓	✓	✓										✓	✓			
Hazard Type: Spontaneous Combustion Scenario(s): Surface fire (SIH); underground fire; worker injury (SIH)	Fuels for vehicles, generators, etc. **Not Applicable**																					
	Acids, solvents, sodium/water reaction **(TA-35 MDA W only)**	✓	✓	✓		✓	✓	✓						✓				✓	✓			

Table A-1 (continued)

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Open Flame Scenario(s): Surface fire (SIH); worker injury (SIH)	Welding equipment **Not Applicable**																					
Hazard Type: Chemical Reaction Scenario(s): Underground fire; explosion	Agitation/friction of dry resins **(TA-53 Resin Tank only)**	✓		✓		✓	✓	✓						✓				✓	✓			
Hazard Type: Explosive Scenario(s): Explosion; hydrogen deflagration/ explosion	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates **As Applicable**	✓		✓		✓	✓	✓						✓				✓	✓			
Hazard Type: Pressure Scenario(s): Worker injury (SIH)	Air system, gas cylinders **Not Applicable**																					

Table A-1 (continued)

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Internal Flooding Sources <u>Scenario(s):</u> Worker injury (SIH)	Domestic water **Not Applicable**																					
	Water trucks/tanks **(TA-35 MDA W only)**	✓	✓	✓		✓	✓	✓						✓			✓	✓	✓			
<u>Hazard Type:</u> Criticality <u>Scenario(s):</u> Worker overexposure and/or fatality	Fissile materials **As Applicable**	✓		✓		✓	✓	✓		✓								✓				
<u>Hazard Type:</u> Ionizing Radiation <u>Scenario(s):</u> Overexposure	Inventory constituents	✓		✓		✓	✓	✓			✓			✓				✓				
	Radioactive sources **Not Applicable**																					
	Accelerator beams or radio-activated materials **As Applicable**	✓		✓		✓	✓	✓			✓			✓				✓				

Table A-1 (continued)

Hazard Type and Scenario(s)	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Penetration of Containment Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion	Drilling or other tasks/activities associated with surveillance and maintenance	✓		✓		✓	✓	✓			✓			✓				✓	✓		✓	
Hazard Type: External and Natural Phenomena Events Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion; surface fire; disturbance of surface material; worker injury	Aircraft impact	✓		✓		✓	✓											✓	✓			
	Lightning **Not Applicable**																					
	Earthquakes	✓		✓		✓	✓											✓				
	High winds **Not Applicable**																					
	Heavy rains/flooding	✓		✓		✓	✓											✓				

Table A-2
Hazard-Barrier Matrix for Covered Shafts (TA-49 MDA AB, TA-54 MDA H, and TA-21 MDA T)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Nuclear Material/ Hazardous Material <u>Scenario(s):</u> Release of material	Radioactive materials in waste inventory, soil, and debris		✓	✓	✓	✓	✓	✓			✓			✓				✓				
	Hazardous materials such as lead, beryllium, solvents, etc. **As Applicable**		✓	✓	✓	✓	✓	✓						✓				✓			✓	
<u>Hazard Type:</u> Kinetic Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Crane loads, drilling rigs, and components **Not Applicable**																					
	Vehicles, forklifts **Not Applicable**																					
	Vibration **Not Applicable**																					
	Projectiles from mowers **Not Applicable**																					
	Shrapnel or debris from explosives firing **Not Applicable**																					

Note: As part of the S&M program, shaft caps will be evaluated to ensure that caps are not affected by surveillance and maintenance activities or other forces at the surface. The caps and configuration of burial are prime elements of the barrier for these sites. Depth of burial is also very effective at TA-49 MDA AB, where virtually all the nuclear material resides near the bottom of deep shafts. The inventory is more vertically distributed in MDA H and MDA T shafts.

Table A-2 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Potential Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Elevated work surfaces, lifts, scaffolds, ladders **Not Applicable**																					
	Stacked material **Not Applicable**																					
	Heavy masses over weak ground areas **Not Applicable**																					
<u>Hazard Type:</u> Combustibles/ Flammables <u>Scenario(s):</u> Surface fire; worker injury	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/ solvents **Not Applicable**																					
<u>Hazard Type:</u> Electrical <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Portable electrical equipment **Not Applicable**																					
	Power generating and distribution equipment **Not Applicable**																					

Table A-2 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Thermal Scenario(s): Surface fire (SIH); worker injury (SIH)	Electrical equipment **Not Applicable**																					
	Vehicle/engine exhaust or heat **Not Applicable**																					
	Welding equipment **Not Applicable**																					
Hazard Type: Pyrophoric Material Scenario(s): Underground fire	Actinides and other waste constituents **As Applicable**		✓	✓		✓	✓	✓										✓	✓			
Hazard Type: Spontaneous Combustion Scenario(s): Surface fire (SIH); underground fire; worker injury (SIH)	Fuels for vehicles, generators, etc. **Not Applicable**																					
	Acids, solvents, sodium/water reaction **Not Applicable**																					

Table A-2 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Open Flame Scenario(s): Surface fire (SIH); worker injury (SIH)	Welding equipment **Not Applicable**																					
Hazard Type: Chemical Reaction Scenario(s): Underground fire; explosion	Agitation/friction of dry resins **Not Applicable**																					
Hazard Type: Explosive Scenario(s): Explosion; hydrogen deflagration/ explosion	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates **As Applicable**		✓	✓		✓	✓	✓						✓				✓	✓			
Hazard Type: Pressure Scenario(s): Worker injury (SIH)	Air system, gas cylinders **Not Applicable**																					

Table A-2 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Internal Flooding Sources Scenario(s): Worker injury (SIH)	Domestic water **Not Applicable**																					
	Water trucks/tanks **Not Applicable**																					
Hazard Type: Criticality Scenario(s): Worker overexposure and/or fatality	Fissile materials **As Applicable**		✓	✓		✓	✓	✓		✓								✓				
Hazard Type: Ionizing Radiation Scenario(s): Overexposure	Inventory constituents		✓	✓		✓	✓	✓			✓			✓				✓				
	Radioactive sources **As Applicable**		✓	✓		✓	✓	✓			✓			✓				✓				
	Accelerator beams or radio-activated materials **As Applicable**		✓	✓		✓	✓	✓			✓			✓				✓				
Hazard Type: Penetration of Containment Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion	Drilling or other tasks/activities associated with surveillance and maintenance		✓	✓	✓	✓	✓	✓			✓			✓		✓		✓	✓		✓	

Table A-2 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: External and Natural Phenomena Events Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion; surface fire; disturbance of surface material; worker injury	Aircraft impact		✓	✓	✓	✓	✓											✓	✓			
	Lightning **Not Applicable**																					
	Earthquakes		✓	✓	✓	✓	✓											✓				
	High winds **Not Applicable**																					
	Heavy rains/flooding		✓	✓	✓	✓	✓											✓				

Table A-3

Hazard-Barrier Matrix for Covered Disposal Areas (pits and trenches at TA-50 MDA C and absorption beds at TA-21 MDA T)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Nuclear Material/ Hazardous Material <u>Scenario(s):</u> Release of material	Radioactive materials in soil, water, sediment and debris		✓	✓	✓	✓	✓	✓			✓							✓				
	Hazardous materials such as lead, beryllium, solvents, etc. **As Applicable**		✓	✓	✓	✓	✓	✓										✓			✓	
<u>Hazard Type:</u> Kinetic Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Crane loads, drilling rigs, and components **Not Applicable**																					
	Vehicles, forklifts **Not Applicable**																					
	Vibration **Not Applicable**																					
	Projectiles from mowers **Not Applicable**																					
	Shrapnel or debris from explosives firing **Not Applicable**																					

Note: The cover at TA-50 MDA C is sufficient to isolate the waste from activities or phenomena acting at the surface; however, some small isolated areas are less than 12 inches thick; TA-21 MDA T will not be affected by surface activities due to the burial depth.

Table A-3 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Potential Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Elevated work surfaces, lifts, scaffolds, ladders **Not Applicable**																					
	Stacked material **Not Applicable**																					
	Heavy masses over weak ground areas **Not Applicable**																					
<u>Hazard Type:</u> Combustibles/ Flammables <u>Scenario(s):</u> Surface fire; worker injury	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/ solvents **Not Applicable**																					
<u>Hazard Type:</u> Electrical <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Portable electrical equipment **Not Applicable**																					
	Power generating and distribution equipment **Not Applicable**																					

Table A-3 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Thermal Scenario(s): Surface fire (SIH); worker injury (SIH)	Electrical equipment **Not Applicable**																					
	Vehicle/engine exhaust or heat **Not Applicable**																					
	Welding equipment **Not Applicable**																					
Hazard Type: Pyrophoric Material Scenario(s): Underground fire	Actinides and other waste constituents **As Applicable**		✓	✓		✓	✓	✓										✓	✓			
Hazard Type: Spontaneous Combustion Scenario(s): Surface fire (SIH); underground fire; worker injury (SIH)	Fuels for vehicles, generators, etc. **Not Applicable**																					
	Acids, solvents, sodium/water reaction **Not Applicable**																					

Table A-3 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Open Flame Scenario(s): Surface fire (SIH); worker injury (SIH)	Welding equipment **Not Applicable**																					
Hazard Type: Chemical Reaction Scenario(s): Underground fire; explosion	Agitation/friction of dry resins **Not Applicable**																					
Hazard Type: Explosive Scenario(s): Explosion; hydrogen deflagration/ explosion	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates **As Applicable**		✓	✓		✓	✓	✓						✓				✓	✓			
Hazard Type: Pressure Scenario(s): Worker injury (SIH)	Air system, gas cylinders **Not Applicable**																					

Table A-3 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Internal Flooding Sources <u>Scenario(s):</u> Worker injury (SIH)	Domestic water **Not Applicable**																					
	Water trucks/tanks **Not Applicable**																					
<u>Hazard Type:</u> Criticality <u>Scenario(s):</u> Worker overexposure and/or fatality	Fissile materials **As Applicable**		✓	✓		✓	✓	✓		✓								✓				
<u>Hazard Type:</u> Ionizing Radiation <u>Scenario(s):</u> Overexposure	Inventory constituents		✓	✓		✓	✓	✓			✓			✓				✓				
	Radioactive sources **As Applicable**		✓	✓		✓	✓	✓			✓			✓				✓				
	Accelerator beams or radio-activated materials **As Applicable**		✓	✓		✓	✓	✓			✓			✓				✓				
<u>Hazard Type:</u> Penetration of Containment <u>Scenario(s):</u> Release of material; underground fire; explosion; hydrogen deflagration/ explosion	Drilling or other tasks/activities associated with surveillance and maintenance		✓	✓	✓	✓	✓	✓			✓			✓				✓	✓		✓	

Table A-3 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: External and Natural Phenomena Events Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion; surface fire; disturbance of surface material; worker injury	Aircraft impact		✓	✓	✓	✓	✓											✓	✓			
	Lightning **Not Applicable**																					
	Earthquakes		✓	✓	✓	✓	✓											✓				
	High winds **Not Applicable**																					
	Heavy rains/flooding		✓	✓	✓	✓	✓											✓				

Table A-4
Hazard-Barrier Matrix for Disposal Areas (pits and trenches at TA-21 MDA A and TA-21 MDA B)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)																
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Nuclear Material/ Hazardous Material <u>Scenario(s):</u> Release of material	Radioactive materials in inventory, soil, and debris		✓	✓	✓		✓	✓			✓			✓				✓				
	Hazardous materials such as lead, beryllium, solvents, etc. **As Applicable**		✓	✓	✓		✓	✓						✓				✓			✓	
<u>Hazard Type:</u> Kinetic Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Crane loads, drilling rigs, and components		✓	✓	✓		✓	✓			✓			✓			✓	✓			✓	
	Vehicles, forklifts		✓	✓	✓		✓	✓			✓			✓			✓	✓			✓	
	Vibration **Not Applicable**																					
	Projectiles from mowers **Not Applicable**																					
	Shrapnel or debris from explosives firing **Not Applicable**																					

Note: Covers on these MDAs are somewhat thin and discontinuous. The inventory may be susceptible to surface events, such as fire or mechanical agitation. However, because the majority of he inventory is buried, distributed throughout the disposal site, generally mixed with clean fill material, and isolated by surrounding rock from external forces, burial remains an important element that contributes to the effectiveness of the physical barrier.

Table A-4 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Potential Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Elevated work surfaces, lifts, scaffolds, ladders **Not Applicable**																					
	Stacked material **Not Applicable**																					
	Heavy masses over weak ground areas			✓	✓		✓	✓						✓				✓				
<u>Hazard Type:</u> Combustibles/ Flammables <u>Scenario(s):</u> Surface fire; worker injury	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/ solvents **As Applicable**			✓	✓		✓	✓			✓			✓				✓	✓		✓	
<u>Hazard Type:</u> Electrical <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Portable electrical equipment			✓	✓		✓	✓						✓			✓	✓	✓			
	Power generating and distribution equipment			✓	✓		✓	✓						✓			✓	✓	✓			
<u>Hazard Type:</u> Thermal <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Electrical equipment			✓	✓		✓	✓						✓			✓	✓	✓			
	Vehicle/engine exhaust or heat			✓	✓		✓	✓						✓			✓	✓	✓			
	Welding equipment			✓	✓		✓	✓						✓			✓	✓	✓			

Table A-4 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Pyrophoric Material <u>Scenario(s):</u> Underground fire	Actinides and other waste constituents **As Applicable**			✓	✓		✓	✓										✓	✓			
<u>Hazard Type:</u> Spontaneous Combustion <u>Scenario(s):</u> Surface fire (SIH); underground fire; worker injury (SIH)	Fuels for vehicles, generators, etc.			✓	✓		✓	✓						✓			✓	✓	✓			
	Acids, solvents, sodium/water reaction **Not Applicable**																					
<u>Hazard Type:</u> Open Flame <u>Scenario(s):</u> Surface fire (SIH); worker injury (SIH)	Welding equipment			✓	✓		✓	✓						✓			✓	✓	✓			
<u>Hazard Type:</u> Chemical Reaction <u>Scenario(s):</u> Underground fire; explosion	Agitation/friction of dry resins **Not Applicable**																					

Table A-4 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Explosive <u>Scenario(s):</u> Explosion; hydrogen deflagration/ explosion	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates **As Applicable**		✓	✓			✓	✓						✓				✓	✓			
<u>Hazard Type:</u> Pressure <u>Scenario(s):</u> Worker injury (SIH)	Air system, gas cylinders **Not Applicable**																					
<u>Hazard Type:</u> Internal Flooding Sources <u>Scenario(s):</u> Worker injury (SIH)	Domestic water **Not Applicable**																					
	Water trucks/tanks **Not Applicable**																					
<u>Hazard Type:</u> Criticality <u>Scenario(s):</u> Worker overexposure and/or fatality	Fissile materials **As Applicable**		✓	✓			✓	✓		✓								✓				

Table A-4 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)																
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Ionizing Radiation <u>Scenario(s):</u> Overexposure	Inventory constituents		✓	✓			✓	✓			✓			✓				✓				
	Radioactive sources **As Applicable**		✓	✓			✓	✓			✓			✓				✓				
	Accelerator beams or radio-activated materials **As Applicable**		✓	✓			✓	✓			✓			✓				✓				
<u>Hazard Type:</u> Penetration of Containment <u>Scenario(s):</u> Release of material; underground fire; explosion; hydrogen deflagration/ explosion	Drilling or other tasks/activities associated with surveillance and maintenance		✓		✓		✓	✓			✓			✓				✓	✓		✓	

Table A-4 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)																
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: External and Natural Phenomena Events Scenario(s): Release of material; underground fire; explosion; hydrogen deflagration/ explosion; surface fire; disturbance of surface material; worker injury	Aircraft impact		✓	✓	✓		✓											✓	✓			
	Lightning **Not Applicable**																					
	Earthquakes		✓	✓	✓		✓											✓				
	High winds			✓	✓		✓							✓				✓				
	Heavy rains/flooding			✓	✓		✓											✓				

Table A-5
Hazard-Barrier Matrix for Contaminated Soil (TA-35 WWTP and TA-35 Pratt Canyon)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Nuclear Material/ Hazardous Material Scenario(s): Release of material	Radioactive materials in soil, sediment, and debris			✓	✓		✓	✓			✓			✓				✓				
	Hazardous materials such as lead, beryllium, solvents, etc. **As Applicable**			✓	✓		✓	✓						✓				✓			✓	
Hazard Type: Kinetic Energy Scenario(s): Disturbance of surface material; worker injury (SIH)	Crane loads, drilling rigs, and components **Not Applicable**																					
	Vehicles, forklifts			✓	✓		✓	✓			✓			✓			✓	✓				
	Vibration **Not Applicable**																					
	Projectiles from mowers **Not Applicable**																					
	Shrapnel or debris from explosives firing **Not Applicable**																					

Note: Most of radioactive material is below the surface and dispersed throughout a large volume of soil or sediment; surface contamination exists in some places. Where surface contamination exists, it is susceptible to surface events, surface fires, or mechanical agitation.

Table A-5 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Potential Energy <u>Scenario(s):</u> Disturbance of surface material; worker injury (SIH)	Elevated work surfaces, lifts, scaffolds, ladders **Not Applicable**																					
	Stacked material **Not Applicable**																					
	Heavy masses over weak ground areas **Not Applicable**																					
<u>Hazard Type:</u> Combustibles/ Flammables <u>Scenario(s):</u> Surface fire; worker injury	Waste constituents and supplies for S&M activities such as plastics, cellulose materials, petroleum products, flammable liquids/ solvents			✓	✓		✓	✓			✓			✓				✓	✓		✓	
<u>Hazard Type:</u> Electrical <u>Scenario(s):</u> Surface fire; worker injury	Portable electrical equipment			✓	✓		✓	✓						✓			✓	✓	✓			
	Power generating and distribution equipment			✓	✓		✓	✓						✓			✓	✓	✓			
<u>Hazard Type:</u> Thermal <u>Scenario(s):</u> Surface fire; worker injury	Electrical equipment			✓	✓		✓	✓						✓			✓	✓	✓			
	Vehicle/engine exhaust or heat			✓	✓		✓	✓						✓			✓	✓	✓			
	Welding equipment			✓	✓		✓	✓						✓			✓	✓	✓			

Table A-5 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)																
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Pyrophoric Material <u>Scenario(s):</u> Underground fire	Actinides and other waste constituents **Not Applicable**																						
<u>Hazard Type:</u> Spontaneous Combustion <u>Scenario(s):</u> Surface fire; underground fire; worker injury	Fuels for vehicles, generators, etc.			✓	✓		✓	✓						✓			✓	✓	✓			
	Acids, solvents, sodium/water reaction **Not Applicable**																					
<u>Hazard Type:</u> Open Flame <u>Scenario(s):</u> Surface fire; worker injury	Welding equipment			✓	✓		✓	✓						✓			✓	✓	✓			
<u>Hazard Type:</u> Chemical Reaction <u>Scenario(s):</u> Underground fire; explosion	Agitation/friction of dry resins **Not Applicable**																					

Table A-5 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
Hazard Type: Explosive Scenario(s): Explosion; hydrogen deflagration/ explosion	Waste constituents such as hydrogen, other gases, chemicals squibs, blasting caps, nitrates **Not Applicable**																					
Hazard Type: Pressure Scenario(s): Worker injury (SIH)	Air system, gas cylinders **Not Applicable**																					
Hazard Type: Internal Flooding Sources Scenario(s): Worker injury (SIH)	Domestic water **Not Applicable**																					
	Water trucks/tanks **Not Applicable**																					
Hazard Type: Criticality Scenario(s): Worker overexposure and/or fatality	Fissile materials **Not Applicable**																					

Table A-5 (continued)

Hazard Type	Material/Energy Source	Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
		Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> Ionizing Radiation <u>Scenario(s):</u> Overexposure	Inventory constituents			✓	✓		✓	✓			✓			✓				✓				
	Radioactive sources **Not Applicable**																					
	Accelerator beams or radio-activated materials **As Applicable**			✓	✓		✓	✓			✓			✓				✓				
<u>Hazard Type:</u> Penetration of Containment <u>Scenario(s):</u> Release of material; underground fire; explosion; hydrogen deflagration/ explosion	Drilling or other tasks/activities associated with surveillance and maintenance				✓		✓	✓			✓			✓				✓	✓		✓	

Table A-5 (continued)

		Barrier 1: Inventory Isolation System (TSR DF)					Barrier 2: Safety Management Programs (TSR AC)															
Hazard Type	Material/Energy Source	Primary Containers/Vessels	Configuration of Burial (e.g., tunnel/shaft, pit/trench)	Burial Depth	Inventory Distribution	Thickness and Characteristics of Cover Materials and Caps	NES S&M Program	Integrated Work Management Program	Unreviewed Safety Question Program	Nuclear Criticality Program	Radiation Protection Program	Quality Assurance Program	Abnormal Event Reporting Program	Qualification and Training Program	Record-Keeping Program	Configuration Management Program	Vehicle and Equipment Maintenance Program	Emergency Management Program	Fire Protection Program	Calibration Program	Hazardous Materials Protection Program	Radioactive and Hazardous Waste Management Program
<u>Hazard Type:</u> External and Natural Phenomena Events <u>Scenario(s):</u> Release of material; underground fire; explosion; hydrogen deflagration/ explosion; surface fire; disturbance of surface material; worker injury	Aircraft impact			✓	✓		✓											✓	✓			
	Lightning **Not Applicable**																					
	Earthquakes				✓		✓											✓				
	High winds			✓	✓		✓							✓				✓				
	Heavy rains/flooding			✓	✓		✓											✓				

Appendix B

Acronyms/Abbreviations,
Glossary, and Metric Conversion Table

B-1.0 ACRONYMS AND ABBREVIATIONS

AC	alternating current
AGL	above ground level
ATV	all-terrain vehicle(s)
CFR	Code of Federal Regulations
DC	direct current
D&D	decontamination and decommissioning
DOE	US Department of Energy
DSA	documented safety analysis
ES&H	environmental safety and health
g	gravity (9.8 m/s^2) relative to peak ground acceleration
HC	hazard category
HE	high explosives
KSL	KBR, Shaw, LATA group
LAMPRE	Los Alamos Molten Plutonium Reactor Experiment
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron-Scattering Center
LASO	Los Alamos Site Office
MDA	material disposal area
Mw	moment magnitude scale
NES	nuclear environmental site
NMED	New Mexico Environmental Department
NNSA	National Nuclear Security Administration
NWO	Nuclear Waste Operations
OSHA	Occupational Safety and Health Administration
PRS	potential release site(s)
RLW	radioactive liquid waste
RRES	Risk Reduction and Environmental Stewardship
RS	Remediation Services
S&M	surveillance and maintenance
SNM	special nuclear materials
SWMU	solid waste management units
TA	technical area
TSR	technical safety requirement
US	United States
USQ	unreviewed safety question
WWTP	wastewater treatment plant

B-2.0 GLOSSARY

absorption—The penetration of substances into the bulk of a solid or liquid.

administrative controls—The provisions relating to organization and management, procedures, recordkeeping, assessment, and reporting necessary to ensure safe operation of a facility.

adsorption—The surface retention of solid, liquid, or gas molecules, atoms, or ions by a solid or a liquid.

alluvial—Relating to geologic deposits or features formed by running water.

alluvium—Clay, silt, sand, and gravel transported by water and deposited on streambeds, flood plains, and alluvial fans.

analysis—Includes physical analysis, chemical analysis, and knowledge-of-process determinations. (Laboratory Hazardous Waste Facility Permit)

aquifer—Body of permeable geologic material whose saturated portion is capable of readily yielding groundwater to wells.

area of concern (AOC)—Areas at the Laboratory that might warrant further investigation for releases based on past facility waste-management activities [Au: Can you clarify "further investigation for releases"? What type of releases, and do they lie in the future or past?].

as low as reasonably achievable—a phrase used to describe an approach to radiation protection to control or manage exposures (both for individual workers and collectively for the work force and the general public) and releases of radioactive material to the environment at levels as low as social, technical, economic, practical, and public policy considerations permit.

barrier—these are physical, procedural, administrative, or human-actions that can provide protection against hazards. For this DSA, physical isolation of the radiological and hazardous chemical inventory as provided by burial and other aspects of disposal form the primary barrier to the release of the inventory to the environment. Programs and procedures to maintain and survey the sites are also considered barriers in that they are implemented to prevent unacceptable degradation of the primary (physical) barrier.

barrier analysis—A review of hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or managerially instituted.

bentonite—A clay composed of the mineral montmorillonite and variable amounts of magnesium and iron, formed over time by the alteration of volcanic ash. Because bentonite can *adsorb* large quantities of water and expand to several times its normal volume, it is a common additive to drilling mud.

chemical—Any naturally occurring or human-made substance characterized by a definite molecular composition, including molecules that contain radionuclides.

chemical analysis—Process used to measure one or more attributes of a sample in a clearly defined, controlled, systematic manner. Often requires treating a sample chemically or physically before measurement.

Code of Federal Regulation (CFR)—A codification of all regulations developed by federal government agencies and finalized by publication in the Federal Register.

contaminant—Any chemical (including radionuclides) present in environmental media or on structural debris.

decommissioning—Permanent removal from service of facilities and their components after the discontinued use of structures or buildings deemed no longer useful, in accordance with regulatory requirements and environmental policies.

decontamination—Removal of unwanted material from the surface of, or from within, another material.

design feature—The design features of a nuclear facility specified in the technical safety requirements that, if altered or modified, would have a significant effect on safe operation.

discharge—Accidental or intentional spilling, leaking, pumping, pouring, emitting, emptying, or dumping of hazardous waste into or on any land or water. (RCRA, 40 CFR 260.10)

disposal—The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters. (40 CFR Part 260.10)

disposal unit—An engineered disposal area that has been constructed with defined boundaries to isolate buried wastes from the environment. For the NES, these include shafts, pits, trenches, tanks, and absorption beds.

documented safety analysis—The documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety.

DOE—See US Department of Energy

effluent—Liquid discharged as a waste, such as contaminated water from a factory or the outflow from a sewage works; water discharged from a storm sewer or from land after irrigation.

environmental restoration activities —the process(es) by which contaminated sites and facilities are identified and characterized and by which contamination is contained, treated, or removed and disposed.

ephemeral—Said of a stream or spring that flows only during and immediately after periods of rainfall or snowmelt.

evapotranspiration—The combined discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces, and by transpiration from plants.

exposure pathway—Mode by which a receptor may be exposed to contaminants in environmental media (e.g., by drinking water, ingesting food, or inhaling dust).

fault—A fracture, or zone of fractures, in rock along which there has been vertical or horizontal movement; adjacent rock layers or bodies are displaced.

flood plain—The portion of a river valley that is built of overbank sediment deposited when the river floods.

geohydrology—The science that applies hydrologic methods to the understanding of geologic phenomena.

graded approach—The process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement are commensurate with:

(1) The relative importance to safety, safeguards, and security;
(2) The magnitude of any hazard involved;
(3) The life-cycle stage of a facility;
(4) The programmatic mission of a facility;

(5) The particular characteristics of a facility;
(6) The relative importance of radiological and nonradiological hazards; and
(7) Any other relevant factor.

groundwater—Water in a subsurface saturated zone; water beneath the regional *water table*.

hazard—A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to a person or damage to a facility or to the environment (without regard to the likelihood or credibility of accident scenarios or consequence mitigation).

hazard controls—Measures to eliminate, limit, or mitigate hazards to workers, the public, or the environment, including

(1) Physical, design, structural, and engineering features;
(2) Safety structures, systems, and components;
(3) Safety management programs;
(4) Technical safety requirements; and
(5) Other controls necessary to provide adequate protection from hazards.

hazardous constituent—Those constituents listed in Appendix VIII to 40 CFR Part 261.

HAZARDOUS MATERIAL—In this DSA, materials that are radioactive or are listed in 40 CFR 302 as toxic, explosive, flammable, corrosive, etc.

hazardous waste—Any solid waste is generally a hazardous waste if it

- is not excluded from the regulations as a hazardous waste,
- is listed in the regulations as a hazardous waste,
- exhibits any of the defined characteristics of hazardous waste (ignitability, corrosivity, reactivity, or toxicity), or
- is a mixture o*f* solid waste and hazardous waste.

See 40 CFR 261.3 for a complete definition of hazardous waste.

hydraulic conductivity—The rate at which water moves through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

hydraulic gradient—The rate of change of hydraulic head per unit of distance in the direction of groundwater flow.

hydrogeology—The science that applies geologic methods to the understanding of hydrologic phenomena.

hypothesis—A proposition stated as a basis for further investigation.

infiltration—Entry of water into the ground.

interflow—A runoff process that involves lateral subsurface flow in the soil zone.

intermittent stream—A stream that flows only in certain reaches as a result of losing and gaining characteristics of the channel bed.

leaching—The separation or dissolving out of soluble constituents of a solid material by the natural action of percolating water or by chemicals.

medium (environmental)—Any media capable of absorbing or transporting constituents. Examples of media include tuffs, soils, and sediments derived from these tuffs, surface water, soil water, groundwater, air, structural surfaces, and debris.

medium (geological)—The solid part of the hydrogeological system; may be unsaturated or saturated.

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

migration pathway—A route (e.g., a stream or subsurface flow path) that controls the potential movement of contaminants to environmental receptors (plants, animals, humans).

monitoring well—A well or borehole drilled for the purpose of yielding groundwater samples for analysis.

nuclear environmental site (NES)—Inactive waste handling or disposal areas that have been characterized as nuclear sites because, based on an initial categorization, their inventory identified them as hazard category 2 or 3 according to DOE-STD-1027 thresholds.

Occupational Safety and Health Administration (OSHA)—An agency of the US Department of Labor, established under Public Law 91-596 with major responsibilities to promulgate, prescribe, and enforce occupational safety and health standards.

outfall—The vent or end of a drain, pipe, sewer, ditch, or other conduit that carries wastewater, sewage, storm runoff, or other effluent into a stream.

OSHA—See Occupational Safety and Health Administration.

perched groundwater—Groundwater that lies above the regional water table and is separated from it by one or more unsaturated zones.

percolation—Gravity flow of soil water through the pore spaces in soil or rock below the ground surface.

perennial stream—A stream or reach that flows continuously throughout the year.

physical hazards—Hazards that are routinely encountered in general industry and construction, and for which national consensus codes or standards (e.g., Occupational Safety and Health Administration [OSHA] or Department of Transportation [DOT]) exist to guide safe design and operation without the need for special analysis to define safe design or operational parameters. Physical hazards include those encountered during routine work and construction, including excavation, electrical, hoisting and rigging hazards; noise; and slips, trips, and falls.

porosity—The ratio of the volume of interstices in a soil or rock sample to its total volume, expressed as a percentage or as a fraction.

potential release site (PRS)—Refers to potentially contaminated sites at the Laboratory that are identified either as *solid waste management units* (SWMUs) or *areas of concern* (AOCs). PRS refers to SWMUs and AOCs collectively.

quality assurance—All those actions that provide confidence that quality is achieved.

quality assurance program—The overall program or management system established to assign responsibilities and authorities, define policies and requirements, and provide for the performance and assessment of work.

radiological hazards—Hazards that contain radioactive isotopes that have the potential to cause harm from ionizing radiation.

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

recharge—The process by which water is added to the zone of saturation, either directly from the overlying unsaturated zone or indirectly by way of another material in the saturated zone.

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

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

remediation—The process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health and the environment; the act of restoring a contaminated area to a usable condition based on specified standards.

retardation—The act or process that reduces the rate of movement of a chemical substance in water relative to the average velocity of the water. The movement of chemical substances in water can be retarded by adsorption and precipitation reactions, and by diffusion into the pore water of the rock matrix.

safety basis—The combination of information relating to the identification, analysis, and control of facility disposition hazards (including engineering design and administrative controls) upon which DOE depends for its conclusion that activities at the facility can be conducted safely. For the purposes of DOE Standard 1120-98, the concept of “safety basis,” which has been used in DOE 5480.23 for nuclear facilities, has been extended to radiological and nonnuclear facilities. This does not imply that specific nuclear safety requirements of DOE 5480.23 are applicable to these types of facilities.

safety management program—A program designed to ensure a facility is operated in a manner that adequately protects workers, the public, and the environment by covering topics such as quality assurance; maintenance of safety systems; personnel training; conduct of operations; inadvertent criticality protection; emergency preparedness; fire protection; waste management; or radiological protection of workers, the public, and the environment.

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

site characterization—Defining the pathways and methods of migration of hazardous waste or constituents, including the media affected; the extent, direction, and speed of the contaminants; and complicating factors influencing movement or concentration profiles. (US Environmental Protection Agency, May 1994. “RCRA Corrective Action Plan, Final,” Publication EPA-520/R-94/004, Office of Solid Waste and Emergency Response, Washington, DC)

soil gas—Those gaseous elements and compounds that occur in the void spaces in unsaturated rock or soil. Such gases can move through or leave the rock or soil, depending on changes in pressure.

soil water—Water in the unsaturated zone, regardless of whether it occurs in soil or rock.

solid waste—Any garbage; refuse; sludge from a waste treatment plant, water-supply treatment plant, or air-pollution-control facility; and other discarded material, including solid, liquid, semisolid, or contained gaseous material that result from industrial, commercial, mining, and agricultural operations and from community activities.

solid waste management unit (SWMU)—Any discernible unit into which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility into which solid wastes have been routinely and systematically released. This definition includes regulated units (i.e., landfills, surface impoundments, waste piles, and land treatment units), but does neither includes passive leakage or one-time spills from production areas nor units in which wastes have not been managed (e.g., product-storage areas).

surveillance and maintenance —These activities are conducted throughout the facility life-cycle phase, including times when a facility is not operating and is not expected to operate again, but continues until phased out during decommissioning. Activities include providing, in a cost-effective manner, periodic inspections and maintenance of the structures, systems, or components that are necessary for the satisfactory containment of contamination and for the protection of workers, the public, and the environment. As further explained in DOE Standard 1120-98, a disposition project can be in a quiescent state of long-term surveillance and maintenance prior to deactivation or prior to decommissioning.

spring—The site where groundwater discharges to the ground surface.

task hazard analysis—An analysis of individual facility disposition tasks (i.e., discrete units of work that comprise a project) to understand hazards that may be introduced during the conduct of work activities. This analysis supports the establishment of worker safety controls and the development of work packages or other methods used to plan tasks.

technical area (TA)—The Laboratory established technical areas as administrative units for all its operations. There are currently 49 active TAs spread over approximately 40 square miles.

technical safety requirements (TSRs)—The limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include the following items as appropriate for the work and the hazards identified in the documented safety analysis for the facility: Safety limits, operating limits, surveillance requirements, administrative and managerial controls, use and application provisions, and design features, as well as bases.

transport or transportation—The movement of a hazardous waste by air, rail, highway, or water. (40 CFR 260.10)

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

underflow—Groundwater flow beneath the bed of a nonflowing stream; such water is often perched in the channel alluvium atop the bedrock surface.

unreviewed safety question (USQ)—A situation where

(1) The probability of the occurrence, or the consequences of an accident, or the malfunction of equipment important to safety previously evaluated in the documented safety analysis could be increased;

(2) The possibility of an accident or malfunction of a different type than any evaluated previously in the documented safety analysis could be created;

(3) A margin of safety could be reduced; or

(4) The documented safety analysis may not be bounding or may be otherwise inadequate.

unsaturated zone—The zone between the land surface and the regional water table and between perched zones of saturation. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure.

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

water table—The top of the regional saturated zone; the piezometric surface associated with an unconfined aquifer.

B-3.0 METRIC CONVERSION TABLE

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