APPENDIX I
MAJOR MATERIAL DISPOSAL AREA REMEDIATION, CANYON CLEANUPS, AND OTHER CONSENT ORDER ACTIONS

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Los Alamos National Laboratory (LANL) conducts operations in support of the National Nuclear Security Administration (NNSA), a semi-autonomous administration within the U.S. Department of Energy (DOE). This appendix addresses possible environmental impacts associated with investigations and corrective measures being conducted at LANL in accordance with the Atomic Energy Act of 1954, as amended, and the Resource Conservation and Recovery Act (RCRA) and related legislation, particularly the Hazardous and Solid Waste Amendments (HSWA). RCRA-related investigations and corrective actions will be conducted in accordance with a Compliance Order on Consent[1] (Consent Order) entered into by DOE, the University of California as the management and operating contractor, and the State of New Mexico on March 1, 2005.

Implementing the Consent Order

NNSA intends to implement actions necessary to comply with the Compliance Order on Consent (Consent Order) regardless of decisions it makes on other actions analyzed in the LANL SWEIS. Actions associated with implementing the Consent Order are included in the Expanded Operations Alternative; however, their implementation is not contingent on other actions that are part of that alternative.

The Consent Order includes schedules for completion of investigations and corrective measures by the end of 2015. This appendix accordingly addresses environmental consequences through fiscal year (FY) 2016.

The analyses performed for this Site-Wide Environmental Impact Statement (SWEIS) mainly consider levels of operations and new projects proposed for 2007 through about 2011; the analyses in this appendix consider environmental restoration activities through FY 2016. However, these analyses are applicable to actions that may be taken during this period of time, and if necessary beyond, as long as the actions are bounded by the analytical results presented in this appendix.

I.1 Introduction

I.1.1 Need for Agency Action

In accordance with statutes such as RCRA and the Atomic Energy Act, LANL staff has conducted an environmental restoration project to identify locations where radioactive and hazardous constituents may have been released into the environment and to conduct corrective action. These potential release sites (PRSs)[2] include:

- Material disposal areas (MDAs), where radioactive or hazardous constituents have been disposed of, generally by burial within soil or underlying tuff

[1] The Consent Order can be viewed at http://www.nmenv.state.nm.us/hwb/lanl/OrderConsent/03-01-05/Order_on_Consent_2-24-05.pdf.

[2] For this SWEIS, a potential release site (PRS) means a site suspected of releasing or having the potential to release contaminants (radioactive, chemical, or both). PRS is a general term that includes solid waste management units and areas of concern that are cited and defined in the March 2005 Consent Order.

- Firing sites, where radioactive or hazardous constituents have been explosively dispersed
- Outfalls, where soils, sediments, water bodies, or aquifers have become contaminated with radioactive or hazardous constituents contained in discharged effluents
- Other areas of possible surface, subsurface, or groundwater contamination

Correction action activities at LANL are regulated primarily by DOE pursuant to the Atomic Energy Act, and by the New Mexico Environment Department (NMED) pursuant to RCRA, HSWA, and the New Mexico Hazardous Waste Act. For activities regulated by NMED, since 1990, LANL has conducted investigations and corrective measures in accordance with its Hazardous Waste Facility Permit. But as of March 1, 2005, the corrective action program specified in the permit was replaced by the Consent Order.

The Consent Order prescribes investigation programs for LANL PRSs subject to RCRA and HSWA requirements. From the investigation program results, a determination may be made that no further action is required, or that corrective measures may be needed. If the latter, interim measures may be performed as directed by NMED or as proposed by DOE and approved by NMED. (Emergency interim measures may be implemented without prior NMED approval). As needed and as directed by NMED, alternative corrective measures may be evaluated. After NMED selects the corrective measures to be implemented at the PRSs, the selected corrective measures are implemented and completions of the corrective measures are documented. Activities to be performed in compliance with the Consent Order are similar to those that have taken place for years at LANL (such as drilling exploratory wells or performing removals). But the timing and extent of some activities may be different from those previously anticipated.

The Consent Order provides schedules for all subject PRS remedy completion. Some schedules are explicitly stated, but most are prescribed through aggregate area schedules for remediation completion. That is, there is a schedule for completing remedies in each aggregate area, and every subject PRS is in an aggregate area. If regulatory delays occur in the investigations or corrective measure selection processes, then the remedy completion schedules are adjusted to account for these delays.

> An aggregate area is an area within a single watershed or canyon made up of one or more solid waste management units (SWMUs) and areas of concern (AOCs) and the media affected or potentially affected by SWMUs or AOCs releases and for which investigation or remediation, in part or in entirety, is conducted for the area as a whole to address area-wide contamination, ecological risk assessment, and other factors (NMED 2005).

The majority of investigations and corrective measures that will occur under the Consent Order will probably not be environmentally significant. For example, if a sump formerly used for drainage of liquids containing hazardous constituents is decontaminated, and a small amount of waste products are properly disposed of, then these corrective measures may be of such a short-term nature that they do not require a detailed National Environmental Policy Act (NEPA) analysis. But if a large number of small-scale corrective measures take place, then there may be concerns about the cumulative impacts of all actions. In addition, some corrective measures for some PRSs may be of larger significance in terms of cost, time to complete, and possible short- and long-term environmental impacts.

I.1.2 Purpose and Approach

The purpose of this appendix is to address Consent Order NEPA implications on LANL operations. The following approach is used:

- Review the Consent Order to identify and describe those PRSs that may require investigation or remediation through FY 2016 (Section I.2).
- Address in detail a limited number of large MDAs that may require significant efforts to remediate (Section I.3).
- Aggregate the remaining MDAs and other PRSs where remediation efforts will probably be more significant in totality than individually (Section I.3).
- Analyze a bounding range of remediation options (Section I.3).
- Review the environmental setting, emphasizing site-wide variations (Section I.4).
- Assess environmental impacts of the bounding range of options (Section I.5).

The analysis in this appendix is being conducted in advance of all information to be collected from the LANL corrective measure investigation program and is not meant to circumvent remediation decisions about any PRS. Work being performed to characterize, assess, and provide recommendations for corrective measures at all LANL PRSs may require several years to complete, and decisions will be made in accordance with prescribed regulatory processes. After a decision is reached on an MDA or PRS alternative, implementing that decision may require detailed engineering and safety assessments. Therefore, options in this appendix are meant to bound possible environmental impacts. The analysis is intended to provide information that could be used to develop mitigative measures, if needed, if a particular option is implemented. If it is determined that implementing an option may result in impacts that exceed those considered in this appendix, then additional NEPA review may be needed.

For this appendix, the PRSs that will be investigated and may be remediated through FY 2016 are grouped into large MDAs, small MDAs, and additional PRSs.

MDAs are emphasized because decisions about their remediation may significantly affect site-wide operations and the environment. Because MDAs contain contamination mainly in the subsurface, two broad-scope remediation options are envisioned: stabilization in place or removal (see Section I.1.3). Although several variations or suboptions may be addressed in future analyses, these two options should bound possible environmental impacts.

The large MDAs addressed in this appendix are listed in **Table I–1**. Schedules for submittal of corrective measure reports for these MDAs are presented in **Table I–2**. These MDAs generally contain larger inventories of hazardous and radioactive constituents compared with other MDAs and PRSs. A second group of smaller MDAs is listed in **Table I–3**.

Table I–1 Large Material Disposal Areas

Technical Area	*MDA and SWMU*	*Description*
TA-21	MDA A 21-014	Inactive. Contains two 50,000-gallon underground tanks, two small pits, and one large pit.
TA-21	MDA B 21-015	Inactive. Used for solid radioactive waste and chemical waste disposal. Uncertain number of disposal trenches.
TA-21	MDA T 21-016(a)-99	Inactive. Includes four absorption beds, more than 60 shafts, and other potential release sites associated with decommissioned waste treatment facilities and storage areas. Beds received untreated liquids containing plutonium from 1945 to 1952, and treated liquids thereafter until 1967. Liquids included fluoride and ammonium citrate. Shafts contain solids, sludge mixed with cement, and alkaline fluoride.
TA-21 [a]	MDA U [a] 21-017 (a-c)	Inactive. Contains two absorption beds used from 1948 to 1968 for subsurface disposal of contaminated liquid wastes. [a]
TA-49	MDA AB 49-001 (a-g)	Inactive. Includes multiple shafts and chambers at depths between 60 and 80 feet that were used from 1959 to 1961 for hydronuclear safety experiments. Contains uranium-235, plutonium-239, solid lead shielding, and beryllium.
TA-50	MDA C 50-009	Inactive. Contains seven pits and 108 shafts. One chemical waste pit contains pyrophoric metals, hydrides, and powders, sodium-potassium alloy, and compressed gasses. Other pits contain process wastes, demolition waste, classified materials, and tuballoy (a uranium alloy) chips. Shafts were used for disposal of high-surface-exposure waste.
TA-54	MDA G (multiple SWMUs)	MDA G is inactive. It consists of numerous pits and shafts within active Area G, which is used for low-level radioactive waste disposal and transuranic waste storage. Area G is being expanded but a portion will close consistent with the Consent Order requirement to complete corrective action for MDA G by August 2015 and with the need to develop new low-level radioactive waste disposal capacity.
TA-54	MDA L (SWMU-54-006)	Inactive. MDA L was used for waste disposal from 1959 through 1985 (contains one chemical waste disposal pit, 34 disposal shafts, and three chemical waste impoundments). MDA L is within Area L, which is used for storage of RCRA, PCB, and mixed wastes.

TA = technical area, MDA = material disposal area, SWMU = solid waste management unit, RCRA = Resource Conservation and Recovery Act, PCB = polychlorinated biphenyl.

[a] MDA U is smaller than the other MDAs in this table, and, in September 2006, NMED issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b). It was included for purposes of NEPA analysis and because of its location in TA-21.

Note: To convert feet to meters, multiply by 0.3048; gallons to liters, multiply by 3.7854.

Table I–2 Updated Corrective Measure Report Schedules for Large Material Disposal Areas

MDA	*Investigation Work Plan*	*Investigation Report*	*CME Work Plan*	*CME Report*	*Remedy Completion Report*
A	Submitted	Submitted	TBD	TBD	3/11/2011
B	Submitted	Not applicable	Not applicable	Not applicable	12/31/2010 [a]
T	Submitted	Submitted	TBD	TBD	12/19/2010
U	Submitted	Submitted	TBD	TBD	11/6/2011 [b]
C	Submitted	Submitted	TBD	TBD	9/5/2010
L	Submitted	Submitted	Submitted	Submitted	7/9/2011 [c]
G	Submitted	Submitted	Submitted	Pending [d]	12/6/2015
AB	Submitted	5/31/2010	TBD	TBD	1/31/2015

MDA = material disposal area, CME = corrective measure evaluation, TBD = to be determined.

[a] MDA B will not go through the Corrective Measure Evaluation Process, but will proceed directly to remediation by removal.

[b] In September 2006, NMED issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).

[c] The original schedule in the Consent Order was June 30, 2011.

[d] Submittal is expected in September 2008.

Note: Current schedules have been approved by NMED and may differ from those in the Consent Order.

Table I–3 Additional Material Disposal Areas

Technical Area	*MDA and SWMU*	*Description*
TA-6	MDA F 6-007(a)	Contains an uncertain number of pits and trenches.
TA-8	MDA Q 8-006(a)	Inactive site, received waste in 1946 from naval gun experiments for the Little Boy atomic weapon.
TA-15	MDA N 15-007(a)	Small site containing a pit that received demolition wastes.
TA-15	MDA Z 15-007(b)	Small site used from 1965 to 1981 for disposal of construction debris and other wastes. Some wastes are exposed.
TA-16	MDA R 16-019	Inactive site that received debris from a high-explosives burning ground. It was partially remediated after the Cerro Grande Fire.
TA-33	MDA D 33-003(a, b)	Small site consisting of two underground chambers and elevator shafts used for explosives tests of weapons components.
TA-33	MDA E 33-001(a)-99	Site contains an underground experimental chamber used for explosives tests plus four disposal pits.
TA-33	MDA K 33-002(a)-99	Site currently consists of two small surface-disposal areas containing piled debris.
TA-36	MDA AA 36-001	Small site consists of at least two trenches containing firing site debris.
TA-39	MDA Y 39-001(b)	Small site in Ancho Canyon containing three pits used for disposal of firing site debris.

MDA = material disposal area, SWMU = solid waste management unit, TA = technical area.

The third group of PRSs comprises hundreds of sites containing low levels of radioactive or hazardous constituents, generally concentrated on the surface of the ground or in the near subsurface. A variety of remediation activities may take place, often requiring removal of relatively small quantities of wastes. These PRSs would be investigated as part of the aggregate area investigations. Schedules for conducting aggregate area investigations are specified in the Consent Order. Once an aggregate area investigation is complete, plans for remediating the PRSs in the aggregate area would be determined. Examples of PRSs composing this last group are shown in **Table I–4**.

Table I–4 Examples of Potential Release Sites Being Addressed Under the Consent Order

Technical Area	*Potential Release Site*	*Description*
TA-15	Site E-F 15-004(f)-99	High-explosives firing site; inactive.
TA-15	Site R-44 15-006(c)	High-explosives firing site; inactive.
TA-16	260 Outfall 16-021(c)-99	Site contaminated by outfall from an explosives manufacturing facility.
TA-73	Ash pile 73-002	Site contaminated by ashes from a former incinerator.

TA = technical area.

I.1.3 Options Considered in this Appendix

Three broad-scope options are considered for purposes of NEPA:

> The No Action Option is considered in this appendix because such an action is required by NEPA. DOE is legally required to carry out the provisions of the Consent Order.

- **No Action Option**. Environmental investigations and restoration efforts are assumed not to be carried out in accordance with the Consent Order provisions. The LANL environmental restoration project would continue at pre-Consent Order levels, but no extensive corrective measures would be conducted for major PRSs.

- **Capping Option**. The Consent Order would be implemented. For this appendix it was assumed that MDAs would be stabilized in place by placing final covers over them and conducting certain other environmental restoration activities such as remediating volatile organic compound plumes in soil at some MDAs. The underground "General's Tanks" (see Section I.2.5.2.1) within MDA A would be grouted in place. Transuranic waste in subsurface storage at MDA G would be removed, processed, and shipped to the Waste Isolation Pilot Plant (WIPP). Because some of the stored, transuranic waste in subsurface shafts within MDA G may be difficult to retrieve, an option to leave this stored waste in place would be considered. If this option were pursued, a performance assessment pursuant to Title 40 of the *Code of Federal Regulations* (CFR) Part 191, may be required. If such an assessment is required, the assessment results may indicate the need for additional waste stabilization or MDA cover final design modification.

  In addition, numerous other PRSs would be remediated by methods such as contamination removal, surge bed grouting, contaminated sediment natural flushing, permeable reactive barriers, pump and treat system installation, or other measures.

- **Removal Option**. The Consent Order would be implemented. For this appendix it was assumed that LANL MDA waste and contamination would be removed. Transuranic waste stored belowground at MDA G would be removed and shipped to WIPP along with other transuranic-contaminated material disposed of before 1970. Remediation of other PRSs would again occur by various methods as discussed for the Capping Option.

Environmental impacts assessed under the three options should bound those that could result from eventual implementation of MDA and PRS corrective measures. Remediation decisions will be made for specific MDAs and PRSs rather than groups and may prescribe a combination of corrective measures. For example, some waste within an MDA may be removed and the remainder may be stabilized in place.

For all options, appropriate safety and environmental surveillance and maintenance would continue at LANL to maintain compliance with DOE and external criteria and standards, including those for nuclear environmental sites (Section I.3.2.3).

I.1.4 Related National Environmental Policy Act Analyses

Two NEPA analyses related to this appendix are:

- *Environmental Assessment for Proposed Corrective Measures at Material Disposal Area H within Technical Area 54 at Los Alamos National Laboratory, Los Alamos, New Mexico* (DOE 2004b)

- *Categorical Exclusion for Proposed Remediation of MDA V within Technical Area 21 (TA-21)* (LANL 2004j)

I.2 Background

Introducing this chapter are sections summarizing (1) LANL's general setting, and (2) LANL's environmental restoration project and the March 1, 2005, Consent Order. The remaining sections address each PRS cited in the Consent Order consistent with their grouping in the Consent Order.

I.2.1 General Setting

LANL and its TAs are shown in **Figure I–1**. LANL is bordered by the Santa Fe National Forest to the north, west, and south. The Rio Grande and the Native American Pueblo of San Ildefonso border LANL on the east; the Bandelier National Monument and Bandelier Wilderness Area lie directly south. The areas surrounding LANL, Los Alamos County, and much of the neighboring counties are undeveloped. The two closest communities are the Los Alamos townsite and White Rock. Population centers within 50 miles (80 kilometers) of LANL include Española and Santa Fe. Thirteen American Indian Pueblos are within 50 miles (80 kilometers). LANL is on the Pajarito Plateau, consisting of east-southeast-trending canyons and mesas. The plateau mesas are generally devoid of surface water. Canyons may be wet or dry. Wet canyons contain continuous streams and may contain groundwater in canyon bottom alluvium. Dry canyons contain streams only occasionally flowing with water, and lack alluvial groundwater (LANL 1999b). The LANL region contains numerous natural and cultural resources, including habitats of threatened and endangered species such as the Mexican spotted owl (*Strix occidentalis lucida*), bald eagle (*Haliceetus leucocephalus*), and southwestern willow flycatcher (*Empidonex treillii extimus*) (see Chapter 4, Table 4–22, of this SWEIS).

I.2.2 The Los Alamos National Laboratory Environmental Restoration Project

Some of the hazardous and radioactive materials used at LANL have been released into the environment or disposed of as waste. Public and environmental protection has been maintained through a combination of site natural features; technology implementation; administrative and institutional controls; health, safety, and environmental monitoring; and adherence to applicable standards. Nonetheless, concerns about future efficacy of disposal and discharge areas to retain contaminants within regulatory standards have prompted efforts to remediate LANL areas where hazardous constituent releases may have occurred (LANL 2000b).

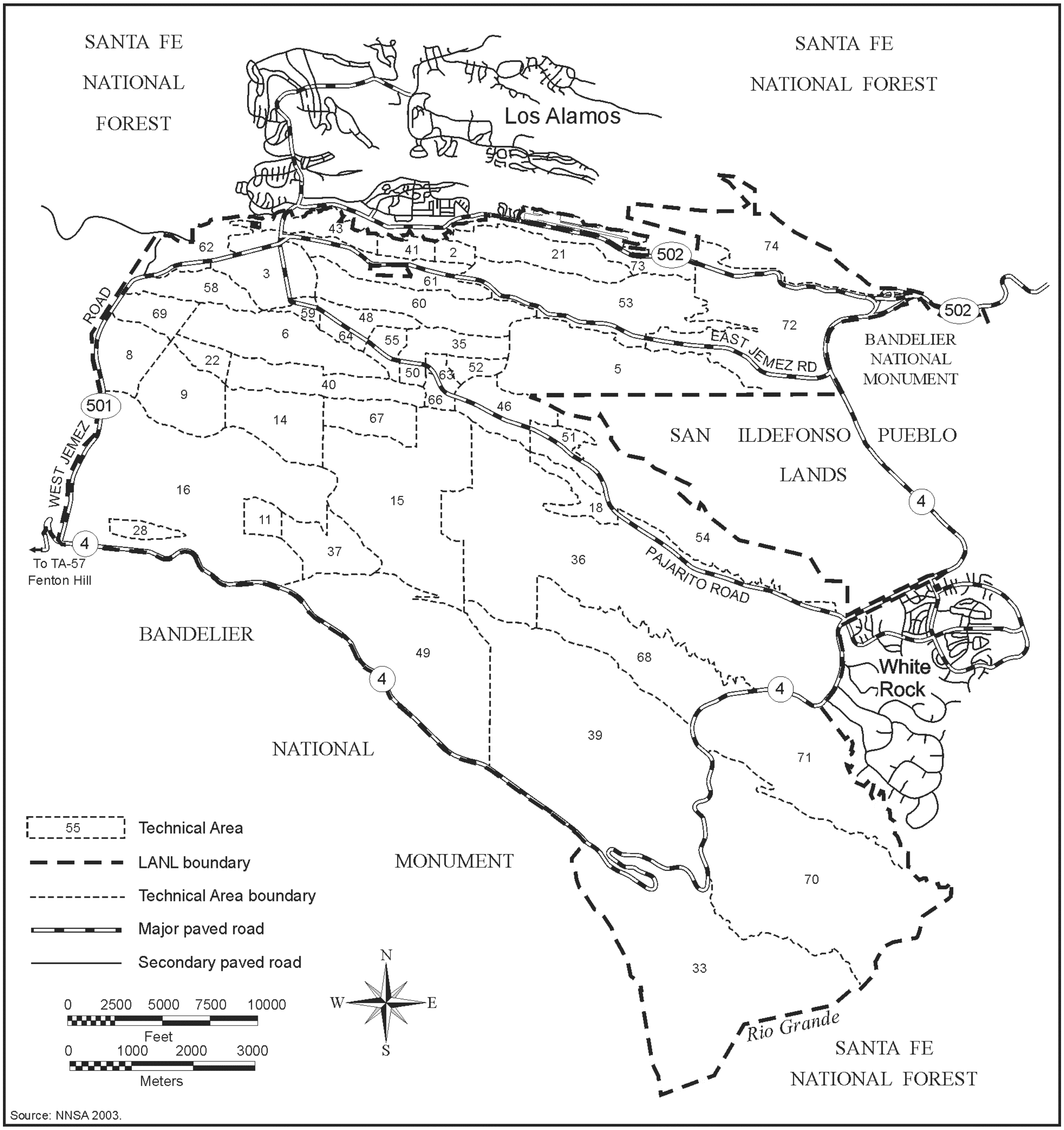

Figure I–1 Los Alamos National Laboratory Technical Area Locations

I.2.2.1 The Los Alamos National Laboratory Environmental Restoration Project Background

DOE and LANL employees must conduct activities in compliance with regulatory requirements derived from Federal and state statutes and Executive orders. Laws, regulations, agreements, and environmental protection orders applicable to LANL are presented in Chapter 6 of this SWEIS.

Operations involving radioactive materials have been historically conducted by DOE and its predecessors under Atomic Energy Act authority. However, during the last several decades, the

Congress enacted several major statutes addressing environmental protection, including RCRA, HSWA, and the Federal Facility Compliance Act. LANL currently operates under the regulatory authority of DOE, the U.S. Environmental Protection Agency (EPA), and the State of New Mexico. Under the Atomic Energy Act, DOE continues to have general landlord authority for protecting the public and environment, as well as specific authority for protecting workers, the public, and the environment from deleterious effects of radioactive and other toxic or hazardous materials. EPA has overall Federal regulatory authority for management of hazardous materials defined under RCRA and its amendments, particularly HSWA, as well as corrective actions taken pursuant to these statutes. EPA has authorized the State of New Mexico to implement this regulatory authority.

In 1989, DOE created the Office of Environmental Restoration and Waste Management; LANL's environmental restoration project was established the same year to undertake environmental restoration and decommissioning activities (LANL 2000b). In November 1989, the New Mexico Environmental Improvement Division (now NMED) issued LANL's Hazardous Waste Facility Permit. In March 1990, EPA issued Module VIII to the permit, setting forth procedural requirements for HSWA corrective actions and specifying development of an installation work plan. LANL's environmental restoration project identified 2,124 PRSs, consisting of 1,099 PRSs that EPA listed in the Hazardous Waste Facility Permit and 1,025 PRSs not listed in the permit. Through 1995, EPA had sole authority over HSWA corrective actions at LANL. In January 1996, EPA delegated this authority to NMED (LANL 2000b).

LANL staff grouped the PRSs into 24 operable units (LANL 2000b) and, in the early to mid-1990s, issued RCRA facility investigation (RFI) Work Plans describing the history of activities within each operable unit, potential contaminants and release pathways, and site investigation plans. Site investigations included: installation of borings and wells; sampling of surface soils, vegetation, drainage channel sediments; and subsurface material, including soil vapor; monitoring of surface water and groundwater; and measurement of external radiation and airborne contaminants. The investigations sampled and monitored for radionuclides and nonradiological contaminants, including polychlorinated biphenyls (PCBs), explosives, and organic and inorganic constituents (LANL 2000b).

In December 1997, LANL staff and NMED began to consolidate corrective action sites that were related by contaminant source, geographic location, and potential cumulative risk. In 1999, LANL staff began to use watersheds to identify discrete systems within which multiple, consolidated sites would be investigated, assessed, and remediated (LANL 2000b).

Phase I RFIs have been completed for most of the MDAs and many other PRSs. Additional investigations are ongoing. Since 1993, over 100 voluntary cleanup actions have been conducted (LANL 2002g). Through the end of 2005, 774 units had been approved for no further action, including 146 that had been removed from LANL's Hazardous Waste Facility Permit. Of these, 125 non-HSWA Module sites had previously been approved for no further action by DOE and, under the terms of the Consent Order, the no further action determinations will be re-evaluated by NMED. Based on prior no further action approvals and consolidation of geographically proximate sites, 829 sites remain within LANL's environmental restoration project (LANL 2006h).

I.2.2.2 Consent Order

On May 2, 2002, NMED issued a Determination of Imminent and Substantial Endangerment to Health and the Environment and a draft order compelling investigation and cleanup of environmental contamination. After receiving public comments, NMED revised its Determination and issued a final Compliance Order on November 26, 2002. On behalf of DOE, the U.S. Department of Justice filed a lawsuit challenging the final order. The University of California filed a separate lawsuit. NMED, DOE, the Justice Department, and the University of California entered settlement negotiations that led to a Consent Order to replace the November 2002 Compliance Order.

NMED issued a revised Consent Order for public comment on September 1, 2004. The comment period closed on October 1, 2004. NMED delayed issuance of the final Consent Order until surface water and watershed issues were addressed in a separate Federal Facility Compliance Agreement under the Clean Water Act. The agreement was signed on February 3, 2005. On March 1, 2005, the final Consent Order was entered into by NMED, the State of New Mexico Attorney General, DOE, and the University of California (NMED 2005).

The Consent Order requires LANL-wide investigation and cleanup pursuant to stipulated procedures and schedules (NMED 2004). (Schedules in the Consent Order may be adjusted to account for delays in NMED approvals; or to accommodate requests from DOE or its authorized contractor for time extensions.) Most PRSs contain constituents that are regulated under the Consent Order, as well as radionuclides that are regulated under the Atomic Energy Act. To avoid duplication of completed work, the Consent Order does not apply to those PRSs not listed in Module VIII that received No Further Action decisions from EPA when it had primary regulatory authority.

The Consent Order requires the installation of wells, piezometers, and other subsurface units to provide site characteristic or environmental information; the collection and investigation of sample data; and preparation and submittal of investigative reports for various PRSs. Following the investigation phase for a subject PRS, corrective measures are proposed, authorized, and implemented as needed. If NMED determines that a corrective measure evaluation is needed, a corrective measure evaluation report[3] must be prepared that addresses alternative remedies. NMED will determine the remedy to be implemented, although DOE may propose a remedy. After completing the approved corrective measure, a remedy completion report must be prepared and sent to NMED for approval.

Investigations and PRSs addressed in the Consent Order are summarized in the following sections of this appendix:

- Section I.2.3: Firing Sites and Other PRSs within Testing Hazard Zones
- Section I.2.4: Canyons
- Section I.2.5: Technical Area Investigations

[3] A corrective measure evaluation report essentially corresponds to a RCRA corrective measures study report.

- Section I.2.6: Other SWMUs and Areas of Concern (AOCs), Including Aggregate Areas
- Section I.2.7: Continuing Investigations

MDAs that are not specifically cited in the Consent Order but may be addressed as part of required aggregate area investigations are summarized in Section I.2.8.

I.2.3 Firing Sites and Other PRSs within Testing Hazard Zones

Consent Order Section IV.A.5 addresses firing sites and other PRSs within testing hazard zones. Consent Order Table IV-1 lists SWMUs and AOCs located within designated testing hazard zones. Investigations, and if appropriate, corrective actions must be performed for these SWMUs and AOCs. With some exceptions, investigation and corrective action may be deferred for any SWMU or AOC located within a testing hazard zone and identified in Consent Order Table IV-2. These SWMUs and AOCs need not be included in relevant aggregate area investigation work plans. The deferral may continue until the firing site used to delineate the relevant testing hazard zone is closed, or it is inactive and DOE determines that it is reasonably unlikely to be reactivated (NMED 2005). **Table I–5** lists the 107 nondeferred SWMUs and AOCs (Consent Order Table IV-1), and **Table I–6** lists the 45 deferred SWMUs and AOCs (Consent Order Table IV-2).

Each PRS listed in Table I–5 will be remediated in accordance with the schedule for the aggregate area containing the PRS (see Section I.2.6). Some PRSs listed in these tables may require a significant remediation effort. PRSs of particular interest for this appendix include two firing sites (Firing Sites E-F and R-44) and five MDAs (MDAs F, Z, AA, Y, and AB). Thumbnail descriptions of these PRSs are provided below.

I.2.3.1 Technical Area 15: Firing Site E-F

TA-15 (R Site) is in the center of LANL. Most of TA-15 is encompassed by Threemile Mesa, but Water Canyon transverses the southern site boundary and Potrillo Canyon intersects the main portion of Threemile Mesa, dividing the mesa into two areas (**Figure I–2**) (LANL 1993c).

TA-15 has been used since World War II for explosive testing of nuclear weapons components. Several early firing points are no longer used, and most of their structures have been decommissioned and dismantled (LANL 1993c). Firing Site G was in use by 1949, and is listed in the Consent Order as a deferred site (Table I–6). Areas R-40, R-183, and The Hollow contain office buildings. Firing Sites R-44 and R-45 were built in the 1950s (LANL 1993c). R-41 is a container storage area. The Pulsed High-Energy Radiographic Machine Emitting X-Rays (PHERMEX) facility was completed in the 1960s. A second radiographic machine, Ector, was installed in the early 1980s (LANL 1993c).[4]

[4] *A newer facility, the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility, is not shown on Figure I–2 but is located near PHERMEX.*

Table I–5 Non-Deferred Sites Within Testing Hazard Zones

Site Identification	Description	Site Identification	Description
06-005	Firing site pit	15-009(e)	Septic system
06-007(a)	MDA F	15-009(g)	Septic system (active)
06-007(b)	MDA F	15-009(h)	Septic tank
06-007(c)	MDA F	15-009(i)	Septic tank
06-007(d)	MDA F	15-010(c)	Drain line
06-007(e)	MDA F	15-014(l)	Outfall (active)
06-008	Underground storage tank	C-15-001	Surface disposal
07-001(a)	Firing site	C-15-004	Transformers
07-007(b)	Firing site	C-15-011	Former site of underground tank
11-005(a)	Septic system	C-15-013	Underground fuel tank
11-005(b)	Septic system	18-001(a)	Lagoon
11-005(c)	Outfall	27-002	Firing sites
11-006(a)	Sump	27-003	Bazooka impact area
11-006(b)	Tank and/or associated equipment	36-001	MDA AA
11-006(c)	Tank and/or associated equipment	36-002	Sump
11-006(d)	Tank and/or associated equipment	36-003(a)	Septic system
11-011(a)	Industrial or sanitary wastewater treatment	36-003(b)	Septic system
11-011(b)	Industrial or sanitary wastewater treatment	36-004(c)	Firing site – open detonation (active)
11-011(d)	Industrial or sanitary wastewater treatment	36-005	Surface disposal site
C-11-002	Footprint of former laboratory	36-006	Surface disposal site
C-12-001	Footprint of former building	36-008	Surface disposal site
C-12-002	Footprint of former building	C-36-003	Storm drainages
C-12-003	Footprint of former building	37-001	Septic system
C-12-004	Footprint of former building	39-001(b)	MDA Y
14-001(g)	Firing site – Open burn/open detonation (active)	39-002(b)	Storage area
14-002(c)	Building	39-002(c)	Storage area
14-002(f)	Footprint of former junction box shelter	39-002(d)	Storage area
14-003	Open burning ground	39-002(f)	Storage area
14-005	Open burn site (active)	39-004(c)	Firing Site 39-6 (active) – open detonation RCRA unit
14-006	Tank and/or associated equipment	39-004(d)	Firing Site 39-57 (active) – open detonation RCRA unit
14-007	Septic system	39-007(a)	Storage area
14-009	Surface disposal site	39-007(d)	Storage area
14-010	Sump	39-008	Former building footprint (soil contamination)
C-14-001	Footprint of former building	39-010	Excavated soil dump
C-14-003	Footprint of former building	40-001(b)	Septic system
C-14-004	Footprint of former building	40-001(c)	Septic system
C-14-005	Footprint of former building	40-003(a)	Scrap burn site/open detonation (completed RCRA closure)
C-14-006	Footprint of former building	40-003(b)	Burning area (completed RCRA closure)
C-14-007	Footprint of former building	40-004	Operational release
C-14-008	Footprint of former building	40-005	Sump
C-14-009	Footprint of former building	40-009	Landfill
15-001	Surface disposal	40-010	Surface disposal site
15-004(f)	Firing Site E-F	49-001(a)	MDA AB
15-004(h)	Firing Site H	49-001(b)	MDA AB
15-005(c)	Container storage area (R-41)	49-001(c)	MDA AB

Site Identification	Description	Site Identification	Description
15-007(b)	MDA Z	49-001(d)	MDA AB
15-007(c)	Firing site shaft	49-001(e)	MDA AB
15-007(d)	Firing site shaft	49-001(g)	MDA AB
15-008(a)	Surface disposal at E-F site	49-002	Underground chamber
15-008(b)	Surface disposal	49-003	Leach field and small-shot area
15-008(c)	Surface disposal	49-005(a)	Landfill
15-008(g)	Surface disposal	49-006	Sump
15-009(b)	Septic system	49-008(d)	Firing sites and underground chamber
15-009(c)	Septic tank		

MDA = material disposal area, RCRA = Resource Conservation and Recovery Act.
Source: NMED 2005.

Table I–6 Deferred Sites in Testing Hazard Zones

Site Identification	Description	Site Identification	Description
06-003(a)	Firing site	14-002(b)	Firing site
06-003(h)	Firing site	15-003	Firing site
C-06-019	Footprint of former structure	15-004(a)	Firing site
07-001(c)	Firing site	15-004(g)	Firing site
07-001(d)	Firing site	15-006(a)	Firing site
11-001(a)	Firing site	15-006(b)	Firing site
11-001(b)	Firing site	15-006(c)	Firing site
11-002	Burn site	15-006(d)	Firing site
11-003(b)	Air gun	15-008(f)	Firing site
11-004(a)	Firing site	36-004(a)	Firing site
11-004(b)	Firing site	36-004(b)	Firing site
11-004(c)	Firing site	36-004(d)	Firing site
11-004(d)	Firing site	36-004(e)	Firing site
11-004(e)	Firing site	39-004(a)	Firing site
11-004(f)	Firing site	39-004(b)	Firing site
11-009	MDA S	39-004(e)	Firing site
11-012(c)	Footprint of former building	40-006(a)	Firing site
11-012(d)	Footprint of former laboratory	40-006(b)	Firing site
C-11-001	Footprint of former laboratory	40-006(c)	Firing site
14-001(f)	Firing site	49-008(a)	Soil contamination
14-002(a)	Firing site	49-008(b)	Soil contamination (Area 6)
14-002(d)	Firing site	49-008(c)	Soil contamination
14-002(e)	Firing site		

MDA = material disposal area.
Source: NMED 2005.

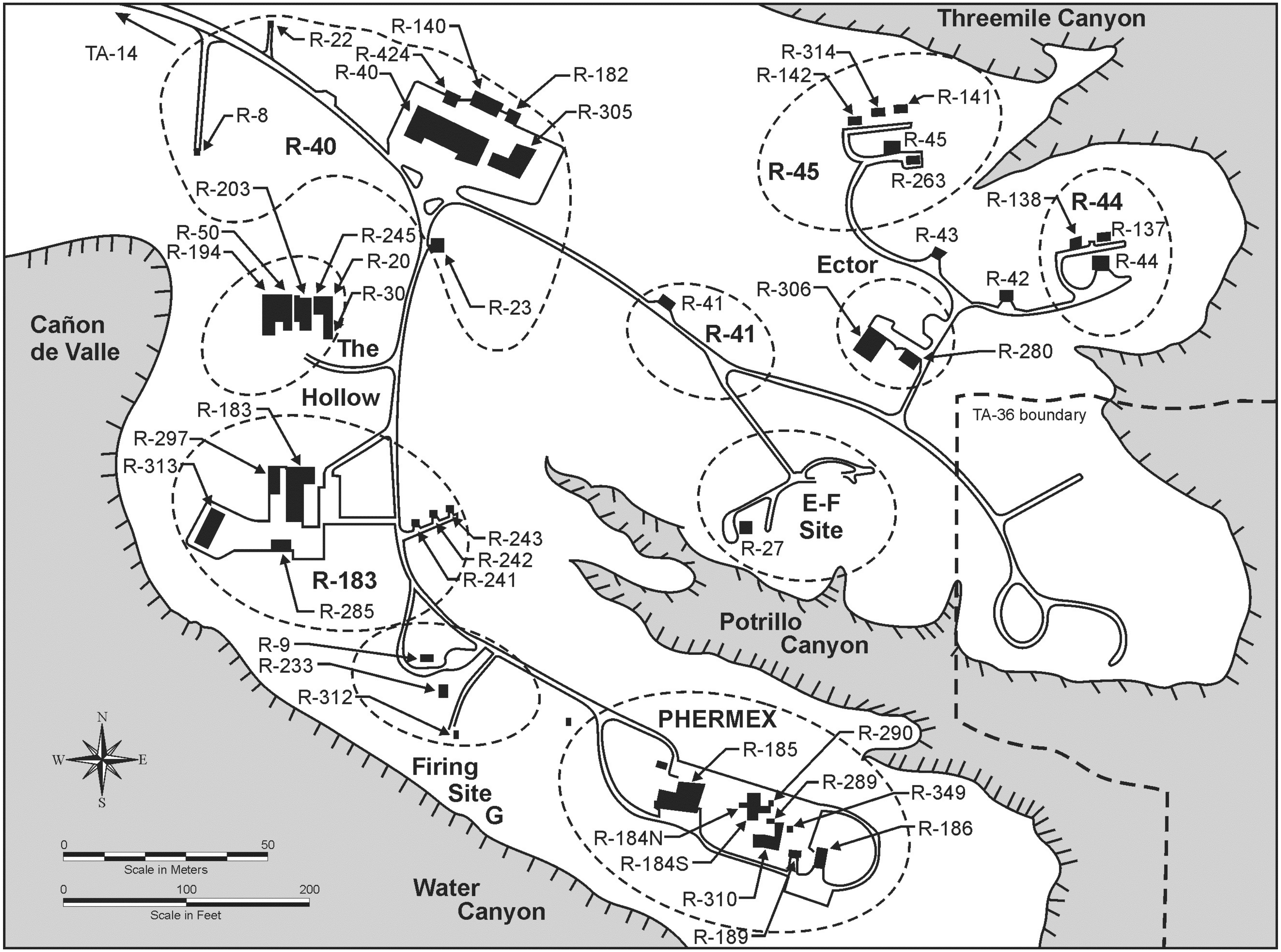

Figure I–2 Technical Area 15 Firing Sites and Other Facilities

The E-F Site (Consolidated Unit 15-004(f)-99) is north of Potrillo Canyon and southeast of Ector. It includes the firing site (SWMU 15-004(f)), a surface disposal area (SWMU 15-008(a)), a septic system (SWMU 15-009(e)), and the site of a removed transformer station (C-15-004) (LANL 1993c). The septic system has been recommended for no further action (LANL 2005c).

History of Firing Site E-F. Firing Site E-F was created in 1947, possibly from an earlier firing point. Firing Site E is larger and about 800 feet (244 meters) from Firing Site F. Firing Sites E and F were both connected to an underground, timbered, control room (Building TA-15-27, or R-27) 600 feet (183 meters) to the southwest of Firing Site E (LANL 1993c). The sites were used extensively through 1973 and were last used in 1981. Firing Sites E and F were once merely surface depressions. As testing progressed, soil was either regraded to the previous depression level or new gravel was imported to fill holes. Eventually, soil was mounded to the north and south to protect buildings from shrapnel. No major effort was made to remove the scattered materials, although, after each explosion, test debris and obvious pieces of uranium metal were recovered. Between 1945 and 1957, 95,000 pounds (43,000 kilograms) of natural uranium metal was expended. After 1957, 44,000 pounds (20,000 kilograms) of depleted uranium was expended (LANL 1993c).

Two small surface-disposal areas (SWMU 12-008), 200 feet (61 meters) apart, are south of Firing Site E-F. The areas contain mounded rubble (LANL 1993c).

Waste Inventory. Up to 139,000 pounds (63,000 kilograms) of natural and depleted uranium may have been expended. Shrapnel or other pieces of uranium may have scattered up to 3,500 feet (1,070 meters) from the firing site, although most debris deposited within 1,000 feet (305 meters). Much of the uranium has oxidized. About 705 pounds (320 kilograms) of beryllium metal was scattered, and much of this metal has oxidized. Other toxic metals include lead (about 220 pounds [100 kilograms]), mercury (less than 220 pounds [100 kilograms]), bismuth, copper, cobalt, nickel, tin, and thorium. Little high explosive (HE) probably survived the tests (LANL 1993c).

The two disposal areas south of Firing Site E-F include metal pieces, soil, plastic, rock, pebbles, electrical cable, electrical accessories, and miscellaneous debris. Potential contaminants include uranium, beryllium, lead, and mercury (LANL 2005c).

Site Investigations. Studies since the late 1970s have shown extensive uranium contamination, varying from concentrations exceeding 4,500 milligrams per kilogram at the firing point to less than 200 milligrams per kilogram 980 feet (300 meters) away. Soil samples collected in 1980 showed an order of magnitude decrease in uranium concentrations within the top 10 to 12 inches (25 to 30 centimeters) of soil, although the trend was not uniform (LANL 1993c). In 1994, numerous surface and subsurface samples were collected as part of a Phase I RFI. Contaminants included uranium, protactinium-234m, thorium-234, americium-241, cesium-137, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and zinc. Similar radionuclides and inorganic chemicals were found at the surface disposal site (LANL 2005c).

Current Configuration. Firing Site E-F is wooded. Scattered debris includes chunks of oxidized metal. The two piles of debris in the surface disposal area are each 8 feet (2.4 meters) in diameter and 2 feet (0.6 meters) high (LANL 2005c).

I.2.3.2 Firing Site R-44

Firing Site R-44 (Consolidated Unit 15-006(c)-99) is near Firing Site E-F (Figure I–2) (LANL 1993c, 2001f) and includes the firing site itself (SWMU 15-006(c)), the septic system associated with the R-44 site (SWMU 15-009(c)), and a surface disposal area (SWMU 15-008(b)). The firing site itself is listed as a deferred site (Table I–6).

History of Firing Site R-44. Named after the site control room, R-44 was built in 1951 and used from 1956 through 1978 for tests of weapons components. But since PHERMEX and Ector were put into operation, the site was used less and for small experiments. R-44 was last used in September 1992. From 1953 to 1978, 15,000 pounds (7,000 kilograms) of uranium (mostly depleted uranium), 770 pounds (350 kilograms) of beryllium, and 33 pounds (15 kilograms) of lead were expended. Debris scattered into the canyons on either side of the firing site. The surface disposal area comprises two small areas at the edge of Threemile Canyon containing pieces of metal and plastic, soil, rocks and pebbles, electrical cable, other electrical accessories, and other debris (LANL 1993c).

Waste Inventory. An aerial radiological survey suggested that in 1982, the amount of uranium in the soil at R-44 was about four percent of that at Firing Site E-F, or about 5,070 pounds (2,300 kilograms) (LANL 1993c). A 1991 land-based radiological survey found pieces of uranium near the firing site. The area was partially remediated. In 1987, samples were collected at four radial distances (10, 100, 250, and 450 feet [3, 30, 76, and 137 meters]) from the center of the firing site. High explosives were not detected. Concentrations of lead, beryllium, and uranium-238 at 450 feet (137 meters) were all more than a magnitude smaller than those in the center. Average soil background levels were 28.4 milligrams per kilogram for lead, 2.4 milligrams per kilogram for beryllium, and 3.4 milligrams per kilogram for uranium (LANL 1993c).

The 1993 RFI Work Plan for Operable Unit 1086 estimated that the volume of piled debris in the surface disposal area amounted to a few dump truck loads. At least 80 percent was contaminated with uranium, beryllium, and lead (LANL 1993c).

Site Investigations. The Phase I RFI for the firing site (June 1995 through March 1996) found uranium, beryllium, lead, arsenic, and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). The Phase I RFI for the surface disposal area found uranium and inorganic chemicals, including antimony, arsenic, beryllium, chromium, copper, lead, mercury, nickel, silver, and zinc (LANL 2005c).

Current Configuration. The Cerro Grande Fire damaged the firing site, which is wooded with ponderosa pine. Debris was exposed throughout the site, mainly toward the east. Within a year, straw wattles, rock check dams, and silt fencing were installed and the area was hydromulched. Sediment migration was minimal. A year after the fire, the site had a vegetative cover greater than 70 percent (LANL 2001f). Much of the exposed debris was recovered and disposed of.

I.2.3.3 Technical Area 6: Material Disposal Area F

TA-6 (Twomile Mesa Site) is on Twomile Mesa, which is bordered to the north by Twomile Canyon and to the south by Pajarito Canyon. During the Manhattan Project, TA-6 was used to test explosive detonators for the Fat Man weapon; to purify the explosive pentaerythritol tetranitrate (PETN), used to achieve implosion; and to destroy shaped explosive charges called lenses. After the war, MDA F was created to dispose of classified objects. Test firing continued at TA-6 until 1952. Explosives development, laser, chemical laboratory, and photographic operations continued through February 1976, and several small operations continued until the 1980s (LANL 1993g).

History of MDA F. MDA F is a small site to the north of Twomile Mesa Road. MDA F is at an elevation of 7,460 feet (2,274 meters). Runoff flows north to the southwest fork of Twomile Canyon, which is part of the Pajarito Canyon Watershed (LANL 1999b).

A May 15, 1946, memorandum from the Director of Los Alamos Scientific Laboratory, N. E. Bradbury, announced preparation of a pit for disposal of classified objects and shapes. The memorandum stated that the pit was located at TD Site, but a penciled correction indicated Twomile Mesa (Rogers 1977). A second pit was dug in 1947 in accordance with a July 16, 1947, memorandum from Bradbury. The locations of these two pits were not recorded on contemporary documents (LANL 1993g).

From 1949 through 1951, work orders were written for three smaller pits on Twomile Mesa (LANL 1993g):

- 1949 – A pit 40 by 20 by 10 feet deep (12 by 6.1 by 3.0 meters)
- 1950 – A pit 6 by 6 x 6 feet deep (1.8 by 1.8 by 1.8 meters)
- 1951 – A pit 2 by 2 by 4 feet deep (0.6 by 0.6 by 1.2 meters)

The locations of these pits are unknown, as are their as-built dimensions and contents.

From 1950 to 1952, three shafts may have been drilled to dispose of spark gaps containing cesium-137. None of the shafts correlates with archived job and work orders (LANL 1993g). Arial photographs from 1954 show two large disturbed areas that may be the two pits referenced in the Bradbury memoranda (LANL 1993g). The two chain-link fences at MDA F were erected in 1981. The smaller fenced area basically corresponds to the disturbed areas on aerial photographs, but the larger fenced area is mostly north of the larger pits.

Waste Inventory. The inventory is poorly known. MDA F was used for disposal of classified items. Spark gaps containing cesium-137 were probably buried. In 1964, the total estimated amount of cesium-137 was 30 microcuries. Other hazardous materials may have been placed in the pits (LANL 1993g).

The pits may contain explosives. This concern was prompted by a statement from a person responsible for digging the 1946 pit that “large blocks of HE, Primacord, etc.” were placed in the pit (LANL 1993g). Yet later this individual stated that no hazardous materials were buried, and that burial was not the accepted practice for disposal of explosives (LANL 1993g). The RFI Work Plan for Operable Unit 1111 found no primary sources stating that explosives were buried. All reports of squibs, detonators, depleted uranium, and strontium-90 buried in pits at MDA F were from secondary sources (LANL 1993g).

Current Configuration. MDA F comprises a small area encompassed by, and in the vicinity of, a pair of fenced areas (**Figure I–3**). Southeast of MDA F are depressions that may have resulted from explosive destruction of defective lenses for the Fat Man weapon in 1945 (LANL 1993g, 1999b). Some of these lenses contained Baratol, which contains barium nitrate and 2,4,6-trinitrotoluene (TNT) (LANL 1999b). West of MDA F is the "timbered pit" that may have been used for test firing Jumbino vessels.[5] A 1944 progress report contains a photograph of a Jumbino in a pit, and a 1986 geophysical survey located an anomaly in this area (LANL 1993g). Aerial photography and satellite imagery in 2000 suggested two long, narrow trenches and six small pits in the vicinity of the two fenced areas (Pope et al. 2000). One pit may be the timbered pit.

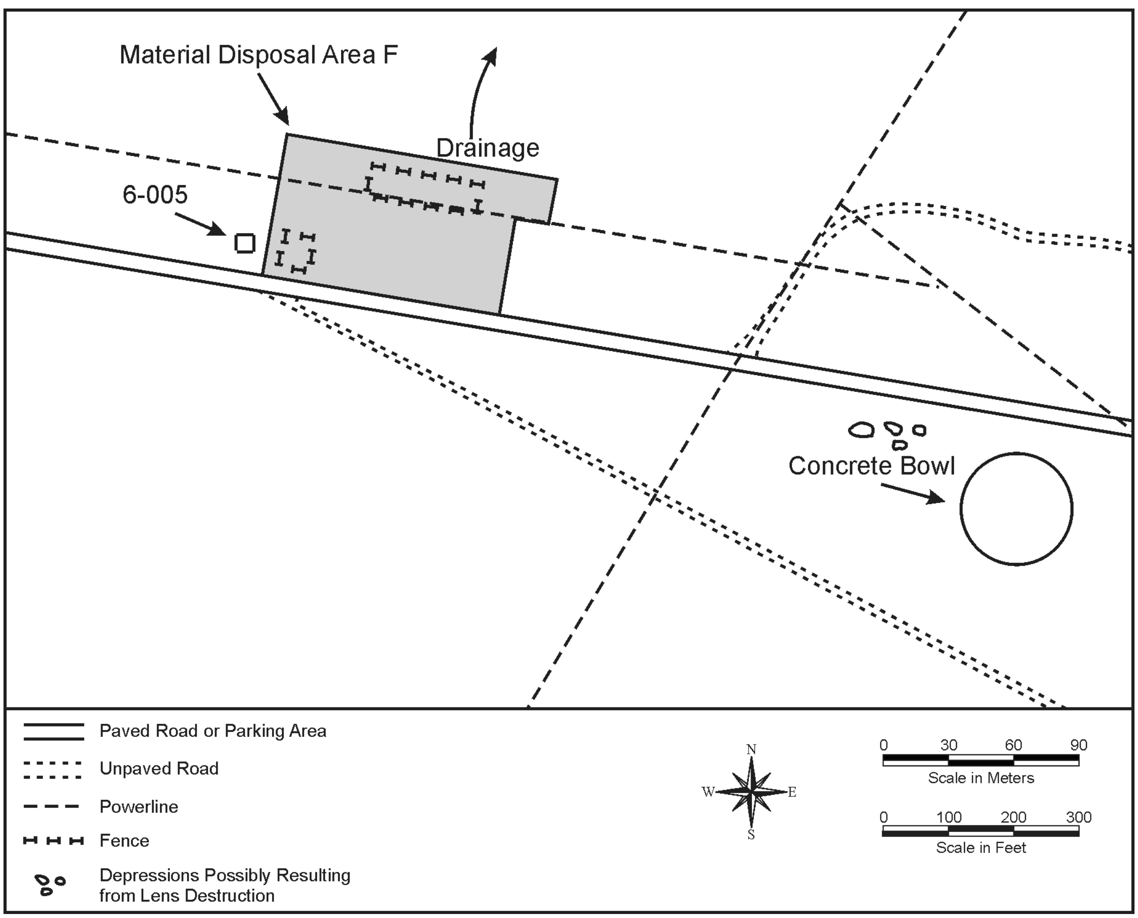

Figure I–3 Material Disposal Area F

[5] A Jumbino is a stainless steel vessel used to test methods for containment and recovery of fissionable materials such as plutonium from explosives implosion tests. Recovery was needed because of the very limited supply of the fissionable materials. From 1944 tests involving Jumbino vessels, Los Alamos scientists constructed a much larger vessel called Jumbo for containment of the Trinity Test. Jumbo was never used for this purpose because by 1945 plutonium availability was much greater (LANL 1993b).

The site was contoured and reseeded with native grasses in 1996. The MDA vicinity is dotted with scrub oak (Pope et al. 2000). A power line crosses the site in an east-west direction.

Waste management units are:

- SWMU 6-005 – the timbered pit to the west of the smaller fenced area
- SWMU 6-007(a) – the pair of fenced areas
- SWMU 6-007(b) – the pit from the 1940s photographs
- SWMUs 6-007(c and d) – the two pits described by the 1946 and 1947 Bradbury memoranda
- SWMU 6-007(e) – additional pits that may exist at MDA F

Site Investigations. The areas inside the fences have been monitored for radioactivity since 1981. No readings above background have been observed (LANL 1999b). According to the 1993 RFI Work Plan for Operable Unit 1111 (LANL 1993g), vegetation at MDA F was sampled in 1981 and 1983 for radioactive contaminants; none were found. In 1986, a site survey was performed using ground-penetrating radar and magnetometry. Survey data were difficult to interpret. The Phase I RFI for MDA F was to determine: (1) pit boundaries, (2) whether contaminants of concern were present in media surrounding the pits, and (3) whether barium and TNT were in surface soils south and east of MDA F (LANL 1993g). Aerial photography and satellite imagery were conducted in 2000 to help locate the disposal unit positions.

I.2.3.4 Technical Area 15: Material Disposal Area Z

MDA Z (SWMU 15-007(b)) is south of the side road leading to Building TA-15-233 near Firing Site G. MDA Z is teardrop-shaped and measures 200 feet (60 meters) by 50 feet (15 meters) at its widest. The MDA was used between 1965 and 1981 for disposal of construction debris. The waste was placed in a natural depression. (Concrete-filled sandbags at the site were probably piled as a retaining wall.) One face of the MDA grades to native soil; the other face is exposed, standing 15 feet (4.6 meters) high. The debris on the exposed face was probably bulldozed from PHERMEX and includes metals from wire and blast mats, volatile organic compounds or semi-volatile organic compounds from charred wood, road and construction debris, and radioactive substances (LANL 1993c, 1999b). One reference states that chunks of uranium are visible (LANL 1999b), although a 1982 aerial radiological survey detected no radioactive contamination above background values (LANL 1993c).

A Phase I RFI conducted from June 1995 to March 1996 collected surface and subsurface samples. Inorganic chemicals found above background values were beryllium, copper, lead, mercury, and silver. Uranium was found with a maximum concentration of 349 milligrams per kilogram. Twelve organic chemicals were found. The RFI report recommended material removal following a baseline ecological risk assessment (LANL 2005c).

I.2.3.5 Technical Area 36: Material Disposal Area AA

Located in the southeastern portion of LANL, TA-36 (Kappa Site) has four active firing sites.

MDA AA (SWMU 36-001) is within Potrillo Canyon. MDA AA is near the active Lower Slobbovia firing range (SWMU 36-004(d)) and consists of two to four disposal trenches used to burn and dispose of debris and sand from firing sites. The trenches likely contain wood, nails, and sand contaminated with barium, uranium, other inorganic chemicals, plastics, and possibly high explosive. When a trench became filled with waste, it was covered with 4 feet (1.2 meters) of soil. The first trench was dug in the mid-1960s, and the site was closed in 1989 in accordance with New Mexico solid waste regulations.[6] The MDA AA trench area was graded to lessen the potential for stormwater runon. Samples taken from the last active trench in 1987 and 1988 showed elevated levels of cadmium and uranium (LANL 1993a, 1999b, 2005c).

A Phase I RFI was conducted from 1993 through 1995. Two trenches were identified: the northern trench is 80 by 40 by 8 to 13 feet deep (24 by 12 by 2.4 to 4.0 meters deep); the southern trench is 120 by 20 to 30 by 3 to 12 feet deep (37 by 6.1 to 9.1 by 0.9 to 3.7 meters deep). Boreholes into the trenches were sampled for inorganic and organic chemicals and radionuclides. The RFI report recommended no further action. NMED disagreed. A Phase II sampling and analysis program was planned. In 1996, an interim action stabilized erosion gullies using wire mesh and cobbles (LANL 2005c).

I.2.3.6 Technical Area 39: Material Disposal Area Y

TA-39 (Ancho Canyon Site) is at the bottom of Ancho Canyon between Los Alamos and White Rock. MDA Y (SWMU 39-001(b)) is part of Consolidated Unit 39-001(b)-00 consisting of SWMUs 39-008 and 39-001(b) (LANL 1999b, 2005c).

SWMU 39-008 is a former firing range. Testing began in 1960, continued until 1975, was suspended for 13 years, and resumed in 1988. Building 39-137 housed a gun using gas to fire projectiles at targets on a cliff face. Most debris from this and other gas gun experiments lies in an area west of the building, but projectiles and target fragments occasionally hit the cliff face 200 feet (61 meters) west of Building 39-56. The area between the buildings and the cliff was leveled and surface materials pushed into a mound. A 1977 RFI report, later withdrawn, recommended deferring action on SWMU 39-008 because it was still active. However, SWMU 39-008 is a nondeferred site in the Consent Order, where it is described as soil contamination associated with a former building footprint (see Table I–5) (LANL 2005c).

SWMU 39-001(b) (MDA Y) consists of three pits that, beginning in the late 1960s, received debris from the firing range (SWMU 39-008), empty chemical containers, and office waste (LANL 1999b, 2005c). The RFI Work Plan for Operable Unit 1132 indicates that the first pit measured 148 by 20 by 12 feet deep (45 by 6.1 by 3.7 meters deep); the second pit next to and west of the first pit had the same dimensions, and the third pit was south of the other pits (LANL 1993b). Figure 5–3 of this reference suggests that the first two pits were 40 feet (12 meters) apart. The third pit is depicted as being about twice as long as the first two pits but

[6] *A permitted burn area west of MDA AA is still used to burn combustible firing site debris (LANL 1999a).*

about as wide. Pit 1 may have been surveyed and dug in 1973; Pit 2 was in use from about 1976 to 1981; and Pit 3 from 1981 to 1989 (LANL 1993b).

The most probable locations of the pits were estimated from geophysical surveys, historical information, and radiation surveys. In 1994, two separate field activities investigated whether waste constituents had migrated from the pits. The 1994 field activities guided RFI sampling conducted in 1996. Test pits were trenched to below 12 feet (3.7 meters), the approximate depth of waste burial. The 1994 and 1996 field activity results were summarized in an RFI report that was later withdrawn (LANL 2005c).

I.2.3.7 Technical Area 49: Material Disposal Area AB

PRSs associated with MDA AB are addressed in Section I.2.5.3.

I.2.4 Canyons

The Consent Order requires investigations within canyon watersheds in accordance with approved work plans.[7] The Consent Order requires construction of new wells, abandonment of some existing wells, and environmental sampling. Newly constructed wells must include alluvial, intermediate, and regional aquifer wells in the following watersheds (NMED 2005):

- Los Alamos/Pueblo Canyons Watershed
- Mortandad Canyon Watershed
- Water Canyon/Cañon de Valle Watershed
- Pajarito Canyon Watershed
- Sandia Canyon Watershed
- Other canyons (Ancho, Chaquehui, Indio, Potrillo, Fence, and North Canyons [Bayo, Guaje, Barrancas, and Rendija])

These wells would supplement existing wells. The numbers and locations of the wells, however, will be defined in approved work plans and may be different from numbers and locations identified in the Consent Order.

Canyon investigations implemented in 2005 focused primarily on Mortandad Canyon, and involved the characterization of sediment, biota, and groundwater to determine the nature and extent of contamination in media and to collect sufficient data to perform human and ecological risk assessments. Additional investigations in Pajarito Canyon were focused on sediment characterization to evaluate the nature and extent of contamination and the distribution of contaminant inventory (LANL 2006h).

[7] *At the time of Consent Order issuance, some canyon work plans had already been submitted to NMED while others were still under development.*

The canyon investigation results may lead, as approved by NMED, to corrective measure programs. The scope of any remediation program for any watershed cannot be fully defined at this time. However, potential remediation alternatives could range from no action to more significant activities such as installation of additional shallow and deep groundwater monitoring wells, vadose zone monitoring systems, in situ bioremediation, permeable reactive barriers, or groundwater pump-and-treat systems. The more complex and involved remedies might require staging areas and moderate augmentation of infrastructure (such as plumbing for extracted water or other wastes) to support remedy operational aspects.

I.2.5 Technical Area Investigations

Requirements for TAs are typically prescribed for individual MDAs. (An exception is the investigative program prescribed for the Bayo Canyon Site, which consists of several PRSs but no MDAs.) Investigations for each MDA must be conducted in accordance with approved work plans and may include disposal unit surveys, drilling explorations, soil and rock sampling, sediment sampling, vapor monitoring and sampling (if present or discovered), intermediate and regional aquifer groundwater well installation, and groundwater monitoring.

I.2.5.1 Technical Area 10: Bayo Canyon Site

The Bayo Canyon Site (former TA-10) is in Bayo Canyon next to the western boundary of TA-74 and 4 miles (6.4 kilometers) west of the intersection of Bayo and Los Alamos Canyons. From 1943 to 1961, tests were conducted for nuclear weapons development. The Radiochemistry Laboratory, Building TA-10-1, prepared radiation sources for blast diagnostics. Explosives dispersed aerosols and debris containing uranium, lanthanum, and strontium-90. Liquid wastes were discharged to Bayo Canyon (NMED 2005). Bayo Canyon PRSs were investigated in accordance with the RFI Work Plan for Operable Unit 1079 (LANL 1992d). They include: (1) Consolidated Unit 10-001(a)-99; (2) Consolidated Unit 10-002(a)-99; (3) SWMU 10-004(a); (4) SWMU 10-006; and (5) AOC 10-009. The Consent Order requires additional investigations in accordance with the Bayo Canyon Aggregate Area Investigation Work Plan (NMED 2005). The work plan was submitted to NMED by the July 30, 2005, deadline, as was the required Historical Investigation Report for Bayo Canyon (LANL 2005m).

I.2.5.2 Technical Area 21: Material Disposal Areas A, B, T, and U

TA-21 (DP Site) is on DP Mesa east-southeast of the Los Alamos township. From 1945 to 1978, TA-21 was used for chemical research and for plutonium and uranium metal production (LANL 1999b, 2002a). DP West was used for radioactive-materials processing. Operations ceased in the 1980s, although process buildings remained until decommissioning began in the 1990s. DP East includes the Tritium Science and Fabrication Facility and the Tritium Systems Test Assembly (DOE 1999a). Operations will be relocated and structures decommissioned as addressed in Appendix H, Section H.2, of this SWEIS.

MDAs A, B, T, U, and V within TA-21 are shown in **Figure I–4** (LANL 2005b). The complex of structures to the east of MDA A is DP East, while the complex of structures to the west of MDA A is DP West. MDA V within TA-21 has been removed.

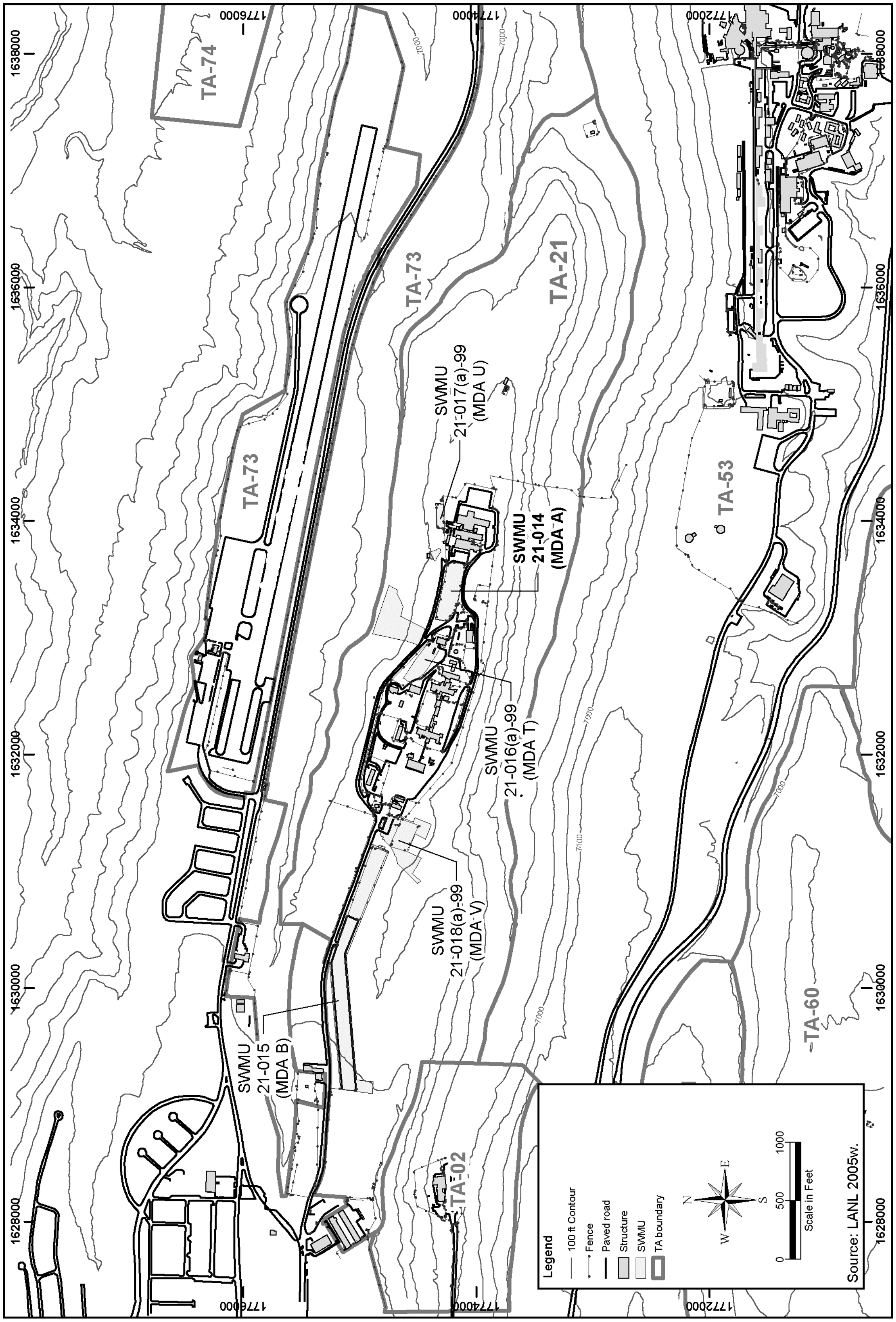

Figure I–4 MDAs A, B, T, U, and V within TA-21

I.2.5.2.1 Material Disposal Area A

MDA A (SWMU 21-014) is on a site covering 1.25 acres (0.51 hectare) between DP West and DP East.

History of MDA A. In 1945, two disposal pits were dug at the east end of the MDA, and two underground tanks ("General's Tanks") for liquid waste storage were emplaced at the west end. During 1969, a large pit in the center of the MDA was dug for demolition debris (**Figure I–5**) (LANL 1991).

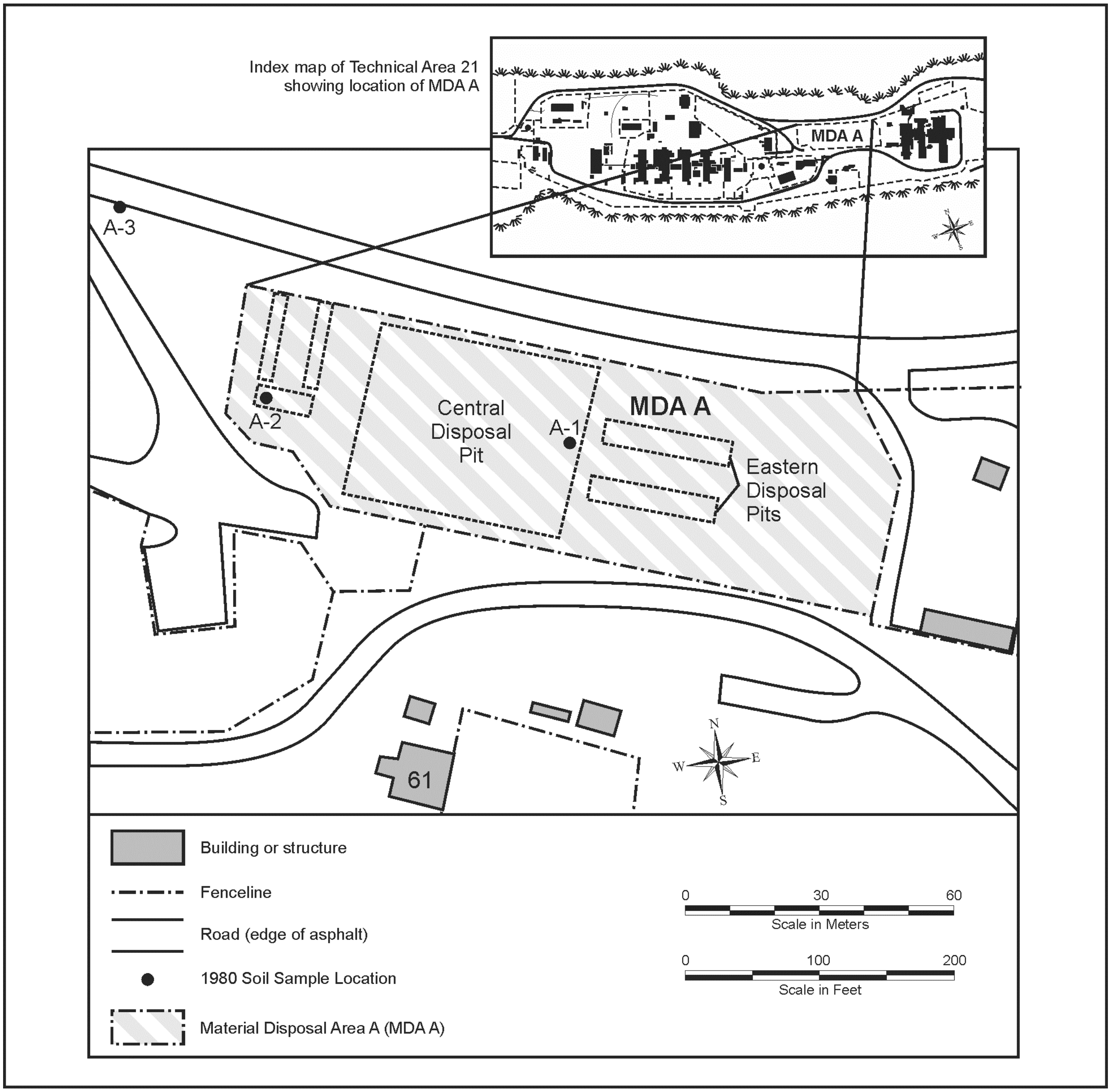

Figure I–5 Material Disposal Area A

Eastern Pits. Contemporary engineering drawings depict four pits. Yet only two pits were built, based on later engineering drawings showing pits roughly 15 feet (4.6 meters) wide at the top and 12 feet (3.7 meters) deep, as well as other documentation (Rogers 1977, LANL 1991). The MDA Core Document (LANL 1999b) states that the pits were 13 feet (4 meters) deep and received 36,000 cubic feet (1,020 cubic meters) of "solid wastes with alpha contamination accompanied by small amounts of beta and gamma" (Rogers 1977). The work plan for TA-21 states that the pits received "laboratory equipment, building construction material, paper, rubber gloves, filters from air cleaning systems, and contaminated or toxic chemicals." The possibility exists that "plutonium, polonium, uranium, americium, curium, Radium-Lanthanum [sic], actinium, and waste products from the Water Boiler" were present in the waste. "Polonium and plutonium-239 and plutonium-240 were also thought to be the major contaminants in the waste" (LANL 1991).

During the early 1950s, several 55-gallon (208-liter) drums were stored at the east end of the MDA containing a solution of sodium hydroxide and stable iodine used to scrub ventilation air containing plutonium and possibly uranium. The liquid volume and its chemical content are unknown. Drum corrosion released some of the solution to surface soil. The drums were removed in 1960 and the storage area paved (LANL 1999b).

General's Tanks. In 1945, two 50,000-gallon (189,000-liter) steel tanks (named after General Leslie Groves) were buried on the west end of the MDA to store solutions containing plutonium-239 and plutonium-240 (LANL 1999b). The tanks are shown in **Figure I–6** and described below (Rogers 1977):

> The tanks are 12 feet (3.7 meters) in diameter and 62 feet-10 inches (19.1 meters) long. They were placed 20 feet (6.1 meters) apart in pits 12 feet (3.7 meters) deep, 15 feet (4.6 meters) wide, and probably 86 feet 10 inches (21.0 meters) long on four concrete piers. Each pier was 4 feet-10 inches (1.5 meters) high, with the bottom 2 feet (0.6 meters) below the bottom of the pit. Each tank rested on piers 1 foot (0.3 meters) above the bottom of the pit. Sand was placed in the bottom of the pit up to the top of the piers—a depth of 1 foot-10 inches (0.5 meters). Thoroughly packed earth filled the area between the tank and most of the rest of the pit. Directly above the tanks, loose dirt fill was specified. A concrete slab 8 inches (20.3 centimeters) thick, 56 feet (17.1 meters) wide, and 68 feet 10 inches (21 meters) long was poured 1.5 feet (0.5 meters) above the tanks. Approximately 5 feet (1.5 meters) of earth fill was placed above the concrete slab. This final earth fill formed a mound 2.25 to 5.75 feet (0.7 to 1.8 meters) above grade. On the north end of each tank, a vent extended 15 feet (4.6 meters) above the mound. On the south end of each tank, the fill pipe is enclosed in a concrete box with outside dimensions 2 feet-10 inches (0.9 meters) high, 2 feet-10 inches (0.9 meters) wide, and 4 feet-4 inches (1.3 meters) long. The box extended 1 foot (0.3 meter) above the mound.

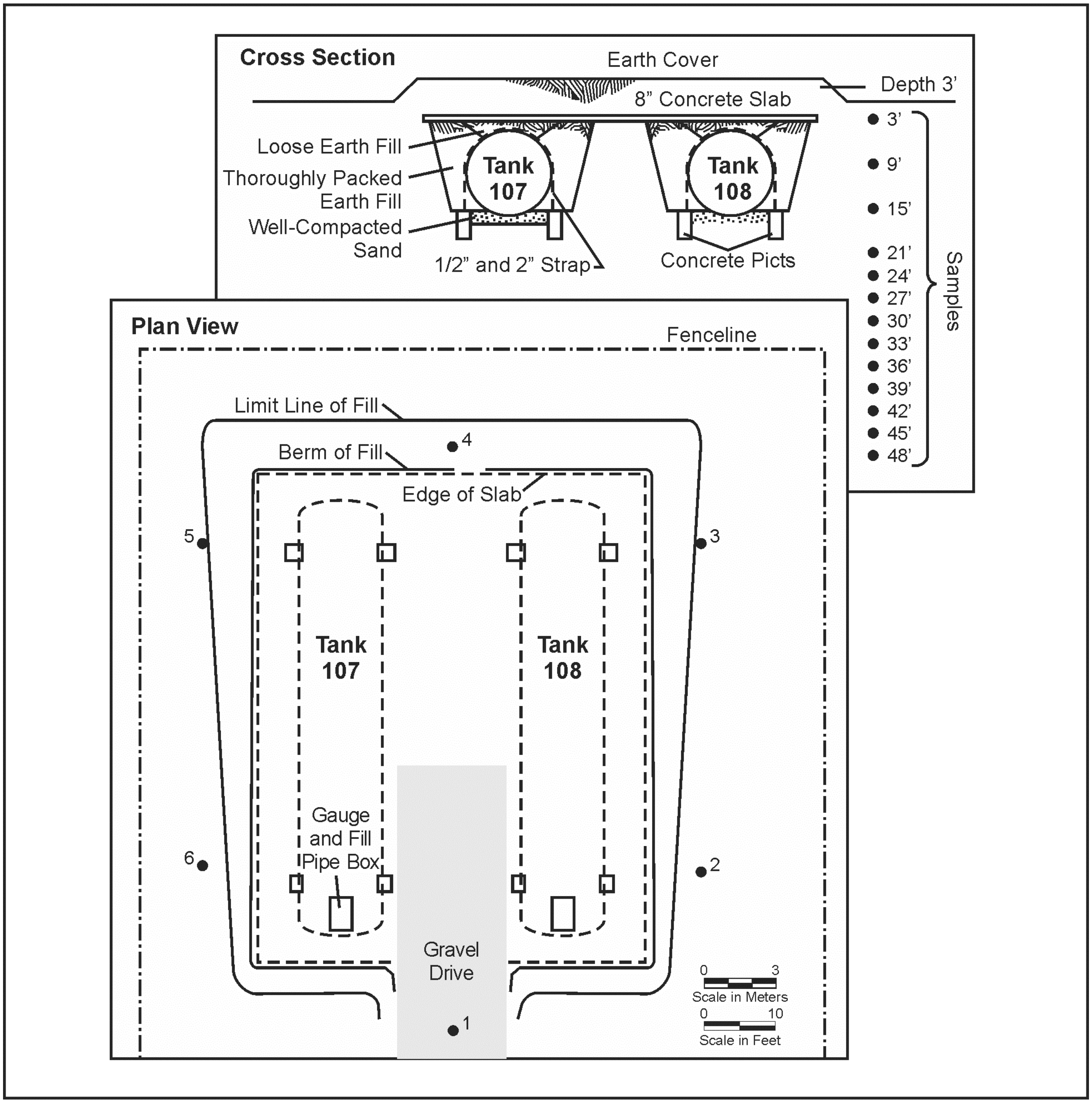

Figure I–6 General's Tanks within Material Disposal Area A

Solutions containing plutonium-239 and plutonium-240 in sodium hydroxide were to be stored until the plutonium could be extracted (LANL 1991, 1999b). But in 1975, the solution was removed, solidified in cement, and buried in MDA A, leaving a residual sludge within the tanks. The solidified waste was subsequently moved to Pit 29 in MDA G, where it is being stored (LANL 1999b). Evidence of rain water entry into the tanks led to the sealing of openings in the top of the tanks in 1985 (LANL 1991).

Central Pit. In 1969, a pit was dug in the center of MDA A to a depth of 22 feet (6.7 meters), leading to a waste capacity of 4,885 cubic yards (3,735 cubic meters). The pit received waste from operations in TA-21. In 1972, the pit was enlarged (but not deepened) to a total capacity of

18,736 cubic yards (14,325 cubic meters). The pit received plutonium-contaminated debris from demolition of a frame and masonry building. Demolition was finished in 1974, after which the remaining portions of the pit were filled with waste. A soil cover was emplaced in May 1978. Radionuclides included plutonium-238, plutonium-239, plutonium-240, uranium-235, depleted uranium, and other isotopes (LANL 1989, 1991).

Waste Inventory. Documentation about waste inventory is limited.

Eastern Pits. Memoranda and other information suggest that the dominant radionuclide contaminants were plutonium-239, plutonium-240, and polonium. The pit may contain small quantities of uranium, americium-241, and other isotopes. The pit and its surroundings may contain residues from the leaking drums of iodine in a sodium hydroxide solution (LANL 1991).

General's Tanks. The 1991 work plan for TA-21 estimated the total tank inventory to be 12 to 25 curies, mostly plutonium-239 and plutonium-240, but including plutonium-241 and americium-241 (LANL 1991).[8] It was estimated that one-third of the activity was americium-241 (Rogers 1977). A more recent report estimates 54.3 curies of plutonium-239, 78.9 curies of plutonium-241, 6.07 curies of americium-241, and small quantities of uranium-235 and plutonium-238 (LANL 2004l). The tanks probably contain metals and solvents (LANL 1991).

Central Pit. This pit probably contains plutonium-238, plutonium-239, plutonium-240, uranium-235, depleted uranium, and other isotopes (Rogers 1977). It is unknown whether the pit contains chemically hazardous wastes (LANL 1991).

Current Configuration. MDA A consists of a fenced grassy area between DP East and DP West, bordered to the north and south by paved roads. Photographs suggest that about 10 to 20 percent of the MDA is paved with asphalt.

Site Investigations. Historical site investigations included surface and subsurface sampling in 1980 and 1984 and a geophysical investigation in 1989. Four test holes were drilled next to the General's Tanks in 1974 and six holes in 1983. Surface soil samples found uranium and plutonium-238, plutonium-239, plutonium-240, above background levels in most of the area over and near the General's Tanks. Limited data suggested elevated uranium levels in vegetation. This contamination was covered after site remediation in 1985 and 1987. Subsurface samples collected in 1974 and 1983 near the General's Tanks to 30-foot (9.1-meter) depths found uranium and plutonium-238, plutonium-239, and plutonium-240, above background levels in most sampling intervals (LANL 1991). The 1989 geophysical investigation used several remote sensing techniques (magnetics, electromagnetics, resistivity, radar, and self-potential) to improve knowledge of pit and trench geometries and to locate other buried material (LANL 1989).

The MDA A Investigation Work Plan required by the Consent Order was submitted to NMED by the January 31, 2005 due date (LANL 2005m, 2005b). The MDA A Investigation Report was completed and submitted to NMED on November 9, 2006.

[8] Having a 13-year half-life, plutonium-241 is formed along with plutonium-239/240 in a nuclear reactor and is essentially inseparable from it. Plutonium-241 decays to americium-241, an isotope having a 458-year half-life (LANL 1991).

I.2.5.2.2 Material Disposal Area B

MDA B (SWMU 21-015) is the largest MDA in TA-21. It is within a narrow site covering 6 acres (2.4 hectares) south of and parallel to DP Road west of MDA V (**Figure I–7**).

History of MDA B. MDA B operated from 1945 to 1948 (LANL 1999b) and received waste from DP East and DP West, including laboratory waste and debris, and probably limited volumes of liquid wastes (LANL 2004d). It also received waste from other areas of LANL. Unlike the practice at other MDAs of layering waste within disposal pits (see MDA C in Section I.2.5.4), the depth and width of the MDA B pits were filled with waste before backfilling. This disposal practice used pit capacity efficiently but led to cover subsidence. After MDA B was closed following a 1948 pit fire[9], subsidence craters were filled with noncontaminated concrete and soil from construction sites (LANL 1991).

The 1948 pit fire was probably caused by spontaneous combustion of mixed chemicals in waste. The fire was intense, lasted an estimated 2 hours, and covered an area of 2,500 square feet (232 square meters) (LANL 1991). MDA B was closed and another disposal site was developed (probably MDA C) that was farther from living and working areas (Rogers 1977). In 1966, the western two-thirds of the MDA was fenced, paved, and leased to Los Alamos County for trailer storage. The storage park has since been closed (LANL 1991).

Work performed in 1982 to stabilize the eastern end of MDA B included moving the fence, decontaminating surfaces, removing vegetation, and covering the area with soil that was compacted and seeded (LANL 1991). In 1984, the eastern portion of MDA B was resurfaced using several different experimental cover systems. The experimental program included field studies of barriers against biological intrusion and erosion (LANL 1986). The current cover features several variations of a nominal 3-foot-thick (1-meter-thick) crushed-tuff cover placed over the original cover (LANL 1999b).

Waste Inventory. Inventory information is largely anecdotal. The following description is from the Historical Investigation Report for the 2004 MDA B Investigation Work Plan (LANL 2004d):

> The principal radioactive contaminants consist of the types of radioactive materials used at the time: plutonium, polonium, uranium, americium, curium, radioactive lanthanum, actinium, and waste products from the water boiler reactor. However, approximately 90 percent of the waste consisted of radioactively contaminated paper, rags, paper gloves, glassware, and small metal apparatuses placed in cardboard boxes by the waste originator and sealed with masking tape. The remainder of the material consisted of metal, including air ducts and large metal apparatuses. The latter type of material was placed in wood boxes or wrapped with paper. At least one truck, contaminated with fission products from the Trinity test, is buried in MDA B.

Limited volumes of liquid waste are believed to have been emplaced in at least one chemical trench in the eastern end of the MDA (LANL 2004d).

[9] A chemical fire also occurred in 1946 that lasted about two hours and was extinguished by bulldozing dirt over the affected area (LANL 2006f).

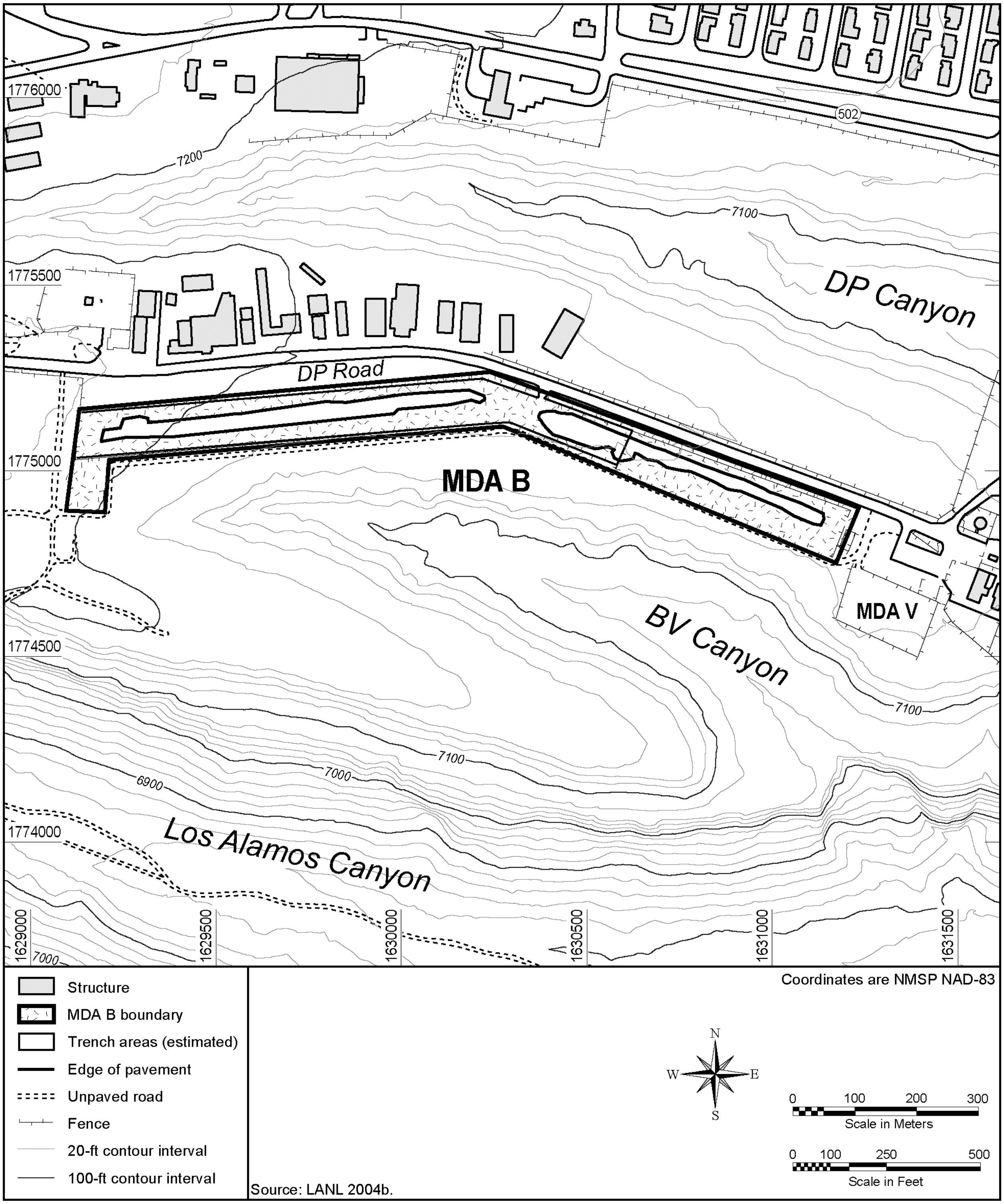

Figure I–7 Material Disposal Area B Incorporating 1998 Geophysical Survey Information

The 1977 report by Rogers (Rogers 1977) references a January 4, 1971, memorandum:

> The total volume of the pits, after deducting the three foot of cover materials, is 28,000 cubic yards. These pits actually contain very little plutonium. At the time they were in use, plutonium was scarce and only that which was present as contamination was buried. (It is estimated) that the entire pit contains no more than 100 grams (6.13 curies) of plutonium-239.

The following summary of nonradioactive wastes is from the MDA B Historical Work Plan (LANL 2004d):

> There are some indications hazardous chemicals may be present at MDA B. Drager, commenting on the 1948 fire, reported there was some evidence chemicals had been disposed of in the dump in an unauthorized manner; that is, in cardboard containers used for the regular disposal of common laboratory waste. In the fire, several cartons of waste caused minor explosions, and on one occasion, a cloud of pink gas arose from the debris in the dump. Documented employee interviews stated chemical disposal occurred at the east end of MDA B. Chemicals disposed of included old bottles of organic chemicals, including perchlorate, ethers, and solvents. The 1987 DOE document also stated lecture bottles, mixtures of spent chemicals, old chemicals, and corrosive gases may be in trench(es) at the east end of MDA B.

Current Configuration. The number of disposal units is uncertain (LANL 1991). A 1977 report estimated at least five pits (Rogers 1977). This reference suggests that four disposal pits were dug parallel to the fence along DP Road and that two pits were dug in the MDA at its western end (Rogers 1977). The RFI Work Plan for TA-21 references a 1964 memorandum stating that a covered shallow trench was at the extreme eastern end of the MDA. Another source indicated that several small slit trenches were dug in the eastern end of the MDA for chemical disposal (LANL 1991). The RFI Work Plan for TA-21 concluded that the MDA likely contained a minimum of four pits plus at least one chemical trench (LANL 1991). The 1991 RFI Work Plan estimated that the disposal trench surface area was 1.1 acres (0.46 hectare), covering 27,780 cubic yards (21,240 cubic meters) of buried waste (LANL 1991).

Geophysical surveys conducted in 1998 (LANL 2004d) found a single primary trench in the eastern leg of MDA B, and one to three trenches in the western leg (Figure I–7). The eastern trench is 800 feet (244 meters) long and varies from 25 to 60 feet (7.6 to 1.8 meters) wide. The western trench may contain one continuous trench or three trenches excavated end to end. The total length is 1,000 feet (305 meters)—or 300 to 400 feet (91 to 122 meters) per trench if three trenches—and its width is about 40 feet (12.2 meters). Trench depths appear to be 11 to 15 feet (3.4 to 4.6 meters) beneath the current ground surface. Depths from the top of the ground surface to the top of the waste (estimated to occur at the locations of numerous metal objects) range from 1.3 to 7.2 feet (0.4 to 2.2 meters) (mean 4.1 feet [1.2 meters]) (LANL 2004d). The MDA B Investigation Work Plan estimates that the disposal trench surface area is 2.4 acres (0.97 hectare), and the volume is 47,910 cubic yards (36,630 cubic meters) (LANL 2004d).

The investigations were not able to distinguish the slit trenches for chemical wastes reputed to be at the eastern end of MDA B. The investigations did suggest that several small chemical pits may be in the area of these slit trenches. The investigations were not able to distinguish the short trenches reputedly excavated in the western portion of the MDA, although buried metal objects were found. The area occupied by buried objects appears to extend beyond the fence to the west and south. Their calculated depths range from 0.1 to 6.8 feet (0.03 to 2.1 meters). Partially exposed buried objects were seen (LANL 2004d).

In 2004, workshops were conducted wherein subject matter experts concluded that for purposes of a planned program of investigation and remediation, MDA B could be best envisioned as comprising two sections containing chemical slit trenches, a section that may contain slit trenches or disposal pits, five sections containing debris pits, and two sections of suspected chemical waste discharge (LANL 2005p). The investigation and remediation program for MDA B is addressed in Section I.3.3.2.7.

MDA B contains no structures. The site is surrounded by a galvanized steel chain-link fence and consists of (LANL 2004d):

- a soil-covered, unpaved area covering 15,750 square feet (1,463 square meters) (105 by 150 feet [32 by 46 meters]) at the western end of MDA B
- an asphalt-paved area comprising the long western leg and the central portion of the site (1,500 by 120 feet [457 by 37 meters])
- an unpaved area comprising the eastern leg of the site (600 by 150 feet [183 by 46 meters])

Vegetation has penetrated through cracks in the asphalt, and portions of the northern and southern boundaries of the site are lined with trees (LANL 2004d).

North of the MDA and south of DP Road is an unpaved area used by businesses for parking and deliveries. Commercial buildings occupy the paved area alongside and north of DP Road. West of MDA B is a vacant lot. An abandoned underground radioactive liquid waste line that ran outside the fence along the southern boundary of the site was removed in 2007. Buried water and communication lines are beneath the area between DP Road and the north fence. A water hydrant is inside the northwest corner of the fence, and air monitoring stations are located on the northern and northeastern sides of the fence along DP Road (LANL 2004d, 2006a, 2006i).

Site Investigations. Numerous investigations have occurred since 1948. Pre-RFI investigations are summarized in the Operable Unit RFI Work Plan for TA-21, the Investigation Work Plan for MDA B, and Revision 1 of the Investigation/Remediation Work Plan for MDA B (LANL 1991, 2004d, 2006i). RFI investigations are summarized below:

Surface investigations from 1966 to 2001 have included surface soil sampling and surface flux measurements of volatile organic compounds. Americium-241, cesium-137, plutonium-238, plutonium-239, and tritium were detected consistently across the surface of MDA B. Organic chemicals were detected very infrequently at the surface of MDA B. Lead and zinc were detected above background values consistently across MDA B. Other inorganic chemicals were also detected (LANL 2006i).

Three subsurface investigation campaigns occurred in 1966, 1983, and 1998. The 1966 and 1983 investigations included vertical boreholes drilled alongside the MDA boundary. The 1983 investigations indicated potential tritium contamination at depth. The 1998 investigations included seven angled boreholes drilled beneath the disposal trenches. Lead was found at several depths in one borehole in the west end of the MDA, and in one sample from a borehole in the central portion of the MDA. Aluminum, arsenic, cadmium, mercury, and zinc were also detected. Tritium was found above background in six of seven boreholes. The tritium concentration in the borehole beneath the assumed location of the chemical trench increased slightly over the length of the boring, but decreased in concentration in the deepest sample. Hence, tritium may have been released from the disposal trenches to the subsurface tuff. Tritium sample results over all of DP Mesa may also have been affected by the operation of the Tritium Systems Test Assembly and Tritium Systems Fabrication Facility. In 1983, both of these facilities had atmospheric releases of tritium that would have been noted over all of DP Mesa (LANL 2006a). Americium-241 and strontium-90 were found in this borehole in concentrations that decreased with depth. In a different borehole, uranium-234, uranium-235, and uranium-238 were found above background in one sample (LANL 2006i).

Pore-gas sampling from the angled boreholes found trace levels of several volatile organic compounds, primarily trichloroethene (TCE) and 1,1,1-trichloroethane (TCA), in the parts-per-billion-by volume range (LANL 2006i).

The average moisture content in soils beneath the asphalt at MDA B (10.6 weight-percent) is elevated compared with surrounding surface soils (5.1 weight percent) and subsurface materials (5.6 weight percent) (LANL 2006i).

The objectives of Revision 1 of the Investigation/Remediation Work Plan are to characterize the types and quantities of waste contained in the historical disposal trenches at MDA B; to remove and properly dispose of the waste in these trenches; to collect confirmation samples to characterize the radiological, organic chemical, and inorganic chemical concentrations in the soil and rock next to the disposal trench sides and bottoms and in the deeper subsurface beneath the site; and to obtain data needed to prepare a sampling and analysis plan to support the evaluation of any potential residual risk to human health and the environment after the waste is removed (LANL 2006i). In January 2007, the work plan was approved with modifications by NMED (NMED 2007b). Additional information about the investigation/remediation program for MDA B is in Section I.3.3.2.7.

I.2.5.2.3 Material Disposal Area T

MDA T is on a site covering 2.2 acres (0.9 hectare) (**Figure I–8**). MDA T comprises Consolidated Unit 21-016(a)-99, consisting of SWMUs 21-007, 21-010(a-h), 21-011(a), 21-011(c-g, i, j), and 21-01g(a-c); and AOCs 21-001, 21-011(h), 21-028(a), C-21-009, and C-21-012 (LANL 2005c). It includes four absorption beds, more than 60 shafts, an area once used for solidified waste storage, two industrial wastewater treatment plants, associated buried piping, and various surface features that may have been impacted by facility operations (LANL 2005c).

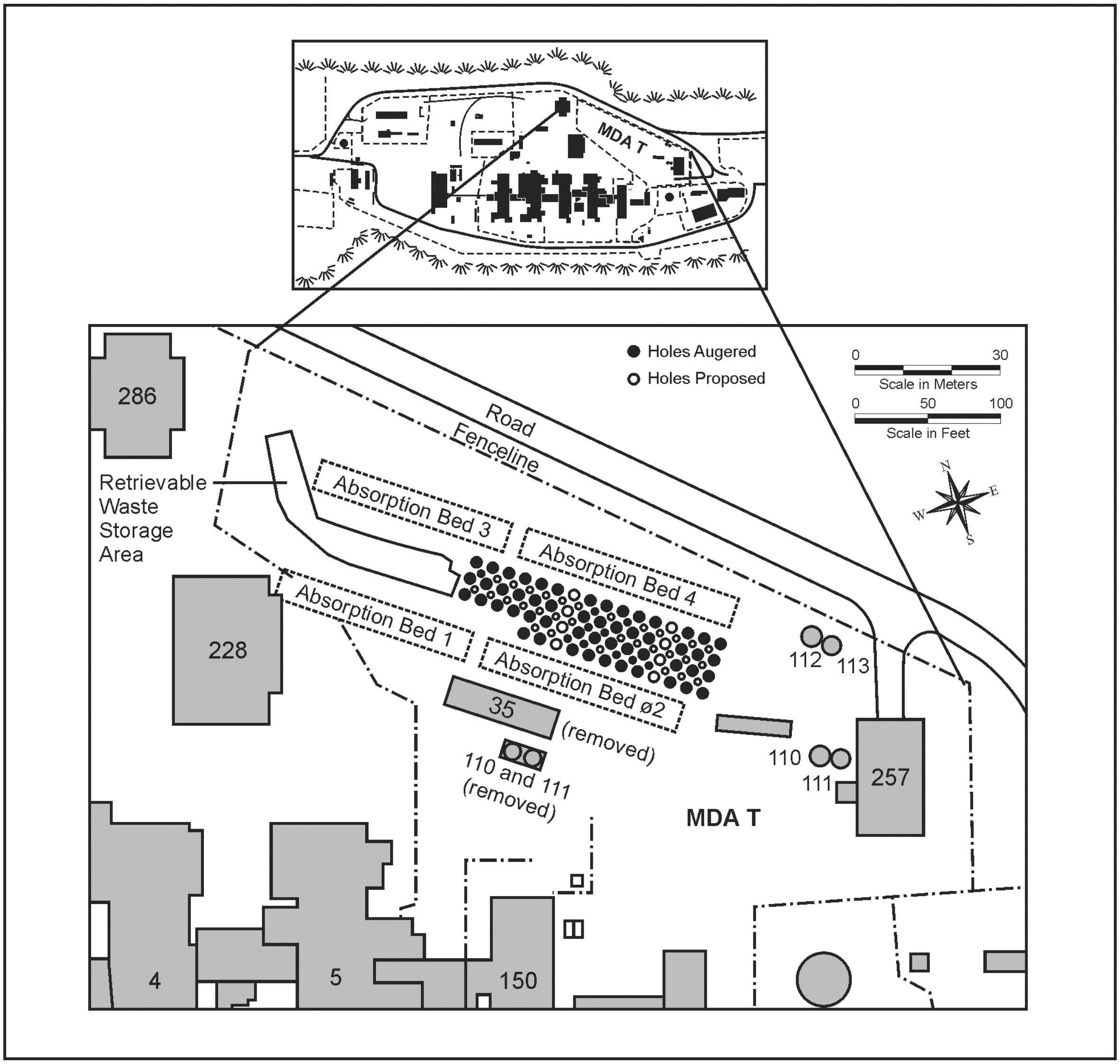

Figure I–8 Material Disposal Area T

History of MDA T. From 1945 to 1952, the absorption beds received liquids from the TA-21 plutonium laboratories. After 1952, when a liquid waste treatment plant was installed in Building 035, the beds were used only occasionally, receiving small quantities of liquid effluent until 1967, when a new liquid waste treatment process began operating in Building 257. The shafts were used between 1968 and 1983 for disposal of liquids combined into a cement paste as well as some solid wastes (LANL 1991, 2004a).

Absorption Beds. The four absorption beds (SWMU 21-016(a)) were built "about 1945" (LANL 1991).[10] The four absorption beds were each 120 by 20 by 6 feet deep (36.6 by 6.1 by 1.8 meters deep).[11] The distance between the centers of Beds 1 and 3 and Beds 2 and 4 is 80 feet (24.4 meters) (Rogers 1977). The beds are shown in cross section in **Figure I–9** (LANL 1991).

[10] MDA T may have received wastes as early as 1943 (LANL 1991).
[11] The beds were 4 feet (1.2 meters) deep, the bottoms of the beds were cut level, and the east and west sides of each bed were sloped so that only the center 100 feet (30.5 meters) of each bed had a depth of 4 feet (1.2 meters) (Rogers 1977).

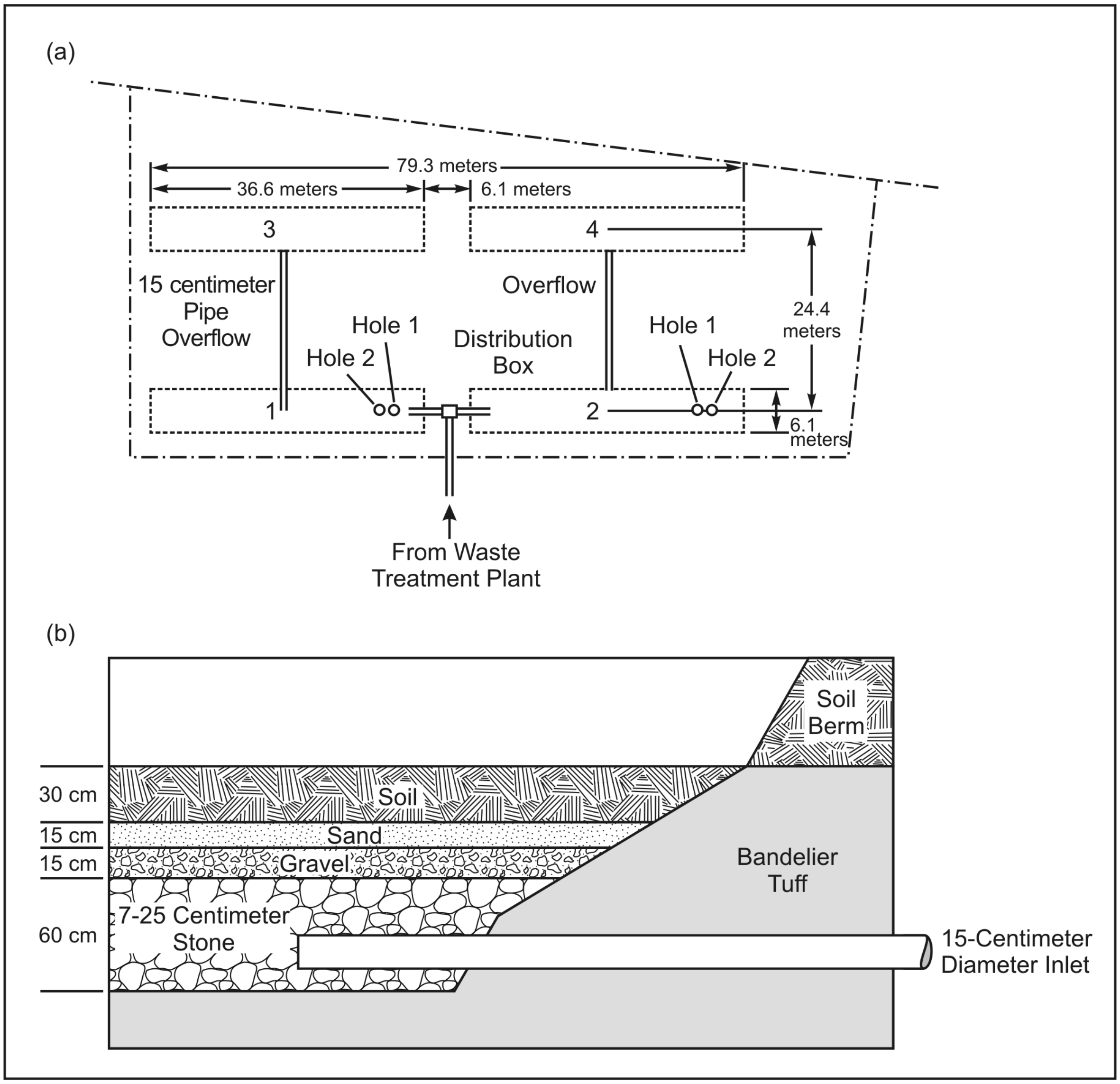

Figure I–9 Absorption Bed and Distribution Pipe Cross-Section

The two sources for liquid waste from DP West were (**Figure I–10**) (LANL 1991, Rogers 1977):

- Effluent from sumps in Buildings 2, 3, 4, and 5 that was piped to a distribution box located between Beds 1 and 2
- Effluent from the Building 12[12] floor drain that was piped directly to Bed 1

The concrete distribution box (SWMU 21-011(c)) has dimensions of 4 by 3 by 4 feet (1.2 by 0.9 by 1.2 meters) with 6-inch-thick (15.2-centimeter-thick) walls. Overflow pipes connect Bed 1 with Bed 3 and Bed 2 with Bed 4 (Rogers 1977).

[12] *This building was removed in 1973 (Rogers 1977).*

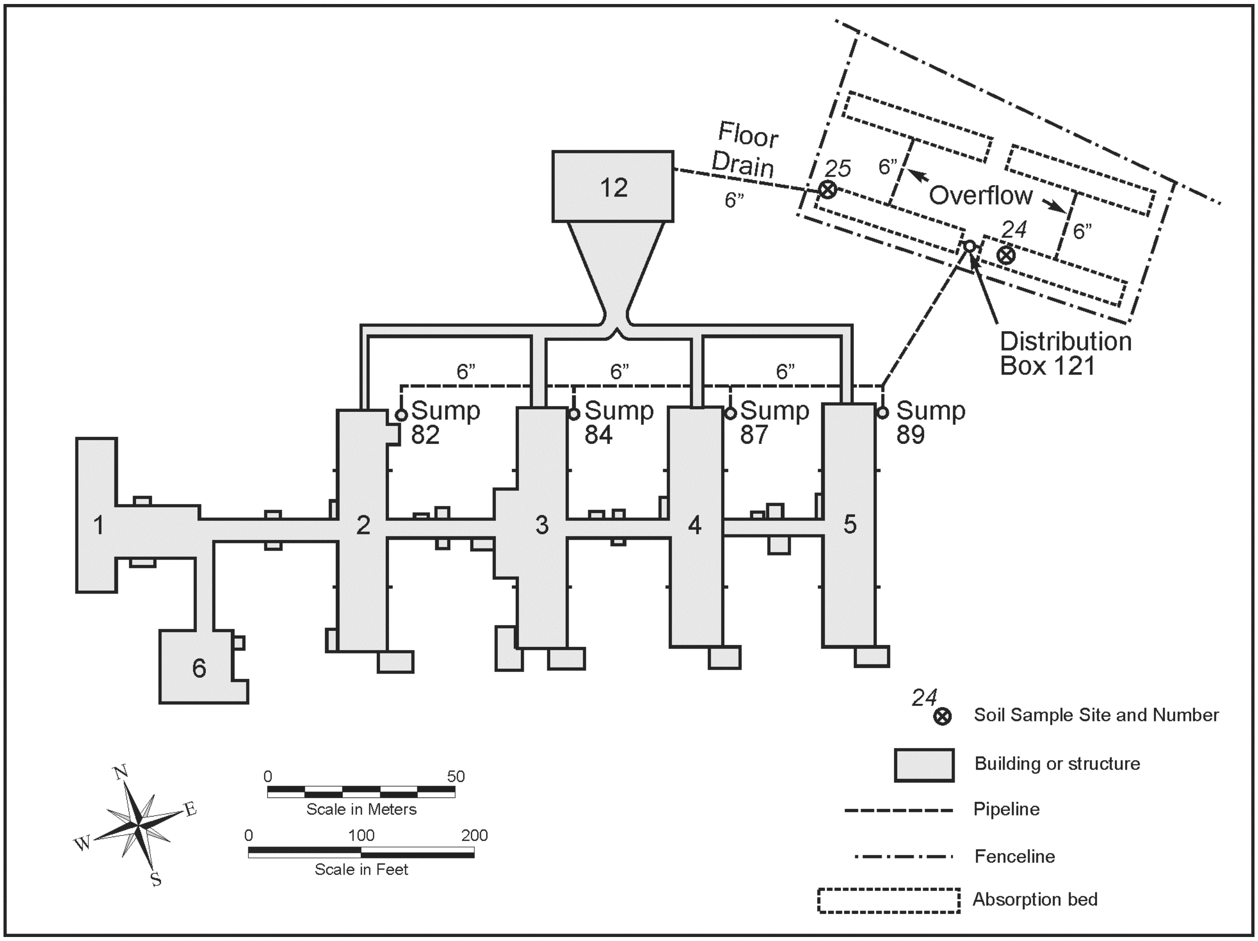

Figure I–10 Location of Lines Discharging to Absorption Beds at Material Disposal Area T Before 1952

The absorption beds occasionally became saturated and overflowed northward toward DP Canyon (Rogers 1977). Overflow associated with operational use of the beds, release of effluents from outfalls, and possibly from experimental studies has contributed to contamination in soils north of the site. The western end of the MDA has experienced erosion (LANL 1993h).

Disposal Shafts. Starting on May 1, 1968, more than 60 disposal shafts (SWMU 21-016) were augured (**Table I–7**), mostly between Beds 2 and 4 and, after being lined with asphalt, used mostly to dispose of cement paste from liquid waste treatment at Building 257 (LANL 1991). The larger shafts (numbers 1 through 60) are on 12-foot (3.7-meter) centers. (There are gaps in the sequencing of the shafts because several shafts were not augured.) The smaller shafts (shafts 70 through 100) were placed between the surface matrices of the larger shafts (Rogers 1977).

Wastes in Retrievable Storage. In 1974, a pit 30 by 60 by 20 feet deep (9 by 18 by 6 meters deep) was dug between Absorption Beds 1 and 3 for storage of liquid wastes cemented into corrugated metal pipes. These pipes were moved to MDA G in the 1980s (LANL 1991). The excavation (SWMU 21-016(b)) was backfilled (LANL 2004a).

Table I–7 Material Disposal Area T Waste Disposal Shaft Depths and Diameters

Shaft	*Diameter (feet)*	*Depth (feet)*	*Shaft*	*Diameter (feet)*	*Depth (feet)*
1	8	61	42	8	21
2	8	21	43	8	62
3	8	27	44	8	63
5	8	29	46	8	66
6	8	27	47	8	25
8	8	67	48	8	63
9	8	63	49	8	67
10	8	23	50	8	65
11	8	28	51	8	30
13	8	65	52	8	23
17	8	50	53	8	52
18	8	59	54	8	63
19	8	65	55	8	69
20	8	63	56	8	62
21	8	62	57	8	25
22	8	64	58	8	22
23	8	63	59	8	54
24	8	61	60	8	63
25	8	16	70	6	68
26	8	15	75	6	67
27	8	58	76	6	67
28	8	67	78	6	65
29	8	61	80	6	66
30	8	62	82	6	64
31	8	18	83	6	24
32	8	15	84	6	50
33	8	64	87	6	66
34	8	60	91	6	26
35	8	62	92	6	27
36	8	61	94	6	22
41	8	62	95	6	16
–	–	–	100	6	66

Note: The citations in the source for this table (LANL 1991) are in meters. To convert feet to meters, multiply by 0.3048.
Source: LANL 1991.

Additional Facilities and PRSs. Numerous additional faculties and PRSs are associated with MDA T (Consolidated Unit 21-016(a)-99), including:

- Building 035 (SWMU 21-010(a)). Construction on this industrial liquid waste treatment plant began in 1949 and was completed in 1952. It operated until 1967. It was decontaminated and decommissioned in 1967, and the building and some associated tanks and piping were removed and disposed of; other tanks were relocated (LANL 2005c). A septic tank and leach field were abandoned in place (LANL 2004a).

- Building 257 (SWMU 21-011(a)). This treatment plant treated and prepared wastes for disposal at MDA T and included an outfall (SWMU 21-011(k)) that discharged to

DP Canyon.[13] The treatment plant includes a clarifier-flocculator, aboveground storage tanks and pumps, and a cement silo. Tanks associated with Building 257 include a 13,500-gallon (51,103-liter) acid holding tank (SWMU 21-011(d)), effluent holding tanks (SWMUs 21-011(f) and 21-011(g)), the Pug Mill Tank (AOC 21-011(h)), a sodium-hydroxide storage tank (SWMU 21-011(i)), and an americium raffinate storage tank (SWMU 21-011(j)) (LANL 2005c).

- SWMU 21-007. This SWMU represents airborne releases from salamanders (incinerators for waste oils and organics). The incinerators were used between 1964 and 1972 and were located atop MDA T (LANL 2005c).

- AOC 21-018(a). This former surface storage area within the MDA T fence was the location for temporary storage of alcohol, acetone, and freon (LANL 2005c).

Waste Inventory

Absorption beds. Between 1945 and 1952, the beds received 14 million gallons (53 million liters) of untreated wastewater containing plutonium and fluoride. In addition, from June 1951 to July 1952, 10,450 gallons (40,000 liters) of ammonium citrate effluent were released containing plutonium and fluoride. From 1953 through 1967, 4.3 million gallons (16 million liters) of effluent were discharged (LANL 2004a). As of January 1973, the absorption beds had received 4 curies of tritium and 10 curies of plutonium-239, plutonium-240 (94 weight-percent plutonium-239 and 6 weight-percent plutonium-240). The beds also received plutonium-238, uranium-235, and americium-241. Wastewater discharged to the beds contained fluorine, iodine, cadmium, beryllium, lead, mercury, sodium, nitrates, and chorine. It probably contained solvents and other organic chemicals (LANL 2004a).

Shafts. Radioactive wastes included cement-stabilized americium, alkaline fluoride, and plant sludge. Some shafts temporarily held wastewater. Personal protective equipment and other contaminated items were also disposed of, including (LANL 2004a):

- Shafts 3, 17, 18, 19, and 26 contain 3-foot diameter (0.9-meter-diameter) "bathyspheres" containing plutonium-239 and plutonium-240 and other mixed fission products. **Table I–8** presents the plutonium-239 inventory contributed by the bathyspheres.

- Shaft 17 contains six drums of cyanide salts fixed in asphalt.

Table I–8 Plutonium-239 Disposed of in Material Disposal Area T Shaft Bathyspheres

Shaft Number	*Plutonium-239 Bathysphere Inventory (grams)*
3	290
17	342
18	134
19	245
20	210

Note: To convert grams to ounces, multiply by 0.035274.

[13] *Remediation of the outfall SWMU (21-011k) has been completed (see Section I.2.7.6).*

- Shafts 50 and 54 contain demolition debris from Filter Building 012.
- Shafts 52 and 58 together contain four drums of uranium-233.

Shaft-specific inventories (as of 2004) of plutonium-239, plutonium-238, plutonium-240, americium-241, uranium-233, and uranium-235 are listed in **Table I–9**, along with volumes of the plutonium cement pastes. The shafts also contain mixed fission products (LANL 2004a).[14]

Table I–9 Radionuclide Inventories and Cement Paste Volume by Shaft

Shaft	*Cement Paste Volume (liters)*	*Pu-239 (grams)*	*Pu-238 (grams)*	*Pu-240 (grams)*	*Am-241 (grams)*	*U-233 (grams)*	*U-235 (grams)*
1	67,440	20.8	0.025	1.2	21	–	–
2	23,920	3.7	0.004	0.2	2.5	–	–
3	10,750	300.2	0.012	18	5.3	–	–
5	87,200	12	0.014	0.7	24.1	–	–
9	88,780	25	0.029	1.5	23.3	–	–
10	18,660	4	0.005	0.2	4.2	–	–
11	18,950	3.2	0.004	0.2	2.6	–	–
13	85,500	39.6	0.047	2.4	34.6	–	–
17	87,240	373.9	0.038	22.42	16.6	–	–
18	83,440	152.8	0.022	9.14	17.1	–	–
19	80,280	261.3	0.019	15.7	6.2	–	–
20	89,540	11.6	0.014	0.7	26.4	–	–
21	87,290	13.3	0.016	0.8	22.6	–	–
22	88,760	18.8	0.022	1.1	20	–	–
23	80,700	20.4	0.024	1.2	31.4	–	–
24	84,100	17.4	0.021	1	25	–	–
25	23,460	7.2	0.009	0.4	10	–	–
26	21,310	214.5	0.005	12.9	5.6	–	–
27	82,770	32.5	0.038	2	18.1	–	–
28	89,880	40.4	0.048	2.4	33.5	–	–
29	87,850	4.2	0.005	0.3	9.8	–	–
30	87,090	14	0.017	0.8	18.8	–	–
31	25,900	3	0.003	0.2	2.9	–	–
32	22,510	5.4	0.006	0.3	9.4	–	–
33	90,490	24.8	0.029	1.5	20.5	–	–
34	89,270	11.4	0.013	0.7	21.3	–	–
35	87,730	16	0.019	1	25.3	–	–
36	89,410	12.4	0.015	0.7	25.9	–	–
41	68,600	20.5	0.024	1.2	18.1	–	–
42	32,730	4.2	0.005	0.3	2.5	–	–
43	89,000	28.1	0.033	1.7	29.5	–	–
44	87,890	14.5	0.017	0.9	21.2	–	–
46	82,540	33	0.039	2	35.6	–	–

[14] *In July 1976, the shafts were estimated to contain 7 curies of uranium-235, 47 of plutonium-238, 191 of plutonium-239, 3,761 of americium-241, and 3 of mixed fission products (LANL 2004a).*

Shaft	*Cement Paste Volume (liters)*	*Pu-239 (grams)*	*Pu-238 (grams)*	*Pu-240 (grams)*	*Am-241 (grams)*	*U-233 (grams)*	*U-235 (grams)*
47	35,100	16.6	0.02	1	15.5	–	–
48	65,760	21.7	0.026	1.3	23.4	–	–
49	92,800	62.2	0.073	3.7	49.4	–	–
50	72,290	18.5	0.022	1.1	21.2	–	–
51	38,620	11.4	0.013	0.7	11.7	–	–
53	71,610	28.7	0.034	1.7	33.9	–	–
55	90,600	45.9	0.054	2.8	26.7	–	–
56	83,870	23.9	0.028	1.4	32.6	–	–
57	37,200	19.1	0.023	1.1	11.9	–	–
59	77,400	44.2	0.052	2.7	31.1	–	–
60	90,460	38.2	0.045	2.3	33	–	–
70	52,400	79.9	0.094	4.8	29.8	–	–
75	52,800	32.9	0.039	2	35.4	–	–
76	52,600	56.7	0.067	3.4	53.1	–	–
78	49,800	7.6	0.009	0.5	0.8	–	–
80	56,300	20	0.024	1.2	4	–	–
82		8.9	0.01	0.5	2.4	–	–
83	18,000	19.6	0.023	1.2	4.8	–	–
84	37,700	9.5	0.011	0.6	0.3	–	–
87		7.7	0.009	0.5	0.4	–	–
Complex B (52, 58)	64,690	34.2	0.04	2.1	20.1	713	–
Complex A (6, 8, 54, 90, 91, 92, 94)	125,630	99.8	0.118	6	79.6	–	713
Total (grams):	–	2,471	1.5	148	1,112	713	713

Pu = plutonium, Am = americium, U = uranium.
Note: To convert liters to gallons, multiply by 0.26418; grams to ounces, multiply by 0.035274.
Source: LANL 2004a.

Current Configuration. The absorption beds and shafts are enclosed by a chain-link fence (except the southwest corner of Absorption Bed 1). The surface is vegetated with weeds, grasses, chamisa bushes, and two young ponderosa pine trees (LANL 2004a). MDA T has a downward slope from south to north. Backfilling and grading have added 5 to 6 feet (1.5 to 1.8 meters) of soil to the original surface of the beds, shafts, and the retrievable waste storage area. The bottoms of the absorption beds are about 9 feet (2.7 meters) below current ground surface (LANL 2004a).

MDA T is a complex site containing or contingent to several SWMUs, some active and some not. In addition to buried and abandoned piping and lines from utilities and waste treatment and transfer operations, complex groupings of utility lines and corridors pass through MDA T. A corridor of acid waste lines runs underground from the northwest corner of Building 257 to the southwest of former Building 035. Waste drain lines also run from the northwest corner of Building 257 north to effluent tanks 112 and 113. An acid waste line runs southeast from former Building 035 before angling northeast to the effluent tanks. An acid waste line also runs from the southwest corner of former Building 035, under Building 257, and east out of MDA T. A natural gas line runs east-west under Building 257 and along the south side of former Building

035. Main water lines run just south of the MDA T fence lines, with feeder lines north to former Building 035 and Building 257. Aboveground electrical lines run just north of the MDA T fence line, splitting to the south between former Building 035 and Building 257, and to the east over tanks 112 and 113 and along the north side of Building 257. Underground electrical lines run between former Building 035 and Building 247 (LANL 2004a).

Site Investigations. Pre-RFI site investigations at MDA T are summarized in the Operable Unit RFI Work Plan for TA-21 and in the February 2004 Investigation Work Plan for MDA T (LANL 1991, 2004a). Pre-RFI investigations occurred in 1946, 1947, and 1948. In 1953, the U.S. Geological Survey concluded that no appreciable horizontal migration of contamination had occurred. From 1959 to 1961, the U.S. Army Corps of Engineers dug a test pit (caisson) next to Absorption Bed 1 and drilled six angled boreholes under the bed. In 1960 and 1961, infiltration studies were performed by adding large quantities of raw liquid waste and ordinary tap water to Absorption Bed 1 (LANL 2004a).

Additional boreholes were drilled in 1967 and 1974 to measure tuff moisture content. Paleochannels at depths of 15 to 25 feet (4.6 to 7.6 meters) were found. Moisture migration studies occurred in 1978, and shallow soil sampling and radiological characterizations occurred in 1984 and 1986 (LANL 2004a). Results of the field study initiated in 1978 showed plutonium and americium-241 at depths to 100 feet (30 meters) below ground surface (LANL 1984).

Phase I RFIs collected surface soil samples in 1992, 1994, 1995, 1996, and 1997, as well as tuff samples from boreholes. The following contaminants were found (LANL 2004a):

- In the surface soil and shallow subsurface extending to DP Canyon, americium-241, plutonium-238, and plutonium-239 were elevated compared with background values.
- In soil and subsurface soil and tuff samples from boreholes, several metals were detected above background values. Levels of cadmium, copper, and nickel above background values were found near the influent line for Building 035 and at a nearby location.

Additional work was proposed in the 2004 MDA T Investigation Work Plan: a site-wide radiation mapping survey; sampling of drainage channels; borings to characterize release from the absorption beds and the possible presence of perched water and bedrock fractures; and further characterization of the area surrounding former Building 035 and existing Building 257 (LANL 2004a). The Investigation Report for MDA T was completed and submitted to NMED on September 18, 2006. In October 2007, DOE issued a proposed subsurface vapor monitoring plan for MDA T that included installation of three wells for quarterly sampling of tritium and volatile organic compounds (LANL 2007f).

I.2.5.2.4 Material Disposal Area U

MDA U is within a fenced, 0.2-acre (0.08-hectare) site north of Buildings 21-152 and 21-153 in DP East (**Figure I–11**). It contains two absorption beds (SWMUs 21-017(a) and (b)).

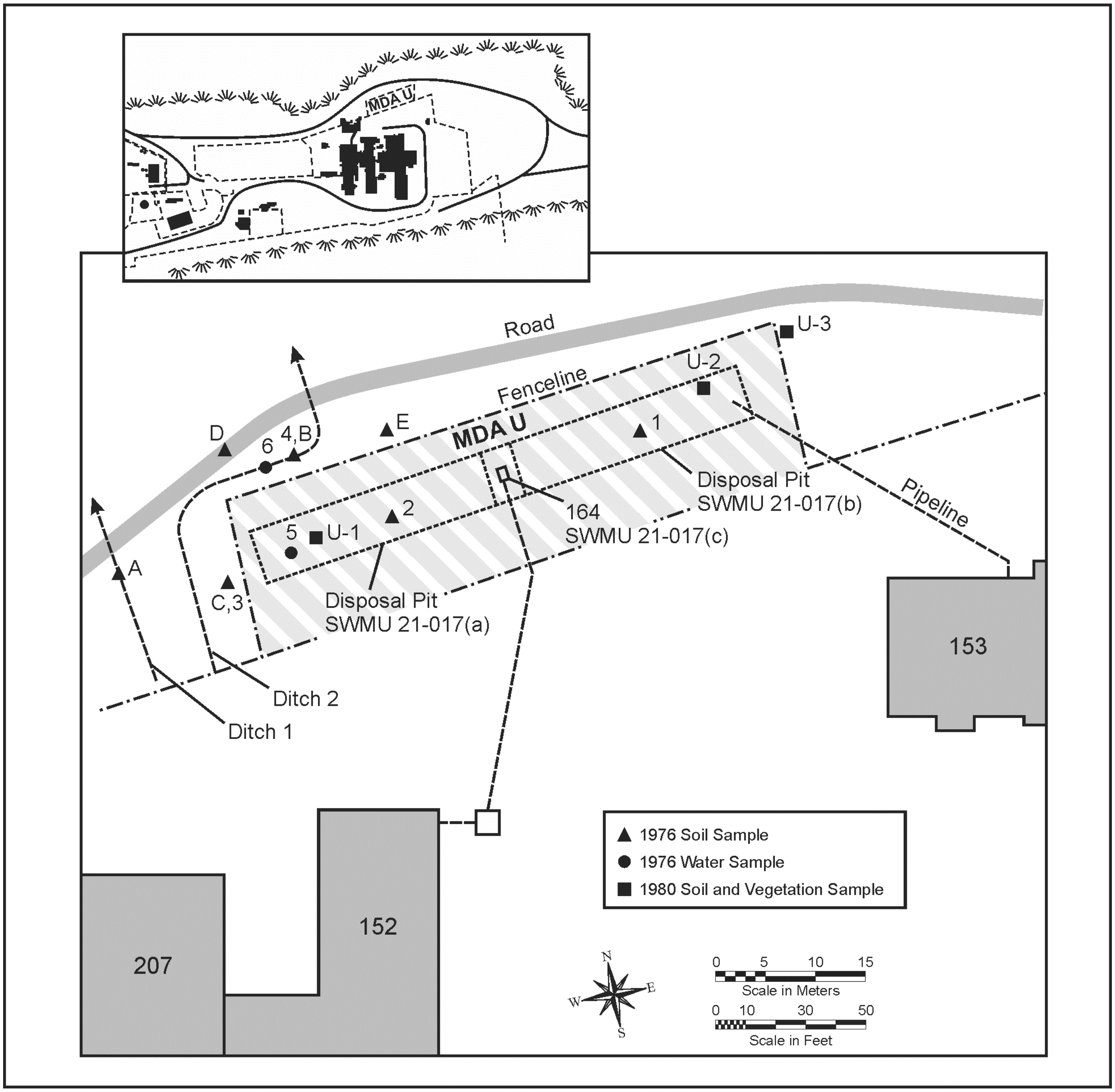

Figure I–11 Material Disposal Area U Showing Pipelines for Liquid Effluents

History of MDA U. The absorption beds were used from 1948 to 1968 for disposal of liquid wastes (LANL 1991). Each bed was 80 by 20 by 6 feet (24 by 6.1 by 1.8 meters) (LANL 2004k). The beds were filled with 24 inches (61 centimeters) of cobbles and overlain by 6 inches (15 centimeters) of gravel and 6 inches (15 centimeters) of sand. Covering the sand was 12 inches (30 centimeters) of soil (LANL 2004k). Between the two beds was a distribution box (SWMU 21-017(c)) with lines leading to the beds (LANL 1999b). Liquid waste included effluent from Buildings 21-152 and 21-153, and from 21-155, the Tritium Systems Test Assembly[15] (LANL 2004k).

Effluent from Buildings 21-152 and 21-153 was received until 1968 (LANL 2004k). Effluent discharge from Building 21-155 presumably ceased at the same time. In addition, until 1976 the west bed received water from a cooling tower for Building 21-155 (LANL 1991, 2004k). MDA U also received oil from precipitrons[16] and from Building 21-152 floor drains (LANL 2004k).

In 1985, the distribution box and lines were removed (LANL 1991), as was a portion of the line from the cooling tower (LANL 2004k). A trench 20 feet (6.1 meters) wide, 100 feet (30 meters) long, and 4 to 13 feet (1.2 to 4.0 meters) deep was dug, and some, but not all, contaminated soil was removed. After a plastic liner was placed in the trench to denote the excavation boundary, the trench was filled with soil. The excavated area was covered with 6 inches (15 centimeters) of topsoil and drainage problems were remedied (LANL 1991).

In 1987, ditches were placed along the south fence to prevent runon; additional topsoil, gravel mulch, and seeds were deposited inside the fence; and brass markers were placed at the corners of the site. Additional collection ditches were excavated in 1990 to prevent runoff from the surrounding area from flowing across MDA U (LANL 1991).

In 2001, exploratory trenches were dug across each absorption bed to find the plastic liner placed over the excavated areas when the drain line and absorption bed material were removed in 1985. Black plastic was found in the west absorption bed at a depth of 3.5 to 4 feet (1.1 to 1.2 meters). Cobbles up to 20 inches (0.5 meters) in diameter were seen under the plastic. In the east absorption bed, a clear liner was found at about 3 feet 0.9 meter) below ground surface and a black liner at 7 feet (2.1 meters), above a cobble layer (LANL 2006g).

Waste Inventory. Between 1945 and 1968, the beds received 135,000 gallons (511,000 liters) of liquid. The primary radionuclide was polonium-210.[17] The beds also received actinium-227, plutonium, and tritium. About 2.5 curies of actinium-227 were discharged in 1953, mainly from Building 21-153.[18] A 1946 memorandum referenced in the MDA U Investigation Work Plan states that plutonium and polonium were measured in effluent discharged to the beds. The beds probably received inorganic materials, organic chemicals, acids, and oils (LANL 2004k).

Much of the contamination discharged to the beds has been removed.

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[15] Building 21-155 (Tritium Systems Test Assembly) is not shown in Figure I–11.
[16] Precipitrons were air filters installed in the filter building, Building 21-153, and used to filter air exhausted from Building 21-152 (LANL 1991).
[17] Because polonium-210 has a half-life of 138.4 days, current inventories of polonium-210 are effectively nonexistent. Polonium-210 decays to stable lead.
[18] A filter building decommissioned in 1978.

Current Configuration. MDA U is a grassy area, fenced to the north, east, and west by a security fence, and to the south by an industrial site. Building 21-153 was unused after March 1970 and demolished in 1978. The effluent pipeline from Building 21-153 has been removed, along with the pipeline from Sump 173 at Building 21-152. Sump 173 remains (LANL 2004k).

Site Investigations. Early site investigations included effluent sampling in 1946; surface soil and water sampling in 1976; an investigation of soil, vegetation, and tar in 1980; a subsurface investigation in 1983; and soil and vegetation sampling in 1984. RFIs were conducted in 1992, 1994, 1998, and 2001. Samples of soil and sediment found americium-241, plutonium-238, plutonium-239, tritium, chromium, lead, mercury, uranium, and zinc in concentrations above background values. Organic chemicals were infrequently found in low concentrations (LANL 2004k).

The 1998 and 2001 investigations sampled fill from the beds. Tritium and uranium-234 were found in levels above background values, and actinium-227 progeny were found in the eastern beds. The 1998 investigations found uranium-234, uranium-235, actinium-227 progeny, and tritium in boreholes. Subsurface samples found aluminum, arsenic, barium, beryllium, chromium, copper, lead, manganese, and mercury at levels above background values. Subsurface pore-gas samples showed numerous low-level detections of organic chemicals (LANL 2004k).

Field investigations in 2005 included characterization drilling and logging of nine boreholes, continuous core sampling in 5-foot (1.5-meter) intervals, field screening for radiation and volatile organic compounds, collecting surface and subsurface samples for chemical characterization, and collecting subsurface samples for geotechnical characterization.

In the 2006 Investigation Report for MDA U, LANL staff concluded that the nature and extent of contamination in surface and subsurface media had been defined, and that no perched saturation zones existed under the site. LANL staff also concluded that neither additional corrective action nor further characterization was warranted. LANL staff recommended that the three SWMUs within the MDA U boundary be designated as "complete with controls," the controls being the maintenance of the land use as industrial (LANL 2006g). On September 28, 2006, NMED approved the Investigation Report and issued a Corrective Action Complete with Controls certification of completion for SWMUs 21-017(a-c) and 21-022(f) pursuant to the Consent Order (NMED 2006b).

I.2.5.3 Technical Area 49: Material Disposal Area AB

Created in 1959 from TA-15, TA-49 is on the southwestern edge of LANL (see Figure I–1). MDA AB is on Frijoles Mesa.

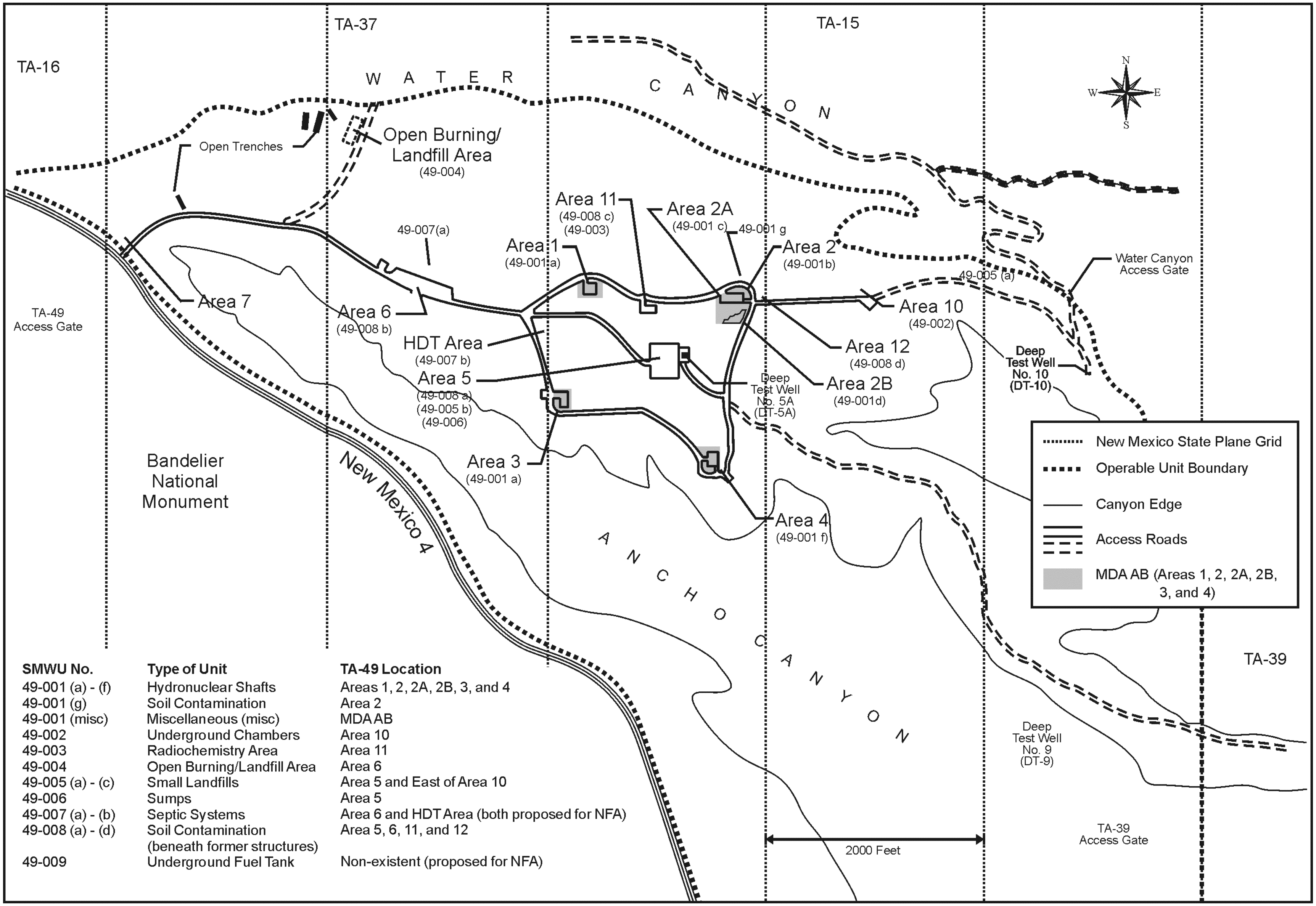
History. Beginning in the fall of 1959, underground hydronuclear experiments were conducted to investigate the possibility of a nuclear yield from accidental detonation of a nuclear weapon's high explosive component. Experiments were conducted through August 1961 (LANL 1992b), mainly in four underground shaft areas (Areas 1-4) to which Areas 2A and 2B were added. (These six areas, plus an area of surface contamination, compose MDA AB.) A site diagram (**Figure I–12**) shows the areas containing the hydronuclear shafts, central control area, supporting areas, and other nearby PRSs and site features (LANL 1992b), including:[19]

- Areas 1, 2, 2A, 2B, 3, and 4: SWMUs 49-001(a-f)
- Surface contamination, particularly in Area 2: SWMU 49-001(g)
- Area 5, central control area: SWMU 49-008(a), soil contamination; SWMU 49-005(b), a small landfill; and SWMU 49-006, a sump
- Area 6, open burning/landfill area: SWMU 49-004
- Area 10, underground experimental area: SWMU 49-002, the experimental area; and SWMU 49-005(a), a small nearby landfill
- Area 11, radiochemistry and small-scale shot area: SWMU 49-008(c), soil contamination; and SWMU 49-003, inactive leach field and drain lines
- Area 12, Bottle House Area: SWMU 49-008(d), soil contamination

Areas 1, 2, 2A, 2B, 3, and 4. Between January 1960 and August 1961, about 4 dozen hydronuclear, calibration, and equation of state experiments were conducted. At least 23 additional underground containment, equipment development, and mockup experiments were conducted using high explosives, and, in a few cases, small quantities of uranium-238 or radioactive tracer. The experiments caused explosive dispersal of uranium-235, plutonium-239, lead, beryllium, and uranium-238 at the bottoms of backfilled shafts that varied in depth from 31 to 142 feet (9.4 to 43 meters) (LANL 1992b). Some experiments used radioactive tracers, and many experiments with and without special nuclear material used uranium-238. The maximum fission energy released in any experiment equaled only a few tenths of a pound of high explosive (LANL 1992b). Less than 10 millicuries of fission products probably remain, and only a few curies of tritium were expended. Special nuclear material was never used in Area 3 (LANL 1992b).

Essentially all of the contamination is deep underground. Most contaminants are confined to within maximum radii of 10 to 15 feet (3.0 to 4.6 meters) from detonation points. Small levels of surface contamination in Area 2 resulted from inadvertent drilling into a subsurface region contaminated from a previous experiment (LANL 1992b).

[19] *Also shown on Figure I–12 is the Hazardous Devices Team training area (HDT Area). Remediation of SWMU 49-007(b) is administratively complete (LANL 2005a).*



SMWU No.	Type of Unit	TA-49 Location
49-001 (a) - (f)	Hydronuclear Shafts	Areas 1, 2, 2A, 2B, 3, and 4
49-001 (g)	Soil Contamination	Area 2
49-001 (misc)	Miscellaneous (misc)	MDA AB
49-002	Underground Chambers	Area 10
49-003	Radiochemistry Area	Area 11
49-004	Open Burning/Landfill Area	Area 6
49-005 (a) - (c)	Small Landfills	Area 5 and East of Area 10
49-006	Sumps	Area 5
49-007 (a) - (b)	Septic Systems	Area 6 and HDT Area (both proposed for NFA)
49-008 (a) - (d)	Soil Contamination (beneath former structures)	Area 5, 6, 11, and 12
49-009	Underground Fuel Tank	Non-existent (proposed for NFA)

Figure I–12 Technical Area 49 Shaft Areas and Other Solid Waste Management Units

Before the experiments began, deep test wells were drilled into the main aquifer to determine the thickness of the tuff and volcanic sediments, hydrologic characteristics of the main aquifer, and presence of perched water (none was found). Two other deep boreholes were drilled that did not penetrate the aquifer. Four boreholes were drilled to depths from 300 to 500 feet (91 to 152 meters) to map the geologic and hydrologic characteristics of the underlying tuff (Core Holes 1 through 4). These holes are used for subsurface monitoring. A large but unquantified volume of drilling fluid was lost in Core Hole 2. Perhaps several million gallons of fluids were also lost in deep test well DT-5A below a level of 285 feet (87 meters) (LANL 1992b).

Before the underground experiments were conducted, containment experiments using "quarter-scale" quantities of high explosive occurred in Area 11. Subsequently, "full-scale" containment experiments occurred in Areas 1, 2, 3, and 4 using much larger quantities of high explosive than those in ensuing experiments (LANL 1992b).[20]

Experimental holes in Areas 1, 2, 3, and 4 were spaced at 25-foot (7.6-meter) intervals on 100-foot (30-meter) square grid patterns. Areas 2A and 2B have irregular shapes. Experimental holes were typically 6 feet (1.8 meters) in diameter and ranged in depth from 31 to 142 feet (9.4 to 43 meters). Experimental holes were not drilled at all grid locations. Some of the holes were backfilled without further use and some were used to bury contaminated debris (LANL 1992b).

Associated with many experimental holes were small-diameter holes containing pipes leading from the shafts to steel boxes near the ground surface. The boxes collected samples of radioactive particles entrained in explosive gases. Recovery of sample collection devices from the boxes occasionally caused localized surface contamination that was cleaned to field detection limits or covered with soil. Pipes connected the boxes to large-diameter gas expansion holes. Each gas expansion hole served several experimental holes (LANL 1992b).

Researchers typically placed an experimental configuration in the bottom of a hole, installed instrument cables leading to the surface, and backfilled the hole with sand and crushed tuff. The down-hole package usually included substantial amounts of metallic lead. After completing measurements and sample collection, researchers severed the cables and backfilled hole subsidence. Holes containing special nuclear material were capped with concrete. The steel sampling boxes were usually filled with concrete and left in place. Researchers usually disconnected the sampling pipes from the sampling box and expansion hole and then reused or buried them in pipe dump holes, 3 feet (0.9 meters) in diameter by 30 feet (9.1 meters) deep, around the experimental area. At least four dump holes were drilled in Area 2B. Similar holes may exist in other areas (LANL 1992b).

Large concrete shields were used to minimize radiation exposure from a pulsing neutron source. The shields may have been activated with short-lived radionuclides. Monitoring with routine field instrumentation has found no detectable levels of surface contamination. Approximately 10 of these shields remain (LANL 1992b).

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[20] *Containment experiments characterized the extent to which the detonations would fracture the tuff in the vicinity of the detonation points (LANL 1992b).*

The most significant contamination incident occurred in 1960 during the drilling of Hole 2-M in Area 2. After contamination was found, equipment that could not be decontaminated, or was of little value was placed in Hole 2-M along with contaminated surface soil. Other contaminated items were disposed of (LANL 1992b).

In January 1961, all open holes were filled with sand and crushed tuff, and the surface of Area 2 was capped with compacted clay and gravel. Historical estimates of the fill thickness in Area 2 range from 1 to 6 feet (0.3 to 1.8 meters), and a field inspection suggested a maximum fill thickness of 6 feet (1.8 meters). The cap was extended 12.5 feet (3.8 meters) beyond the outermost shafts and, in September 1961, paved with asphalt. Near-surface contamination was left beneath the asphalt. In 1977, the La Mesa forest fire burned over most of TA-49, destroying essentially all remaining combustible structures at the site (LANL 1992b).

In March 1975, collapse of asphalt over backfilled Hole 2-M left a hole 6 by 3 by 4 feet deep (1.8 by 0.9 by 1.2 meters deep) in the asphalt and underlying fill. This opening may have caused the 50 feet (15 meters) of standing water seen in 1975 in Core Hole 2. In September 1976, the opening over Hole 2-M was filled and the pad covering Area 2 was repaved with additional asphalt. Samples of water bailed from Core Hole 2 in 1977 and 1978 showed plutonium-239 in concentrations of 1.7 to 3.1 picocuries per gram, indicating that water in Core Hole 2 had contacted contamination beneath Area 2. The contaminated water presumably moved through fractures to the Core Hole 2 borehole and traveled down the annular spacing between the casing and the borehole. Alternatively, the enhanced infiltration caused by the collapsed hole created saturated soil conditions that extended laterally to the Core Hole 2 borehole and then traveled down the annular spacing between the casing and the borehole.

About 150 feet (46 meters) of standing water was measured in Core Hole 2 on several occasions in 1979 and 1980. Water from several levels was bailed from Core Hole 2 and plutonium was found in concentrations of from 0.1 to 5.5 picocuries per liter in filtered water samples, and from 0.54 to 0.72 picocuries per gram in suspended sediment samples. Core Hole 2 was bailed dry in June 1980 and from 1980 through 1987, Core Holes 1 through 4 were checked annually for standing water. No standing water was found. In 1981, the upper 2 feet (0.6 meters) of sand in the sand-filled shafts in Areas 2A and 2B was replaced with concrete. In May 1991, when vegetation was seen growing through cracks in the asphalt, Core Hole 2 contained 100 feet (30 meters) of standing water. In November 1991, cracks in the asphalt were resealed, and through the summer and fall of 1991 and spring of 1992, the water level in Core Hole 2 was measured on about a monthly basis. The water level during this time remained fairly stable. In December 1991, a transducer was installed in Core Hole 2 for continuous monitoring of the water level, which remained stable through April 1992. This water level stability suggested that the response to the summer 1991 rainfall and spring 1992 snowmelt was sluggish. Water analyses for a bailed sample from Core Hole 2 in May 1991 showed low but measurable concentrations of plutonium (LANL 1992b).

In 1998 and 1999, LANL performed an interim action at Areas 2, 2A, and 2B to: (1) plug and abandon Core Hole 2 and two other boreholes; (2) remove asphalt from Area 2; (3) install an evapotranspiration cover consisting of a layer of clean, crushed tuff, topsoil, shallow-rooted grass, and gravel for erosion protection; (4) cover part of the site and vicinity with a biointrusion barrier; (5) install a silt fence surrounding the new evapotranspiration cover; and (6) install a run-on diversion channel (LANL 1998a, 1999a, 1999c). In February 2000, a moisture monitoring system was installed to monitor the new evapotranspiration cover at Area 2. Moisture monitoring continues as required by the Consent Order.

In May 2000, the Cerro Grande forest fire burned the western and northern edges of TA-49, but did not burn vegetation or structures at MDA AB or Area 11.

Area 5. As the main control area, Area 5 contained several structures that were removed or destroyed between 1961 and 1984, including the tower. Other structures were destroyed in June 1977 by the La Mesa forest fire (LANL 1992b). Some of the debris collected during the 1984 cleanup of Area 5 was likely disposed of in a pit 10 by 10 by 10 feet deep (3 by 3 by 3 meters deep) in Area 5 (SWMU 49-005(b)) (LANL 2005c).

Area 6. Area 6 occupies a 150- by 700-foot (46- by 213-meter) area. Area 6 included storage and office structures, although all structures were removed by 1977. In addition, a 400-square-foot (37-square-meter) "boneyard" stored lumber, fencing, and steel. Some materials may have been radioactively contaminated. AOC 49-008(b) consists of contaminated surface soil (LANL 2005c).

The landfill in Area 6 (SWMU 49-004) was used from late 1959 to mid-1961 to burn construction wastes and to bury uncontaminated residues. The landfill was reopened in 1971 and 1984. A trench 30 by 100 by 15 feet deep (9.1 by 30 by 4.5 meters deep) was dug for burial of uncontaminated debris. Assessments of surface contamination in the landfill have found transuranic isotopes as well as lead and beryllium. A 1991 geophysical survey indicated a landfill surface area of 35 by 200 feet (11 by 61 meters). The survey found several magnetic and electromagnetic anomalies. The survey suggested that the buried objects were covered by 4 feet (1.2 meters) of overburden (LANL 1992b).

Area 10. Used for calibration tests, Area 10 contains an inactive underground experimental chamber and two shafts (AOC 49-002), each 6 to 7 feet (1.8 to 21 meters) in diameter and 64 feet (20 meters) deep and connected at the bottom by a tunnel. One shaft contains an elevator. In the other shaft, a pulsed neutron source irradiated calibration samples placed within a 14-foot (4.3 meter-diameter) by 10-foot high (3.0-meter-high) room lined with reinforced concrete faced with steel plate. A hydraulic lift platform at the bottom of the calibration room connects to a hydraulic oil reservoir at the surface. A concrete pad at the tops of both shafts provides a foundation for the elevator building and shielding wall (LANL 2005c).

East of Area 10 is an inactive landfill (SWMU 49-005(a)). The landfill is 50 to 100 feet (15 to 30 meters) northeast of the Area 10 experimental chamber and shafts. The landfill was built in 1984 as a disposal area for debris from the 1984 general surface cleanup of TA-49. The wastes were primarily wood and small pieces of metal (LANL 2005c).

Area 11. Area 11 is a 220- by 300-foot (67- by 91-meter) area, 700 feet (213 meters) west of the main MDA AB shafts, where radiochemistry and small-scale containment experiments took place (LANL 2005c). Containment experiments took place at the bottoms of thirteen 10-inch (25-centimeter-diameter) by 12-foot-deep (3.7-meter-deep) vertical holes encased in steel and backfilled with sand. Some of the shots used irradiated uranium-238 as a tracer. A maximum of

10.5 grams (0.4 ounces) of uranium was used, and the irradiated samples contained microcurie levels of neptunium-239. Some holes may have contained lead and some holes were partially backfilled with concrete. Ten-inch-diameter (25-centimeter-diameter) casing from two capped holes extends above the ground surface (LANL 1992b).

Area 12. Area 12 historically featured confinement experiments where high explosive was detonated in sealed metal “bottles” (up to 5 feet [1.5 meters] in diameter by 16 feet [4.9 meters] long) placed in a shaft 30 feet (9.1 meters) deep. The Bottle House, one of two remaining surface structures, surrounded the shaft. Roughly 26 experiments used a few kilograms of uranium-238. Six used a few microcuries of irradiated uranium tracer. Area 12 then supported operations at the nearby Cable Pull Test Facility, built in the early 1960s. The Bottle House shaft was backfilled with crushed tuff (LANL 1992b).

Waste Inventory

Areas 1, 2, 2A, 2B, 3, and 4. Inventories of plutonium and uranium in each of the experimental areas (as of 1992) are summarized in **Table I–10**. The experimental areas may also contain small quantities of fission products (less than 10 millicuries) and ingrown americium-241 (about 0.33 pounds [0.15 kilograms] in 1992). The experimental shafts contain approximately 24 pounds (11 kilograms) of beryllium and possibly more than 198,000 pounds (90,000 kilograms) of lead (LANL 1992b).

Table I–10 Material Disposal Area AB Principal Radionuclides Inventories

MDA AB Area	*SWMU Number* [a]	*Plutonium* [b] *(kilograms)*	*Uranium-235 (kilograms)*	*Uranium-238 (kilograms)*
Area 1	49-001(a)	1.06	0.00	62.3
Area 2	49-001(b)	12.62	47.4	52.5
Area 2A	49-001(c)	3.75	9.8	10.6
Area 2B	49-001(d)	5.67	6.4	14.7
Area 3	49-001(e)	0.00	0.005	0.030
Area 4	49-001(f)	17.04	29.4	29.0
Total		40.14	93.0	169.1

MDA = material disposal area, SWMU = solid waste management unit.
[a] SWMU 49-001(g) comprises surface contamination at the experimental areas.
[b] Plutonium isotopic composition in weight-percent: plutonium-239 (93.5 - 94.2 percent); plutonium-240 (5.30 - 6.05 percent); plutonium-241 (0.458 - 0.563 percent). Plutonium-241 decays to americium-241.
Note: To convert kilograms to pounds, multiply by 2.2046.
Source: LANL 1992b.

The Hole 2-M incident probably caused the radionuclides seen in surface soils around the Area 2 pad and just outside the Area 2 exclusionary fence (SWMU 49-001(g)). About 0.8 acre (0.3 hectare) may be contaminated with plutonium and americium (LANL 1992b).

Area 5. Only small amounts of hazardous or radioactive materials could have been released to soil. A few hundred gallons of photographic solutions may have been released to sumps or nearby soil (LANL 1992b).

Area 6. The landfill may contain lead or beryllium but probably contains little radioactive material (LANL 2002g).

Area 10. Materials used in calibration tests included uranium, beryllium, and lead shielding. Milligram quantities of enriched uranium were occasionally released, albeit generally recovered. The pulsed neutron source may have activated surrounding soils and structures, but activation products should be significantly decayed. The hydraulic oil in the lift system was not reported to contain PCBs. After 1961, hazardous materials were not used. Materials disposed of in the nearby landfill (SWMU 49-005(a)) were mainly wood and metal (LANL 2005c).

Area 11. Elevated levels of radioactivity have been measured near the east end of the former radiochemistry building. Small levels of radioactivity may be in the vicinity of the leach field. A 1991 geophysical survey suggested near-surface piping and electrically conductive areas possibly related to subsurface chemical contamination or elevated moisture levels. Buried metal was found in the small-shot area (LANL 1992b).

Area 12. Surface contaminants are at low levels and have discontinuous distributions (LANL 1992b).

Current Configuration

Areas 1, 2, 2A, 2B, 3, and 4. All six areas are covered with native soil and vegetation. Few aboveground structures remain. All areas except Area 3 are fenced. Aboveground pipes exist in Area 3, as do exposed patches of concrete. Piping to a gas expansion hole remains in Area 4 (LANL 1992b). Pipe interiors are contaminated (LANL 1992b).

Depths of MDA AB test and support shafts are shown in **Table I–11**. The shafts include shot holes, pipe dump holes, gas expression holes, and unused holes (either backfilled or proposed, but not excavated). This table does not list all possible subsurface contamination such as pipe dump holes, buried pipes, and sampling boxes. The individual down-hole assemblies in the experimental shafts weighed as much as 8 tons (7.3 metric tons) and consisted of cable, steel, iron, aluminum, and other structural materials (LANL 1992b).

A crushed-tuff evapotranspiration cover has been installed at Areas 2, 2A, and 2B. During February and March 2000, the LANL environmental restoration project installed three new shallow neutron access holes and two time-domain-reflectometry arrays in the cover and initiated monthly moisture monitoring to track the cover performance (LANL 2000a).

Area 5. The only surface structures now in Area 5 are the observation well enclosure and the concrete pads from the former transformer station and the photographic tower. Small amounts of metallic debris and lead bricks remain (LANL 1992b).

Area 6. A 1991 geophysical survey showed the footprint of the landfill trench to be 35 by 330 feet (11 by 101 meters). The RFI Work Plan describes four open trenches that are west and southwest of the landfill trench (SWMU 49-004). These previously undocumented trenches may predate activities at TA-49. The trenches are 10 feet wide by 4 to 6 feet deep by 50 to 100 feet long (3.0 by 1.2 to 1.8 by 15 to 30 meters). One trench had been backfilled and one passes through prehistoric ruins (LANL 2005c). Area 6 currently supports microwave research.

Table I–11 Material Disposal Area AB Test and Support Shaft Depths

Area 1	*Area 2*	*Area 2A*	*Area 2B*	*Area 3*	*Area 4*
1-A 58 [a]	2-A 54	2A-E 58	2B-A 58	3-A 87	4-A 88
1-B 31	2-B 54	2A-J 58	2B-B 58	3-B 57	4-B 101
1-C 51	2-C 30	2A-O 58	2B-C 57	3-C 88	4-C 58
1-D 31	2-D 57	2A-T 58	2B-D	3-D 88	4-D 108
1-E 50	2-E 53	2A-Y 58	2B-E	3-E 88	4-E 78
1-F 50	2-F 57	2A-Z 57	2B-F	3-F 88	4-F 78
1-G 31	2-G	–	2B-G	3-G 142	4-G
1-H	2-H 57	–	2B-H 58	3-H	4-H 88
1-I 31	2-I 57	–	2B-I	3-I	4-I
1-J 58	2-J 57	–	2B-J 57	3-J 142	4-J 88
1-K 85	2-K 68	–	2B-K	3-K 142	4-K 88
1-L 31	2-L 57	–	2B-L 58	3-L	4-L
1-M 31	2-M 58	–	2B-M	3-M	4-M 88
1-N 31	2-N 57	–	2B-N	3-N	4-N
1-O 85	2-O 57	–	2B-O	3-O	4-O 84
1-P 58	2-P 57	–	2B-P	3-P	4-P 88
1-Q 31	2-Q 57	–	2B-Q	3-Q	4-Q
1-R 31	2-R	–	2B-R	3-R	4-R 78
1-S 31	2-S 57	–	2B-S	3-S	4-S
1-T 58	2-T 57	–	2B-T 78	3-T	4-T 78
1-U 58	2-U 52	–	2B-U	3-U 88	4-U 108
1-V	2-V 57	–	2B-V 58	3-V 88	4-V
1-W 58	2-W 57	–	2B-W	3-W	4-W 78
1-X	2-X 57	–	2B-X 78	3-X	4-X
1-Y 80	2-Y 78	–	2B-Y 58	3-Y 108	4-Y 78
–	–	–	2B-Z 60	–	4-Z 70

[a] Notation: The first set (1-A) identifies the shaft. The second set is the nominal shaft depth in feet.
Note: To convert feet to meters, multiply by 0.3048.

Area 10. The elevator building has been removed. The concrete pad remains, as do concrete radiation shields at the top of the calibration shaft. The entrances to both shafts are covered with concrete blocks. The elevator shaft is open and the calibration shaft has been backfilled. The hydraulic oil reservoir has been removed (LANL 2005c).

Area 11. In 1970 and 1971, radiochemistry structures were decontaminated, demolished, and removed. The subsurface leach field and drain line remain (LANL 1992b).

Area 12. All structures have been removed except for the Bottle House and the Cable Pull Test Facility. Current use of Area 12 is limited to air monitoring and occasional use of portable microwave experimental equipment in the roadway between Areas 10 and 12 (LANL 1992b).

Site Investigations. Site characterization and monitoring began in 1959. Early studies analyzed information from boreholes drilled in and near the experimental areas and from the three observation holes. A 1987 survey found surface contamination at Areas 1, 3, and 4 and in the northeast corner of the Area 2 pad. The contamination was apparently caused by exhumation of contaminated soil by gophers. A 1991 geophysical study in Area 4 was limited by interference from the chain-link perimeter fence and from buried metallic debris. Additional site investigations have been conducted for Areas 5, 6, 11, and 12 up to the early 1990s as summarized in the RFI Work Plan for Operable Unit 1144 (LANL 1992b).

More recent site investigations are summarized below.

Areas 1, 2, 2A, 2B, 3, and 4. The Phase I RFIs in 1993 and 1994 included installation and sampling of four shallow and three deep boreholes and collection of surface samples at Area 2. In 1999, an interim measure and best management practices program was conducted at Areas 2, 2A, and 2B and the contaminated area northeast of Area 2 (LANL 2005c).

Area 5. A 1995 Phase I RFI was conducted at AOC 49-008(a). The RFI report recommended no further action, although it indicated that the site would be evaluated for ecological risks. In 1997, EPA Region 6 nonconcurred with the recommendation and recommended additional characterization. During 1995, a Phase I RFI was conducted at the Area 5 sump (SWMU 49-006). Based on a human health risk-based screening assessment, the RFI report recommended no further action, although it indicated that the site would be evaluated for ecological risks. EPA concurred with the recommendation. In 2002, a Supplemental Sampling and Analysis Plan for Areas 5, 6, and 10 was prepared (LANL 2005c).

Area 6. In 1995, a Phase I RFI was conducted at the open burning/landfill area (SWMU 49-004). The RFI report recommended no further action, although it indicated that the site would be evaluated for ecological risks. EPA Region 6 nonconcurred with the recommendation and called for Phase II sampling. In 1996, a Phase I RFI was conducted for AOC 49-008(b) (LANL 2005c).

Area 10. In 1995, a Phase I RFI was conducted at the experimental chamber and shaft (AOC 49-002). The RFI report recommended no further action, although it indicated that the site would be evaluated for ecological risks. EPA Region 6 concurred with the recommendation (LANL 2005c). Regarding the nearby landfill (SWMU 49-005(a)), a Phase I RFI was conducted during 1995 and 1996 (LANL 2005c).

Area 11. A 1995 Phase I RFI for the area of soil contamination (AOC 49-008(c)) performed radiation surveys and collected surface and subsurface samples. No further action was recommended, although the RFI report indicated that the site would be evaluated for ecological risks. EPA Region 6 nonconcurred with the recommendation (LANL 2005c). Regarding the leach field (SWMU 49-003), 13 shallow subsurface samples were collected during a 1995 Phase I RFI (LANL 2005c).

Area 12. In 1995, Phase I RFI sampling found radiation levels above background values at four survey points around the Bottle House. Copper and silver were found above background values in soil samples. Radionuclides were found above background values and uranium was present above screening action levels. Five organic chemicals were found. In 1997, a voluntary corrective action was conducted to remove the soils around the Bottle House. Additional soil removal occurred in 1998 (LANL 2005c).

I.2.5.4 Technical Area 50: Material Disposal Area C

TA-50 is on Mesita del Buey. TA-50 was developed for waste management activities because of limitations in disposal capacity in other areas, because of a plan to develop LANL to the south, and because of the 1948 fire in MDA B (see Section I.2.5.2.2). TA-50 includes inactive MDA C (**Figure I–13**) (DOE 1999a, LANL 1999b, 2006k).

History of MDA C. MDA C is adjacent to waste management facilities to the north, while Ten Site Canyon is to the northeast.

MDA C was used from 1948 to 1965. In 1963, the Radioactive Liquid Waste Treatment Facility (Building 50-1) was built to the north of MDA C. Additional facilities near MDA C include the Waste Characterization, Reduction, and Repackaging Facility (Building 50-69), built in 1983.[21] Liquid wastes from these facilities are piped to the Radioactive Liquid Waste Treatment Facility (LANL 1992c).

MDA C (SWMU 50-009) comprises seven pits, including one chemical pit, and 108 shafts. The disposal units are within a site covering 11.8 acres (4.8 hectares) (LANL 1999b). All pits and shafts were dug into the overlying soil and the Tshirege Member of the Bandelier Tuff (LANL 2003k). The MDA C disposal unit dimensions and periods of operation are shown in **Table I–12** (LANL 2003k). Except for 10 shafts, all disposal units are unlined. The shafts were placed in three groups. The first group of 12 shafts was dug between and parallel to Pits 4 and 5; the second group of 55 shafts was dug between and parallel to Pits 1 and 3; the third group of 40 shafts was dug in two lines perpendicular to the western ends of Pits 1 through 5. The strontium-90 disposal shaft was dug at the southwest corner of Pit 1 (LANL 2003k). (Shaft designation numbers do not reflect their sequence of use.)

Limited disposals may have been made following 1966. The last mention of MDA C in quarterly and annual waste disposal reports was in 1968. The last shaft (Shaft 89) was plugged on April 8, 1974 (Rogers 1977).

The pits were filled with wastes arriving in a variety of containers (Rogers 1977). Routine radioactive trash consisted of cardboard boxes, 5-mil plastic bags from chemistry laboratories, and 55-gallon (0.21-cubic-meter) barrels of sludge from wastewater treatment plants in TA-21 and TA-45 (LANL 2003k). Nonroutine waste included debris from the demolition of the Bayo Site and TA-1, classified materials, and tuballoy (a uranium alloy) chips (LANL 2003k). Hazardous constituents and uncontaminated classified material were buried with radioactive waste. A 1959 memorandum complains that much of the waste in one of the pits (probably Pit 6) was outdated technical badges and safety film. Chemicals were commonly burned in the chemical pit (Rogers 1977).

[21] Not shown in Figure I–13 is the Radioactive Materials Research, Operations, and Demonstration Facility (Building 50-37), built in 1975. The facility is now called the Actinide Research and Teaching Integration Center.

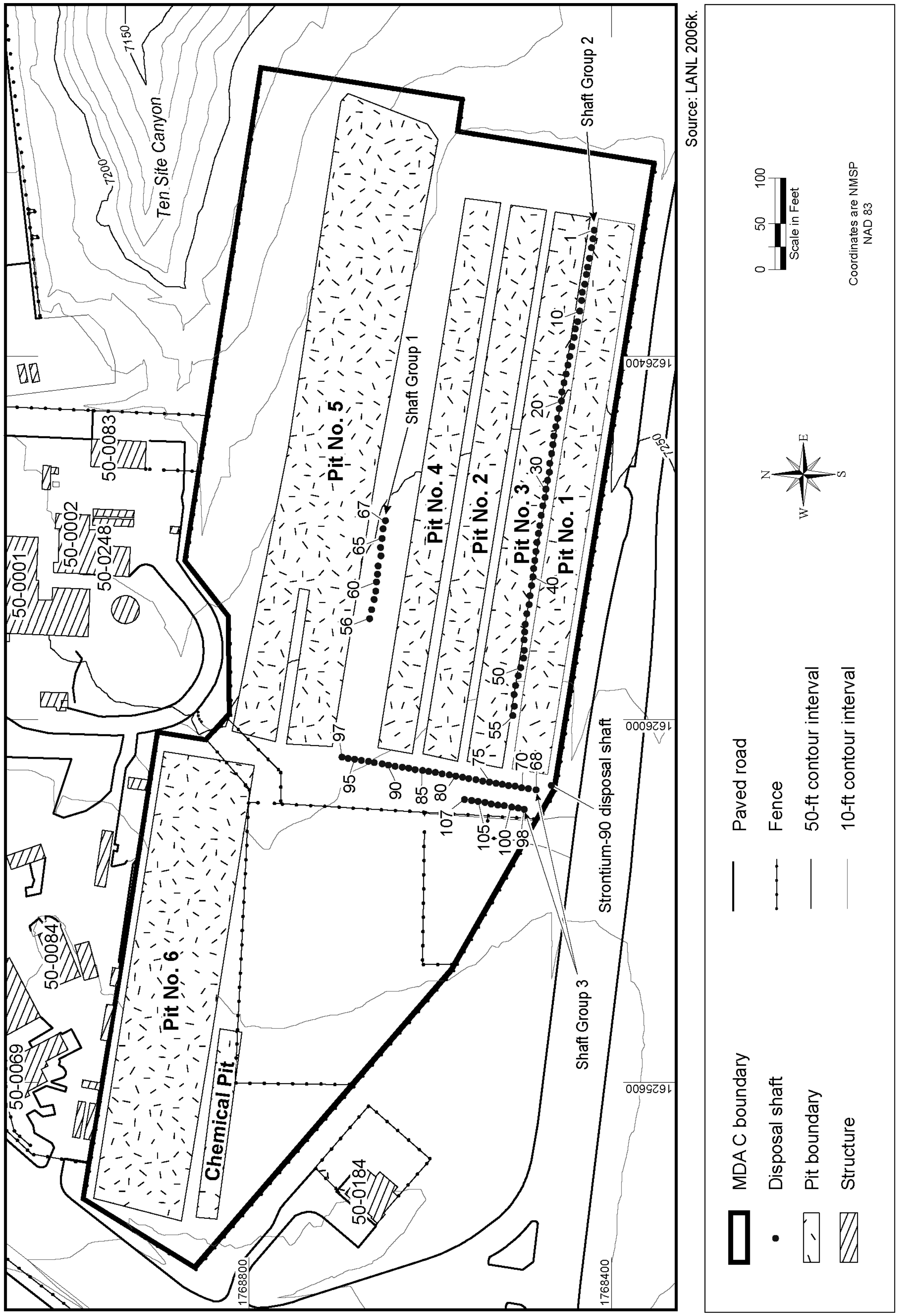

Figure I–13 Locations of Pits and Shafts at Material Disposal Area C

Table I–12 Approximate Dimensions of Material Disposal Area C Disposal Units

Disposal Unit	Dimensions (feet) [a]	Period of Operation
Pit 1	610 × 40 × 25	1948 to 1951
Pit 2	610 × 40 × 25	1950 to 1951
Pit 3	610 × 40 × 25	1951 to 1953
Pit 4	610 × 40 × 25	1951 to 1955
Pit 5	705 × 110 × 18	1953 to 1959
Pit 6	505 × 100 × 25	1956 to 1959
Chemical Pit	180 × 25 × 12	1960 to 1964
Shaft Group 1 (12 shafts; numbers 56-67)	2 × 10	1959
Shaft Group 2 (55 shafts; numbers 1-55)	2 × 15	1959 to 1967
Shaft Group 3 (40 shafts; numbers 68-107)	1-2 × 20-25 [b]	1962 to 1966
Shaft 108 (strontium-90 disposal shaft)	Unknown	1950s or 1960s

[a] Pit dimensions are length by width by depth; shaft dimensions are diameter by depth. Dimensions are approximate.
[b] Shafts 98-107 are 1 foot in diameter and are lined with 12-inch thick concrete. Shafts 68-97 are 2 feet in diameter and are unlined.
Note: To convert feet to meters, multiply by 0.3048.
Source: LANL 2003k.

At first, the waste was covered once a week to reduce the danger of fire, but operating practices were changed in 1957. Wastes were then backfilled when a single layer of waste covered about half the width of the pit, reducing the risk of fire as well as the amount of waste that could be placed in a pit (Rogers 1977). The MDA C Investigation Work Plan references a 1959 memorandum stating that Pit 6 received 10,000 cubic yards (7,645 cubic meters) of waste and 24,000 cubic yards (18,300 cubic meters) of fill, for an approximate ratio of 2.5 cubic yards (1.9 cubic meters) of fill to 1 cubic yard (0.76 cubic meters) of waste (LANL 2003k).

The shafts were used for disposal of "beta-gamma waste," mostly from the Chemical Metallurgy Research Building at TA-3 (Rogers 1977, LANL 2003k). Before February 1958, when the first shafts were drilled, beta-gamma waste was taken to a disposal pit where the waste was placed in a hole dug into the bottom of the pit and covered. After the shafts were opened, containers of waste were transported to the disposal area in lead transfer casks and dropped into the disposal shafts. By 1967, filled disposal shafts were routinely topped with concrete (Rogers 1977).

Five fires occurred at MDA C between 1950 and 1958. The first, in November 1950, involved material that had been placed in one of the pits. The second, in June 1952, involved one box as it was being unloaded. The third, in March 1953, involved containers that had been placed in the pit prior to being covered with backfill. The fourth, in April 1953, involved a single, smoking box from Sigma Building. The final fire, in November 1958 involved two boxes; the suspected cause was the presence of a volatile, flammable chemical such as acetone (Rogers 1977).

In 1974, most of the MDA C surface was covered with crushed tuff and fill, and the new surface was recontoured and seeded with grass. Localized surface subsidence on the north boundary of Pit 6 was seen in 2002. The subsidence produced a hole along an asphalt drainage carrying runoff to Ten Site Canyon and may have promoted infiltration of stormwater into Pit 6. The subsidence was mitigated (LANL 2003k).

Waste Inventory. Table I–13 lists the wastes that were placed into each of the pits and three shaft groups, based—except for the chemical pit—on Los Alamos Scientific Laboratory logbooks (LANL 2003k). No information is available for the strontium-90 shaft.

Table I–13 Los Alamos Scientific Laboratory Logbook Citations of Wastes Placed in Pits and Shafts

Pit 1	Trichloroethylene, boron, sulfuric acid, graphite, medical laboratory solutions, contaminated materials and trash, tritium, americium-241, uranium, classified material, plutonium, cyanide, radium-226, acids, lead, and waste oil.
Pit 2	Trichloroethylene and contaminated materials and trash, boron, tritium, americium-241, uranium, sulfuric acid, biological waste, graphite, classified material, plutonium, cyanide, mercury, radium-226, acids, lead, and waste oil.
Pit 3	Mercury teplers, tritium-contaminated glassware, cyanide solutions, contaminated materials and trash, trichloroethylene, boron, americium-241, uranium, sulfuric acid, biological waste, graphite, classified material, plutonium, radium-226, acids, lead, waste oil, and beryllium.
Pit 4	Tritium-contaminated glassware and boxes, tritium contaminated urine samples, mercury teplers, actinium-227, vials of radium-226, cyanide and cyanide solutions, a 5-gallon can of actinium waste, empty bottles, contaminated materials and trash, trichloroethylene; boron, americium-241, uranium, sulfuric acid, biological waste, graphite, classified material, plutonium, acids, lead, waste oil, silver, and beryllium.
Pit 5	Batteries (acids and lead), a 5-gallon can of actinium-227 waste, lead bricks, vials of radium-226, zirconium shavings, cyanide and cyanide solutions, radionuclide-contaminated boxes and urine samples, contaminated materials and trash, trichloroethylene, boron, americium-241, uranium, sulfuric acid, biological waste; graphite, classified material, and plutonium.
Pit 6	Radionuclide-contaminated oil, tritium-contaminated oil, copper sheets, cobalt chips, bottles of cadmium-boron tungstate, tritium-contaminated boxes and cans, a can of oil, about 100 curies of cobalt-60, a lanthanum source, 10 bottles of platinum chloride, beryllium chips, carbon-14-contaminated graphite, a plutonium slug, contaminated materials and trash, classified material, mercury, actinium-227, radium-226, acids, and lead.
Chemical Pit	No logbook entries were made. A 1964 memorandum provides this summary: "…A variety of chemicals, pyrophoric metals, hydrides and powders, sealed vessels containing sodium-potassium alloy or compressed gasses, and equipment not suitable for salvage, public dump or the contaminated dump have been placed in the pit. No high explosives have ever been disposed of in this pit. Natural uranium powders and hydrides have been disposed of in this pit. Inadvertently, some plutonium-contaminated objects were placed in the pit but have long since been covered. Because of the uranium disposed it should be assumed that the pit is mildly alpha contaminated" (Rogers 1977).
Shaft Group 1 (Shafts 56-67)	Barium, tritium, radium, lanthanum-140, strontium-89 and -90, tantalum, cerium waste, two cerium sources, fission products, one lanthanum-140 static source, phosphoric acid, depleted uranium, a charcoal trap, and polonium-beryllium-fluorine compounds.
Shaft Group 2 (Shafts 1-55)	Barium-140, lanthanum-140, fission products from the Omega reactor, uranyl phosphate, graphite slugs, a cobalt-60 capsule, radioactive graphite, radioactive tantalum, 1 gram of irradiated plutonium, thallium, irradiated uranium, graphite, lead-beryllium sources, thorium, cesium, strontium, plasma thermocouples, fuel elements (rods), cobalt-60 slugs and sources, sulfuric acid solution, zirconium carbide, a copper sphere, two "rabbit" tubes [a] of beryllium, reactor seals, alpha emitters in solution, acid solutions, actinium components, various uranium isotopes, depleted uranium, cerium-141, yttrium, silver-110, sodium-22, cesium-137, cesium-144, plutonium waste, oralloy (enriched uranium from Oak Ridge), benzene, isopropyl alcohol, neptunium-237, contaminated materials and trash, americium-241, biological waste, classified material, radium-226, lead, silver, and "induced activity" (activation products, usually from a linear accelerator).
Shaft Group 3 (Shafts 68-107)	Plutonium-contaminated trash, fission products, aluminum sheets and tubes, acids, cesium-137, sodium, cobalt-60, antimony, lanthanum-140, cobalt-60 sources, polonium, beryllium, vacuum pump oil, empty glass bottles, graphite, plutonium, boron, fuel element end caps, thermocouples, acetone, uranium, zirconium carbide, zinc and aluminum residues, barium, irradiated tantalum, tuballoy (a uranium alloy), shell waste, yttrium-91, radioactive chemicals and organic solutions, hydrochloric acid waste, plutonium in ether solution, zinc and mercury solutions, depleted uranium chips, miscellaneous sources, oralloy solution, iridium-192, tantalum, indium-114, animal tissues, solvents, a LAMPRE (Los Alamos Molten Plutonium Reactor Experiment) rod assembly, waste oil, detonator components, NRX (Navy experiment) reactor parts, trinitrotoluene (TNT) element samples, americium-242, aluminum-105 (sic), zinc-65, neptunium-237, contaminated materials and trash, americium-241, classified material, actinium-227, radium-226, lead, silver, strontium-90, and "induced activity."

[a] Rabbits are containers placed in a reactor neutron flux to irradiate the contents.

Note: To convert gallons to liters, multiply by 3.7854; grams to ounces, multiply by 0.03527.
Data are as stated in the source document.

Source: LANL 2003k.

Radionuclide inventories estimated for the pits and shafts, decay corrected to January 1989, are listed in **Table I–14** (LANL 1992c). These inventories are derived from information in (Rogers 1977). Table I–14 (LANL 1992c) does not list any citation for transuranic isotopes in the MDA C shafts, although a 1999 DOE database on buried transuranic waste (DOE 1999g) estimates 57 curies of plutonium-239 in MDA C shafts.

Table I–14 Material Disposal Area C Estimated Radionuclide Inventories as of January 1989

Disposal Unit	*Radionuclide*	*Activity (curies)*
Pits	Uranium-234, -235, -236, -238	25
	Plutonium-239	26
	Americium-241	145
	Total	**196**
Shafts	Tritium	20,000
	Sodium-22	0.58
	Cobalt-60	2.4
	Strontium-90/Yttrium-90	21
	Radium-226	1
	Uranium-233	5
	Uranium-234, -235, -236, -238	<0.1
	Fission products [a]	50
	Activation products [a]	200
	Total	**20,280**

[a] Uncorrected because exact compositions are unknown.
Source: LANL 1992c.

Current Configuration. The topography slopes from west to northeast, becoming steeper across the northeast quadrant of the site toward Ten Site Canyon. The site is vegetated by grass established after the 1984 addition of fill and topsoil over the disposal units (LANL 2003k).

The area south of Pit 6 and west of Pits 1 through 6 is covered with asphalt, as is much of the ground north of the MDA not occupied by buildings. The MDA is fenced. Many of the buildings and structures north of MDA C are SWMUs. Underground utilities run along and outside the fence line (LANL 2003k), including a water line along Pajarito Road and a radioactive liquid waste line along the west half of the northern site boundary. A new pump house and effluent storage facility is being built 30 feet (9.1 meters) north of the MDA boundary between TA-50 and TA-35 (Stephens 2005).

Geophysical surveys were conducted in 1994, 2001, and 2002. All seven pits probably extend beyond the boundaries shown on historical maps. Pits 1 through 4 extends farther to the east, and Pit 6 possibly extends to the fence on the north side of MDA C.[22] Shafts 98 through 107 were found to correlate with historical data. Neither the other two shaft fields nor the strontium-90 shaft were identified (LANL 2003k).

The 2001 geophysical survey found east-west trending conductivity anomalies that generally coincided with expected pit locations. No anomalies could be positively attributed to the shafts. The cover thicknesses over Pits 1 through 6 ranged from about 2.5 feet (0.8 meters) to about 8 feet (2.4 meters). The depth of cover over Shaft Groups 2 and 3, the western ends of Pits 1 through 4, and the chemical pit was less than 1 foot (0.3 meters)[23] (LANL 2003k).

Site Investigations. Radiation surveys of site soils and vegetation occurred from 1976 through 1984. Additional field surveys and laboratory analyses followed the 1984 placement of crushed tuff and cover material (LANL 1992c, 2003k). The Phase I RFI (1995 through 2003) sampled surface soil, subsurface tuff, and pore gas. A 2003 study obtained samples from 29 ant mounds and small-mammal burrow spoils and from 16 trees growing on the site. All trees were removed. The Phase I site investigations concluded (LANL 2003k):

- Historical releases of radionuclides to surface soils had been largely covered with crushed tuff. Elevated concentrations of americium-241 and isotopic plutonium in surface soils in the northeast area of MDA C were likely from releases from MDA C before placement of the crushed tuff in 1984.
- The only metals detected in concentrations above their respective background values in surface soil were lead and silver. There were sporadic detections of semivolatile organic compounds and Aroclor-1254 and -1260, but no defined pattern was found nor evidence for widespread release of organic chemicals.
- Specific metals (including barium, copper, and lead) and radionuclides (strontium-90 and americium-241) were found in tuff beneath the disposal pits. The extent of this subsurface contamination was not sufficiently defined.
- Subsurface pore gas contains tritium and volatile organic compounds (mainly trichloroethylene, tetrachloroethene, and 1,1,1-trichloroethane). The vertical and horizontal extent of contamination was not sufficiently defined.
- Surface flux of volatile organic compounds and near-surface tritium soil gas concentrations indicated localized areas where releases to the atmosphere were occurring.

[22] The 1994 survey indicated that Pit 6 may possibly extend beyond the fence at the east end of the pit (LANL 2003a). However, a photograph confirms the proximity of the northern edge of Pit 6 to the north perimeter fence (Rogers 1977).
[23] A map showing the variable thickness of cover across MDA C is available in the Investigation Work Plan for MDA C (LANL 2003a) and in a survey of source materials for capping the MDAs (Stephens 2005).

Further work was proposed in the 2003 MDA C Investigative Work Plan to determine: (1) the extent of metals, cyanide, and radionuclide contamination in tuff beneath Pit 6; (2) the concentrations and spatial extent of volatile organic compounds and vapor phase tritium in the subsurface tuff; (3) the nature and extent of potential releases of metals, cyanide, and radionuclides beneath pits and shafts; (4) the extent of radionuclide contamination in surface soil on the eastern boundary of MDA C; (5) the presence of perchlorate, nitrate, dioxin, and furan in tuff; (6) the presence of perched groundwater beneath MDA C; and (7) information on hydrogeologic properties and fracture characteristics (LANL 2003k). The MDA C Investigation Report (LANL 2006k) was completed and submitted to NMED on December 6, 2006. Additional work is ongoing.

I.2.5.5 Technical Area 54: Material Disposal Areas G, H, and L

TA-54 is on Mesita del Buey, which spans the boundary of the Cañada del Buey and Pajarito Canyon Watersheds. The northern border is the boundary between LANL and the San Ildefonso Pueblo; its southeastern boundary borders White Rock (LANL 1999b). The primary function of TA-54 is management of radioactive and hazardous chemical wastes. It contains more than 100 structures (DOE 1999a). The facilities at TA-54 are grouped in different areas according to the types of waste managed (see **Figure I–14**). Areas and MDAs in TA-54 include:

- *Area G*. The current Area G footprint comprises a 63-acre (25.5-hectare) site used since 1957 (LANL 2005h). It includes MDA G, a site having numerous subsurface disposal pits and shafts that are the subject to Consent Order investigations, as well as active low-level radioactive waste disposal operations. It includes above- and belowground transuranic waste storage areas; a facility for decontaminating radioactive waste containers; compactors for transuranic and low-level radioactive waste; an administrative support building; and numerous other structures. Because of space and regulatory consideration, low-level waste disposal operations will be expanded into Zones 4 and 6 at Area G (64 *Federal Register* [FR] 50797); other waste management activities will be transferred to other LANL locations.

- *TA-54 West*. TA-54-West is the site of the Radioassay and Nondestructive Testing Facility, used to determine characteristics of containerized transuranic waste and to prepare the containers for shipment to WIPP.

- *Area L*. This 2.6-acre (1.1-hectare) area is LANL's chemical waste management area. Area L includes MDA L, a site formerly used for subsurface disposal of chemical wastes, and currently subject to Consent Order investigations.

- *MDA H*. This MDA consists of nine inactive shafts used until 1986 for disposal of classified radioactive wastes. The area is being remediated pursuant to the Consent Order.

- *MDA J*. This 2.65-acre (1.1-hectare) MDA was used from 1961 until 2001 for disposal of solid wastes. The six pits at MDA J are covered with clean fill and all four shafts are capped. An asbestos transfer station has been removed. MDA J has undergone closure under the New Mexico Solid Waste Act of 1990, and is under postclosure monitoring.

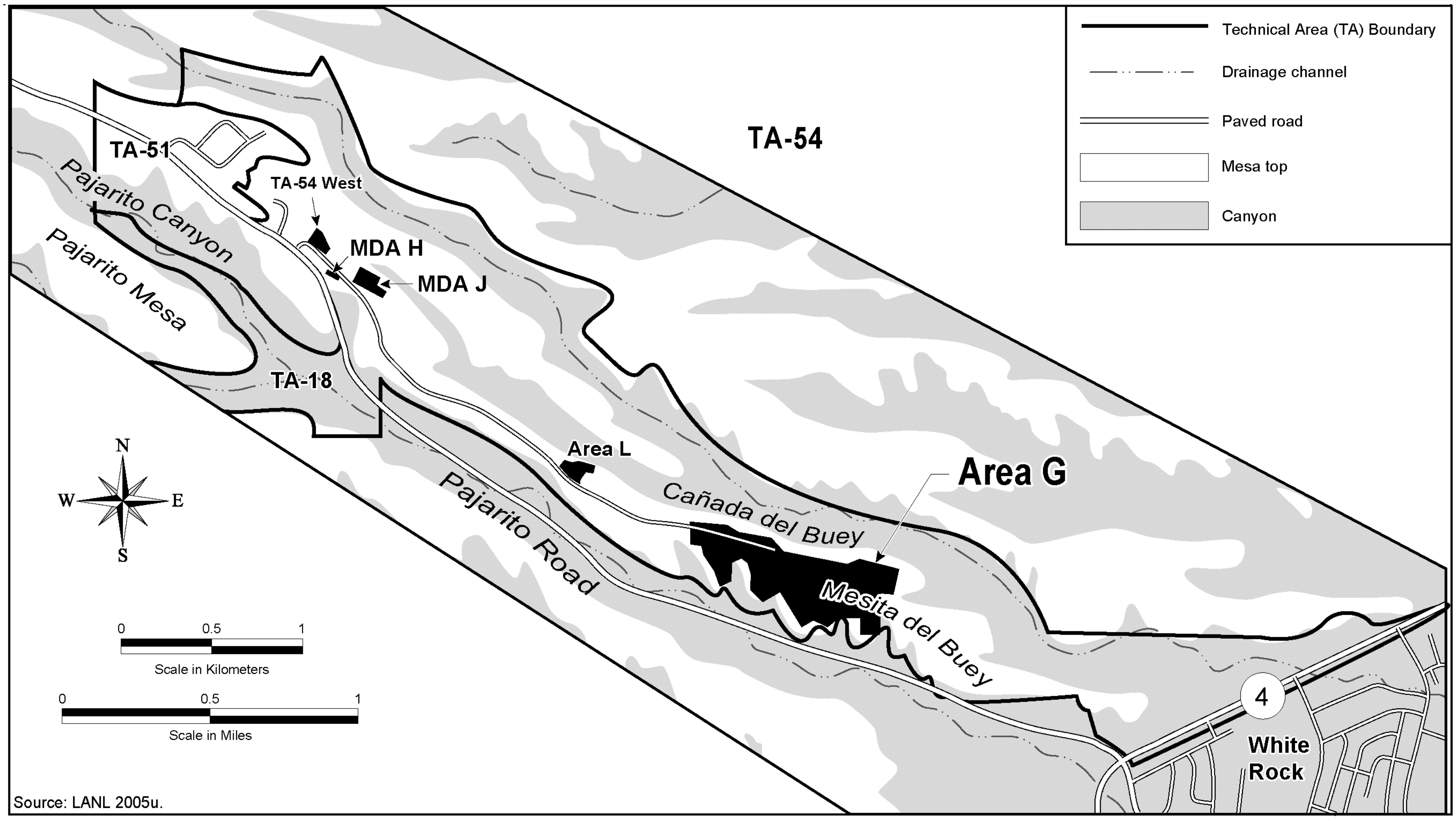

Figure I–14 Area and Material Disposal Area Locations of Technical Area 54

I.2.5.5.1 Material Disposal Area G

Within Area G, MDA G includes subsurface disposal units containing radionuclides and hazardous constituents under RCRA, and subsurface storage units for transuranic waste. The Investigation Work Plan for MDA G identified 32 pits, four trenches, and 194 shafts having depths ranging from 10 to 65 feet (3 to 20 meters) below the ground surface (LANL 2004c). **Figure I–15** shows existing waste areas within the existing Area G footprint (LANL 2005h).

Figure I–15 Waste Management Areas within the Existing Area G Footprint in Technical Area 54

History of MDA G. Disposal began during the 1950s. Up until the early 1970s, some of the waste disposed of at Area G contained transuranic isotopes in concentrations exceeding 10 nanocuries per gram, and some contained nonradioactive hazardous constituents. After DOE began retrievably storing wastes suspected of containing transuranic isotopes exceeding 10 nanocuries per gram, low-level radioactive waste disposed of in Area G contained significantly smaller quantities of transuranic isotopes,[24] but, until July 1986, still contained nonradioactive hazardous constituents (LANL 1997). Thereafter, disposal of mixed low-level radioactive waste was discontinued, but low-level radioactive waste and radioactively contaminated PCB waste continued to be disposed of in Area G (LANL 2004c). MDA G comprises those disposal units of Area G that are subject to corrective action under the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act.

[24] The transuranic limit for DOE disposal of low-level radioactive waste was revised in the early 1980s from 10 to 100 nanocuries per gram.

Tables I–15 and **I–16** describe the dimensions, operational periods, and wastes placed into MDA G pits and trenches (LANL 2004c). **Table I–17** summarizes information about the shafts (LANL 1992a).[25] The trenches are used for retrievable storage of contact-handled transuranic waste. The shaft diameters range from 1 to 6 feet (0.3 to 1.8 meters) (LANL 2004c).

Table I–15 Material Disposal Area G Pits

Pit Number	*Operational Period*	*Dimensions (feet) (length by width by depth)*	*Pit Volume* [a] *(cubic yards)*	*Waste Volume* [a] *(cubic yards)*	*Waste Description*
1	1/59-4/61	616 × 113 × 20	37,080	5,529	Wing tanks from Kirtland Air Force Base, dry boxes, "normal trash." Pit used to burn combustibles.
2	4/61-7/63	618 × 104 × 26	42,911	6,407	Classified Bendix waste, 55-gallon drums, property numbers, D-38, hot dirt.
3	6/63-3/66	655 × 115 × 33	56,759	9,473	Misc. material, lumber, pipe, 55-gallon drums, D&D, D-38, Bendix classified waste, soil from TA-10/Bayo Canyon.
4	1/66-12/67	600 × 110 × 34	44,950	8,212	D&D, graphite, wooden boxes, D-38, 55-gallon drums, classified Bendix waste, property numbers. Burning trench along south wall of pit.
5	1/67-3/74	600 × 100 × 29	41,258	6,624	Scrap material, D&D, graphite hoppers, sludge drums (possibly aqueous solution from TA-50), property numbers.
6	1/70-8/72	600 × 113 × 26	43,933	6,696	Misc. scrap, wood, D&D. Covered with topsoil from TA-1 with up to 20 picocuries per gram plutonium contamination.
7	3/74-10/75	600 × 50 × 30	17,101	4,343	Low-level transuranic waste. Replaced Pit 17 for low-level transuranic waste in 1974. Covered with topsoil from TA-1 with up to 20 picocuries per gram plutonium contamination.
8	9/71-5/74	400 × 25 × 25	6,528	2,311	55-gallon drums of sludge from H-7 and nonretrievable transuranic waste. Also drums from TA-50 (aqueous and nonretrievable transuranic waste).
9 [b]	11/74-11/79	400 × 30 × 20	9,027	(b)	Drums and fiberglassed crates containing retrievable transuranic wastes (>10 nanocuries per gram plutonium-239 or uranium-233 or >100 nanocuries per gram plutonium-238).
10	5/79-3/80	380 × 57 × 27	15,549	4,016	Building debris, lab wastes, sludge drums (from TA-50 dewatering, possibly aqueous).
12	9/71-12/75	400 × 25 × 25	7,303	2,363	Transuranic-contaminated residual material. Originally contained retrievable transuranic waste that was transferred to Pit 9.
13	11/76- 9/77	400 × 42 × 28	12,107	1,931	Uranium, mixed fission and activation products. Uranium fission products and induced-activity wastes.
16	9/71-8/75	400 × 25 × 25	8,081	2,235	Crates and drums containing uranium-contaminated wastes.
17	8/72-3/74	600 × 46 × 24	17,399	4,962	Low-level plutonium transuranic waste, <10 microcuries per gram. Miscellaneous scrap wastes, crates, filter plenums.
18	2/78-8/79	600 × 75 × 40	46,685	12,358	Contaminated dirt, lab wastes, noncompactible waste, D&D, drums.

[25] *Additional shaft information is available in Table B-3 in the Investigation Work Plan for MDA G (LANL 2004c).*

Pit Number	*Operational Period*	*Dimensions (feet) (length by width by depth)*	*Pit Volume [a] (cubic yards)*	*Waste Volume [a] (cubic yards)*	*Waste Description*
19	11/75-8/79	153 × 30 × 18	1,371	(c)	Asbestos and carcinogens, plastic layer placed in bottom.
20	11/75-10/77	600 × 71 × 36	37,454	14,899	Lab waste, oil, sludge drums, trash, contaminated dirt.
21	8/72-12/74	402 × 56 × 26	13,328	3,607	Uranium, classified material, boxes, drums, scrap metal.
22	9/76-3/78	413 × 56 × 33	17,690	3,744	Filter plenum, sludge drums (possibly aqueous from TA-50), lab waste, graphite fuel rods, contaminated dirt.
24	5/75-11/76	600 × 58 × 30	23,388	7,327	Graphite, lab wastes, 22 truck loads of soil. Uranium, tritium, mixed fission and activation products.
25	1/80-5/81	395 × 103 × 39	47,000	6,530	Reactor control rods, D&D, scrap drums, lab wastes, test drums, PCB-contaminated waste forms.
26	2/84-2/85	310 × 100 × 36	22,209	4,312	Building debris, transuranic waste culverts, asbestos, alpha box soil, lumber, PCBs.
27	5/81-/82	400 × 80 × 46	26,946	7,441	Lab waste, contaminated soil and pipe, D&D, PCBs, and unknown chemical waste.
28	12/81-4/83	330 × 83 × 40	21,381	4,422	Barium nitrate, PCB soil, lab waste, property numbers, transformers, clay pipes, building debris, uranium graphite.
29 [d]	10/84-10/86	658 × 80 × 50	45,795	9,784	Retrievable transuranic-waste-contaminated cement paste, D&D soil, gloveboxes, plywood boxes, asbestos, PCBs, and unknown chemical waste.
30	10/88-6/90	568 × 39 × 35	42,843	13,464	Asbestos, PCBs, and unknown chemical waste.
31	6/90-3/03	280 × 52 × 25	(c)	2,702	Asbestos, mixed fission and activation products.
32	11/85-8/87	518 × 74 × 51	36,364	5,367	PCB asphalt, transformers, building debris, contaminated soil, gloveboxes, plywood boxes, capacitors.
33	11/82-7/84	425 × 115 × 40	59,930	7,776	Beryllium in stainless steel, lab waste, building debris, asbestos, noncompactible trash, PCBs, and unknown chemical waste.
35	6/87-2/88	363 × 83 × 40	20,957	3,361	Trash, plywood boxes, asbestos, lab waste, PCBs, and unknown chemical waste.
36	1/88-12/88	435 × 83 × 43	28,057	4,491	Plywood boxes, compactible N.N. trash, rubble, building waste, beryllium, and PCB-contaminated soil (less than 200 parts per million).
37	4/90-4/97	731 × 83 × 61	57,213	24,299	UHTREX reactor vessel and stack, asbestos, PCBs, and unknown chemical waste.
Total			902,668	200,997	–

D-38 = depleted uranium, D&D = decontamination and decommissioning, TA = technical area, PCB = polychlorinated biphenyl, UHTREX = ultra-high-temperature reactor experiment.

[a] Pit Volume = pit volume as field measured; Waste Volume = approximate volume of waste placed in pit.

[b] Pit 9 contains disposed waste and 55,090 cubic feet of contact-handled transuranic waste stored above the pit under a soil cover.

[c] No information available.

[d] Stored above Pit 29 under a soil cover is contact-handled transuranic waste.

Note: To convert cubic feet to cubic meters, multiply by 0.028317, cubic yards to cubic meters, multiply by 0.76456; feet to meters, multiply by 0.3048; gallons to liters, multiply by 3.7854.

Source: LANL 2004c.

Table I–16 Material Disposal Area G Trench Information

Trench Number	*Operational Period*	*Dimensions (feet) (length by width by depth)*	*Waste Description*
A	1974	262.5 × 12.75 × 8	Heat sources containing plutonium (80 percent plutonium-238) and disposed of in casks. Average of 18 grams plutonium-238 per cask, with a maximum of 40 grams.
B	1974 to 1976	218.75 × 12.75 × 8	
C	No information	218.75 × 12.75 × 10 (estimate)	
D	No information	250 × 12.75 × 10 (estimate)	

Note: To convert feet to meters, multiply by 0.3048; grams to ounces, multiply by 0.035274.
Source: LANL 2004c.

Table I–17 Material Disposal Area G Summary Shaft Information

Data Status	*Shaft Number*
High tritium	6, 7, 15, 16, 39, 50, 59, 61, 136, 137, 150-159
Unknown tritium inventory	3, 4, 8-11, 22, 30, 32, 60, 81, 104, 121, 132
High cobalt-60 inventory	22, 23, 97, 102, 108, 122
Unknown cobalt-60 inventory	95, 128
High MAP-MFP [a] inventory	1, 2, 28, 58, 94, 98, 100, 107, 110, 114, 120, 126, 139, 141, 189-192, 196
Generally unknown values of radionuclides	34, 37, 39, 56, 57, 70, 82, 84, 85, 118, 135, 138, 140
Generally high radionuclide activity	129, 133
Generally unknown activity (less than 150 curies)	12, 13, 14, 24, 25, 27, 36, 40-42, 45, 47, 52-55, 68, 69, 72, 74, 75, 77, 78, 79, 80, 83, 87, 93, 103, 106, 112, 115, 124, 134
Activity generally known (less than 20 curies)	5, 17-21, 26, 29, 31, 33, 35, 38, 43, 44, 46, 48, 49, 51, 62-67, 71, 76, 86, 88-92, 96, 99, 101, 105, 109, 111, 119, 123, 125, 127, 130, 131, 160, 206
Polychlorinated-biphenyl-contaminated oil	C1-C13
Transuranic waste storage	200-232, 235-243, 246-253, 262-266, 302-306

[a] MAP-MFP: mixed activation products or mixed fission products.
Source: LANL 1992a.

Table I–18 organizes the disposal units by their SWMU groupings (LANL 2004c).

Table I–18 Material Disposal Area G Solid Waste Management Unit Groupings

Subsurface Disposal and Storage Units	*SWMU*	*Description*
Pit 9	54-014(b)	Pit with retrievably placed transuranic waste
19 pits	54-017	Pits 1-8, 10, 12, 13, 16-22, 24
12 pits	54-018	Pits 25-33, 35-37
Above Pit 19	54-013(b)	Truck decontamination operations that occurred on surface of Pit 19
4 trenches	54-014(d)	Trenches A, B, C, D with retrievably stored transuranic waste
68 shafts	54-020	Shafts C1-C10, C12, C13, 22, 35-37, 93-95, 99-108, 114, 115, 118-136, 138-140, 151-160, 189-192, 196
92 shafts	54-019	Shafts 1-20, 24-34, 38-92, 96, 109-112, 150
34 shafts	54-014(c)	Shafts 200-233
Above Pit 29	54-015(k)	Transuranic waste mound

SWMU = solid waste management unit.
Source: LANL 2004c.

SWMU 54-014(b) is Pit 9. It received retrievable transuranic and mixed transuranic waste from 1974 to 1978. The filled pit was covered with 3.3 feet (1 meter) of crushed and compacted tuff and 4 inches (10 centimeters) of topsoil and reseeded with native grass (LANL 2004c).

SWMU 54-017 and SWMU 54-018 are two sets of pits. Pits comprising SWMU 54-017 are inactive. All but Pit 29 in SWMU 54-018 are inactive. (Although no longer in use, Pit 29 is an active regulated unit until RCRA closure is certified by NMED.) Both sets of pits received a variety of wastes. The filled pits were covered with 3.3 feet (1 meter) of crushed, compacted tuff, covered with 4 inches (10 centimeters) of topsoil, and reseeded with grass (LANL 2004c). Portions of several pits have been covered with concrete and used for purposes such as aboveground transuranic waste storage.

SWMU 54-13(b) was a vehicle monitoring and decontamination area on the surface of Pit 19 in the center of Area G. The area is no longer used (LANL 2004c).

SWMU 54-014(d) consists of four transuranic waste storage trenches. Beginning in 1974, the trenches received transuranic wastes in 30-gallon (0.11-cubic-meter) containers inside concrete casks. The trenches were backfilled with 3.3 feet (1 meter) of crushed tuff, covered with 4 inches (10 centimeters) of topsoil, and reseeded with grass (LANL 2004c).

SWMU 54-020 consists of 68 disposal shafts. Shaft 124 is an active regulated unit pending RCRA closure certification and NMED approval. The shafts contain PCB residues, low-level radioactive waste, and hazardous and mixed wastes. The shafts were filled with waste to within 3 feet (0.9 meters) of the ground surface, backfilled with crushed tuff, and capped with concrete (LANL 2004c).

SWMU 54-019 consists of 92 disposal shafts. The shafts received low-level radioactive waste, chemical and mixed wastes. Disposal shafts were filled with waste to within 3 feet (0.9 meters) of the ground surface, backfilled with crushed tuff, and covered with concrete domes (LANL 2004c).

SWMU 54-014(c) comprises 34 1-foot-diameter (0.3-meter-diameter), 18-foot-deep (5.5-meters-deep), shafts lined with concrete. The SWMU 54-014(c) shafts, now inactive, were used from 1979 to 1987 for transuranic waste. The shafts contain wastes requiring special packaging (mainly tritium), special handling (e.g., high surface-exposure rates), or segregation by activity. The shafts were filled with waste to within 3 feet (0.9 meters) of the ground surface, backfilled, and covered with concrete domes (LANL 2004c).

SWMU 54-015(k) is a layer of retrievable transuranic waste in cement-filled sections of corrugated metal pipes inside a mound of fill above Pit 29 (LANL 2004c). This waste was once stored in MDA T, as discussed in Section I.2.5.2.3.

Disposal units were generally dug, filled, and capped sequentially from the east end of the site to the west. Temporary spring-dome structures on concrete or asphalt pads have been placed over many of the disposal units to support waste operations (LANL 2004c).

Waste Inventory. The performance assessment and composite analysis for Area G contains disposed radionuclide inventories on a pit-by-pit basis and also inventories for groups of shafts in Area G (LANL 1997). **Table I–19** summarizes the hazardous chemical inventories within MDA G as summarized in the MDA G Investigation Work Plan (LANL 2004c).

Table I–19 Material Disposal Area G Hazardous Chemical Inventories

Hazardous Constituent	*Pre-1971 Waste (kilograms)*	*1971 to 1990 Waste (kilograms)*
Aluminum	0	480,000
Arsenic	2.2	380
Barium	520	430
Beryllium	0	19,000
Cadmium	12	1,900
Chromium	96	1,900
Lead	16	230,000
Mercury	1.3	380
Nickel	850	690
Selenium	3.6	3.0
Silver	22	18
Acoclor-1260	0	200

Note: To convert kilograms to pounds, multiply by 2.2046.
Source: LANL 2004c.

Current Configuration. MDA G is within Area G, which, in addition to being the only active low-level radioactive waste disposal facility at LANL, is the focus of several other operations involving radioactive waste, including storage, characterization, and processing by compaction or repackaging of transuranic waste destined for disposal at WIPP; characterization and compaction of low-level radioactive waste before disposal; and storage of mixed low-level radioactive waste destined for offsite treatment or disposal. Portions of the MDA G disposal units are covered with concrete to support Area G waste management activities. Surface runoff from the site is controlled, discharging into drainages to the north to Cañada del Buey, and to the south to Pajarito Canyon. Stormwater and sediment monitoring stations are distributed throughout Area G and in the drainages around Area G (LANL 2006h).

The 63-acre portion of Area G shown in Figure I-15 will be closed to meet the Consent Order deadline for closure of MDA G. The closure approach must integrate and accommodate all applicable regulatory requirements. All storage and disposal units are subject to DOE requirements under the Atomic Energy Act. Many disposal units in Area G are SWMUs and AOCs that comprise MDA G and are subject to corrective action under the Consent Order. Other disposal units are RCRA-regulated disposal units subject to RCRA closure and postclosure care requirements. Low-level waste disposal operations will continue in Zones 4 and 6 at Area G. As analyzed in Appendix H, Section H.3, other waste management activities would be transferred to other LANL locations.

Site Investigations. Early investigations determined the soil moisture characteristic curves; intrinsic permeability and unsaturated hydraulic conductivity of the tuff; infiltration and redistribution of meteoric water in the tuff; presence of core and pore gas in the vadose zone; and presence of perched water. Volatile organic compounds were found in pore gas beneath the MDA. The primary volatile organic compound pore gas constituent was 1,1,1-trichloroethane, present to at least 153 feet (47 meters) below ground surface (LANL 2004c).

MDA G Phase I RFI fieldwork was conducted from 1993 through 2003. The results of these investigations are summarized below (LANL 2004c).

- There were infrequent detections of radionuclides in samples of tuff beneath pits, trenches, and shafts. No pattern of detections was seen from borehole samples.
- There were infrequent detections of inorganic chemicals in samples of tuff beneath the pits, trenches, and shafts. It could not be determined whether inorganic chemicals had been released from the disposal units.
- Tritium had been released into the tuff beneath the disposal units.
- Volatile organic compounds, mainly trichloroethane, were detected in subsurface pore gas.
- Drainage channel sediments contained low concentrations of methoxychlor, americium-241, cobalt-60, plutonium-238, plutonium-239, and tritium. Beryllium, cobalt, mercury, selenium, and silver were not found above background values; however, detection limits for some samples were elevated above background values. Cadmium was found above its background value.
- Volatile organic compounds and tritium were being released into the atmosphere from the subsurface.

The required Investigation Report for MDA G was submitted in September 2005 (LANL 2005q). Thirty-nine boreholes were drilled alongside MDA G disposal units, including two to depths of 556 to 700 feet (169 and 213 meters), respectively. Organic and inorganic chemicals were found beneath the disposal units at trace levels that were generally consistent with results from the Phase I RFI. Naturally-occurring and anthropogenic radionuclides were found above background values in soils and rock samples from beneath MDA G. Generally sporadic detections of americium-241, plutonium-238, plutonium-239, and strontium-90 occurred across the site. Thorium isotopes, uranium,-234, uranium-235, and uranium-238 were found at concentrations within their natural variability in the subsurface. Volatile organic compounds were found in pore-gas samples from 38 of the boreholes, and tritium in pore-gas samples from 35 of the boreholes. The highest concentrations of volatile organic compounds and tritium were from boreholes in the eastern and south-central portions of MDA G. Perched groundwater was not found in any of the boreholes, including the one drilled to 700 feet (213 meters) (LANL 2005q). On July 26, 2006, NMED issued a notice of disapproval for the MDA G Investigation Report (NMED 2006a). On August 31, 2006, LANL staff sent a response to the notice of disapproval agreeing to deepen four existing boreholes to further characterize the vertical extent of organic vapor contamination (LANL 2006e). The results of the pore-gas sampling from boreholes confirmed the results of the Phase I RCRA facility investigations, previous quarterly monitoring, and the 2005 site investigation (LANL 2007a).

In response to a September 13, 2006 letter from NMED about vapor-phase tritium found in increased concentrations with depth in a borehole down-gradient of the active tritium disposal shafts, DOE directed LANL staff to determine whether the trend extends to the basalt layer. The LANL management and operating contractor agreed to increase the depth of a nearby borehole, install equipment to monitor for tritium, and report the results of monitoring to NMED (LANL 2006j). Monitoring results showed that tritium concentrations peaked at 50 feet (15 meters) below ground surface near the base of the nearby 60-foot (18-meter) deep tritium shafts. The concentrations decreased as the sampling depth increased to about 240 feet (73 meters) below ground surface (LANL 2007a).

In July 2007, DOE issued a plan that describes the regulatory basis and the technical approach for performing a Corrective Measures Evaluation at MDA G. The plan identifies specific corrective measure alternatives to be evaluated including source containment or stabilization, source removal, contaminant extraction, or combinations of these alternatives (LANL 2007b). In July 2007, DOE also issued a work plan for implementing an *in situ* soil vapor extraction pilot study at MDA G (LANL 2007c).

I.2.5.5.2 Material Disposal Area H

MDA H (SWMU 54-004) is within a fenced 0.3-acre (0.1-hectare) area of TA-54. Nine shafts were used for disposal of classified waste from 1960 to 1986. A RCRA investigation program was completed and submitted to NMED in 2001, along with an addendum in 2002. A Corrective Measures Study Report for this MDA was completed in May 2003 (LANL 2003b), and an environmental assessment was issued in June 2004 (DOE 2004d).

NMED selected a corrective remedy for MDA H requiring complete encapsulation of the disposal shafts, a soil vapor extraction system, and construction of an engineered evapotranspiration cover (NMED 2007a). The Consent Order also requires collection and analysis of subsurface vapor samples and monitoring of groundwater in canyons potentially affected by MDA H (NMED 2005).

I.2.5.5.3 Material Disposal Area L

MDA L (SWMU 54-006) is within a 2.58-acre (1.0-hectare) site (Area L) north of Mesita del Buey Road between MDA G and MDAs H and J. The land north of MDA L drops steeply away to Cañada del Buey. Pajarito Canyon is to the south. Between about 1959 and 1985, chemical wastes were disposed of within unlined pits and shafts. Since 1986, Area L has stored RCRA waste, PCB waste, and mixed waste such as contaminated lead (LANL 1999b).

History of MDA L. MDA L was used from the late 1950s to 1986 for disposal of containerized and non-containerized nonradiological liquid wastes; bulk quantities of aqueous wastes; treated salt solutions and electroplating wastes, including precipitated heavy metals; and treated lithium hydride. The MDA consists of Pit A; Impoundments B, C, and D for liquids; and 34 shafts (**Figure I–16**). All disposal units are unlined (LANL 1992a, LANL 2003m). The dimensions and operation periods of each of the disposal units are summarized in **Tables I–20** and **I–21** (LANL 2003m). The pit, impoundments, and shafts are collectively identified as SWMU 54-006. Since 1986, Area L has stored RCRA waste, PCB waste, and mixed waste such as contaminated lead (LANL 1999b).

Pit and Impoundments. Pit A had three near-vertical walls on the north, south, and west sides and a ramp on the east side leading to a flat bottom. After being filled to within 3 feet (0.9 meters) of the surface, the pit was covered with crushed tuff in 1978. Impoundments B, C, and D had near-vertical walls on the east and west sides, and ramps on the north and south sides leading to flat bottoms. After Impoundments B and C were decommissioned, residual waste was covered with at least 3 feet (0.9 meters) of crushed tuff (LANL 2003m).

Impoundment D was used for treating small quantities of lithium hydride by reaction with water. The neutralized solutions were evaporated. Treatment was discontinued in 1984. Impoundment D was partially filled with crushed tuff in 1985 and completely filled in 1989. Between 1984 and 1989, aboveground used-oil storage tanks were placed next to Impoundment D (LANL 1992a). The waste oil storage tanks were emptied in 1985 and, in 1989, taken to Area G in TA-54 [26] (LANL 2003m).

Shafts. The 34 shafts range from 3 to 8 feet (0.9 to 2.4 meters) in diameter and from 15 to 65 feet (4.6 to 20 meters) deep. (The depth of most is 60 feet [18 meters].) After layering the bottom 3 feet (0.9 meters) of each shaft with crushed tuff, the shafts were filled with waste to within 3 feet (0.9 meters) of the surface; the remaining void was filled with concrete. Before 1982, liquids were disposed of in containers without adding absorbents. Small containers were often dropped into the shafts. Larger drums were lowered by cranes. Spaces around the drums were filled with crushed tuff, and a 6-inch (15-centimeter) layer of tuff placed between each layer of drums. In early years, uncontainerized liquid wastes were dumped into the shafts. Between 1982 and 1985, only containerized wastes were emplaced. When MDA L was decommissioned in 1986, its surface was partially paved with asphalt for permitted storage of hazardous and mixed wastes (LANL 2003m).

Waste Inventory. Estimates of the waste types and quantities disposed of in MDA L are summarized in the Historical Investigation Report for MDA L (LANL 2003m). Waste disposal records for MDA L are found in un-numbered logbooks. Records before 1974 are incomplete, and many logbooks contain only brief descriptions. Residuals from treatment of wastes in the impoundments may have been left in place (LANL 2003m).

[26] *The tanks were closed in 1990 under RCRA regulations.*

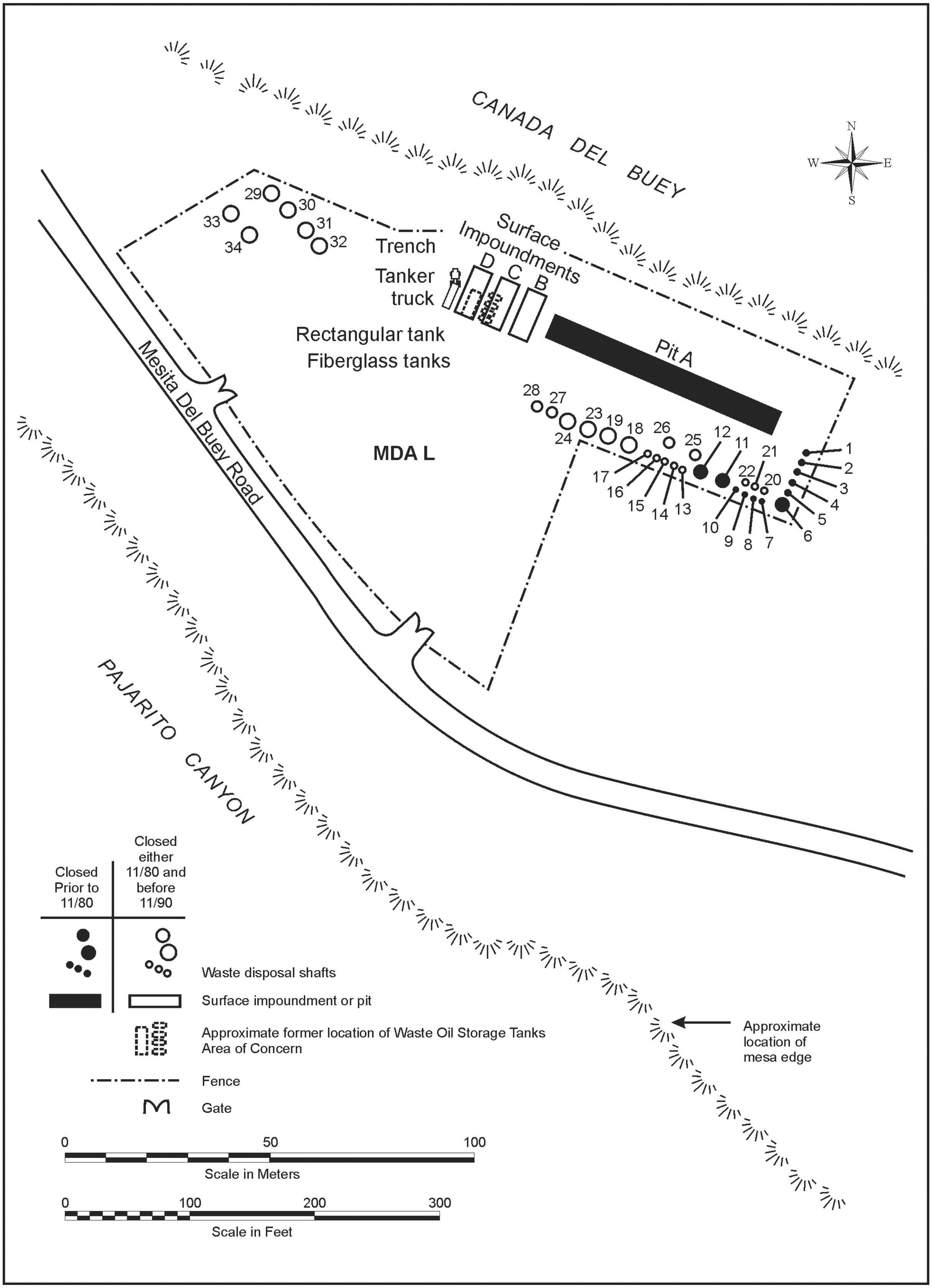

Figure I–16 Material Disposal Area L Inactive Waste Unit Locations

Table I–20 Material Disposal Area L Pit and Impoundment Dimensions and Operation Dates

Pit or Impoundment	*Dimensions (feet) (length by width by depth)*	*Period of Use*
A	$200 \times 12 \times 10$	1950s - 12/1978
B	$60 \times 18 \times 10$	1/1979 - 6/1985
C	$35 \times 12 \times 10$	1964 - 1978
D	$75 \times 18 \times 10$	1972 - 1984

Note: To convert feet to meters, multiply by 0.3048.
Source: LANL 2003m.

Table I–21 Material Disposal Area L Shaft Dimensions and Operation Dates

Shaft	*Diameter/Depth (feet)/(feet)*	*Period of Use*	*Shaft*	*Diameter/Depth (feet)/(feet)*	*Period of Use*
1	3/60	4/80 - 8/83	18	8/60	6/79 - 5/80
2	3/60	2/75 - 6/79	19	8/60	4/80 - 4/82
3	3/60	2/75 - 10/78	20	3/60	3/82 - 8/83
4	3/60	2/75 - 4/80	21	3/60	3/82 - 12/84
5	3/60	2/75 - 5/77	22	3/60	3/82 - 8/83
6	4/60	6/75 - 5/79	23	4/60	4/82 - 2/84
7	3/60	6/75 - 5/79	24	4/60	4/82 - 3/84
8	3/60	6/75 - 5/79	25	6/60	9/82 - 4/85
9	3/60	6/75 - 5/79	26	6/60	9/82 - 2/84
10	3/60	6/75 - 5/79	27	4/60	1/83 - 1/85
11	8/60	1/78 - 6/79	28	4/60	1/82 - 4/85
12	4/60	1/78 - 6/79	29	6/65	12/83 - 7/84
13	8/60	6/79 - 4/82	30	6/65	12/83 - 4/84
14	3/60	6/79 - 4/82	31	6/61	12/83 - 8/84
15	3/60	6/79 - 4/82	32	4/15	3/84 - 8/84
16	3/60	6/79 - 4/82	33	6/65	3/84 - 1/85
17	3/60	6/79 - 4/82	34	6/63	2/85 - 4/85

Note: To convert feet to meters, multiply by 0.3048.
Source: LANL 2003m.

Pit and Impoundments. Pit A received containerized and uncontainerized liquid chemical wastes. About 5,123 cubic feet (145 cubic meters) of liquid waste was discharged to Pit A. A salt layer remained on the pit floor after the aqueous phase evaporated. Impoundments B and C evaporated treated salt solutions and electroplating wastes. Treated wastes placed in Pit A and Impoundments B and C were generated from the following processes (LANL 2003m):

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

- Acids and caustics in quantities larger than 55 gallons (208 liters) were diluted and neutralized. Acids were neutralized with sodium hydroxide; bases with mineral acids. Heavy metals were precipitated and removed before disposal in shafts.

- Cyanide solutions were treated with calcium hypochlorite or calcium chloride and calcium hydroxide, resulting in cyanate, carbon dioxide, and nitrogen. After treatment, the aqueous solution was discharged to the pit or the impoundment. Solids from the process were mixed with cement in metal drums and disposed of in MDA L shafts.

- Chromium waste was treated with sodium hydroxide and a reducing agent (sulfur dioxide or sodium bisulfate). End products were sodium sulfate and chromium hydroxide. Treated chromium waste was disposed of in MDA L shafts.

Shafts. Shafts 1 through 34 were used for disposal of containerized and uncontainerized liquid wastes and precipitated solids from treatment of aqueous wastes. Heavy metals precipitated from acid or caustic solutions were packaged in 15-gallon (57-liter) drums and disposed of in the same shafts as the neutralized acid or caustic solutions. Shafts used for disposal of neutralized acid solutions were also used for disposal of treated chromium waste (LANL 2003m).

Current Configuration. A 3- to 4-foot-high (0.9- to 1.2-meters-high) vertical retaining wall bounds the north and east sides of the site, and a stormwater diversion channel runs outside this retaining wall, immediately above the escarpment. An electrical line is buried outside of the northern boundary of the site (Stephens 2005).

Figure I–17 shows the location of the MDA L disposal units along with important structures (LANL 2003d). Stormwater is directed to an outfall at the northeast corner of the liquid low-level radioactive waste storage dome discharging into Cañada del Buey. The area is surrounded by a security fence and is covered with asphalt. Administrative offices are outside of the security fence adjoining Mesita del Buey Road. The area has water, electricity, and telephone services (LANL 1992a, 2003m).

Site Investigations. Early investigations determined the soil moisture characteristic curves; intrinsic permeability and unsaturated hydraulic conductivity of the tuff; infiltration and redistribution of meteoric water in the tuff; presence of core and pore gas in the vadose zone; and the possible presence of perched water. Early investigations documented a subsurface vapor-phase volatile organic compound plume extending beneath the site and beyond the boundary of MDA L. The primary constituents were 1,1,1-trichloroethane, present to a depth of at least 200 feet (61 meters) below ground surface, and trichloroethene. Other organic vapor-phase compounds included carbon tetrachloride, chloroform, tetrachloroethene (also known as tetrachloroethylene or perchlorethylene), toluene, chlorobenzene, xylene, and 1,2,4-trimethylbenzene (LANL 2003m). Investigations also identified moist-to-wet conditions at multiple depths within basalt beneath MDA L (see below) (LANL 2003m).

Phase I RFI fieldwork was conducted from 1993 through 2003 (LANL 2003m). Channel sediment samples contained inorganic chemicals, methoxylchlor, and a single instance of plutonium-238. Inorganic materials, organic chemicals, and tritium were detected in tuff, and tritium was detected in ambient air. Pore gas samples showed detectable levels of volatile organic compounds. The primary volatile organic compound was trichloroethane, followed by trichloroethene (LANL 2003m).

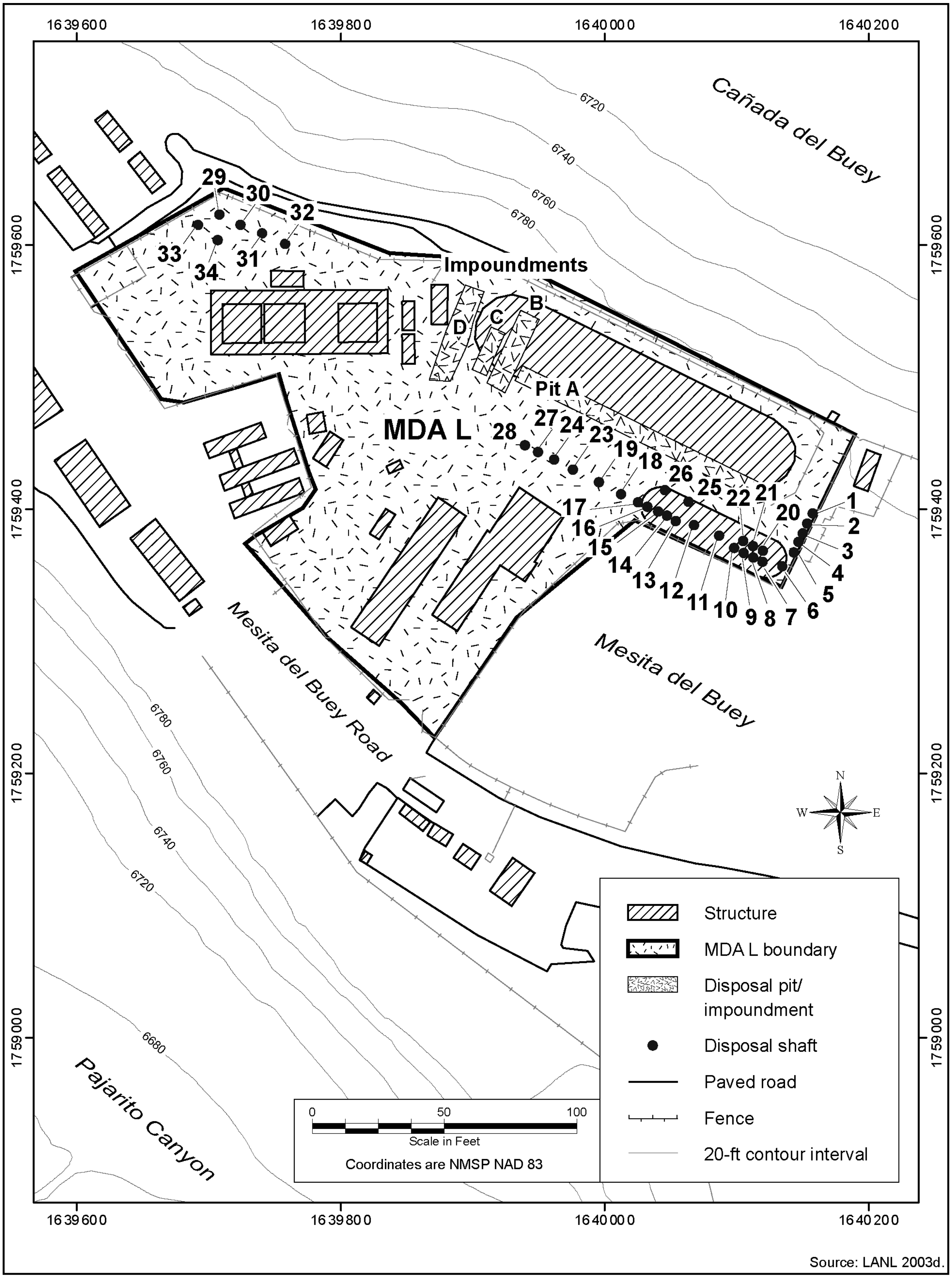

Figure I–17 Location of Subsurface Disposal Units at MDA L

Samples of surface flux were measured for tritium and for volatile organic compounds. All samples were obtained from areas of MDA L not covered by asphalt. Six samples had measured tritium emission fluxes of 2 to 5.5 picocuries per minute per square meter; one had a flux of 20,000 picocuries per minute per square meter; and one had a flux of 29,000 picocuries per minute per square meter. Twenty volatile organic compounds were detected, the most prevalent being trichloroethane, trichloroethene, and perchlorethylene (LANL 2003m).

The required Investigation Report for MDA L was submitted to NMED in September 2005 (LANL 2005r). Subsurface samples collected to evaluate moisture properties did not identify any perched groundwater zones to a depth of 660 feet (201 meters) beneath MDA L. Volatile organic compounds and tritium were found in pore-gas samples collected from 8 boreholes, each drilled to a minimum depth of 150 feet (46 meters). Among other points, the Investigation Report recommended using the results of a soil vapor extraction pilot study to evaluate this method as a potential remediation strategy (LANL 2005r). The workplan for this pilot study was submitted to NMED in May 2005 (LANL 2006h). Results of the study were addressed in a November 2006 Summary Report (LANL 2006m). In 2007, DOE issued an addendum to the Investigation Report for MDA L describing the results of supplemental drilling and sampling activities conducted to complete the investigation of MDA L (LANL 2007d) and issued a revision to the interim subsurface vapor monitoring plan for MDA L (LANL 2007e). In January 2008, DOE submitted a Corrective Measures Evaluation Report for MDA L to NMED recommending a corrective remedy that would feature an engineered evapotranspiration cover, a soil vapor extraction system, monitoring, and maintenance (LANL 2008a).

I.2.6 Other Solid Waste Management Units and Areas of Concern, Including Aggregate Areas

Section V of the Consent Order addresses requirements for all SWMUs and AOCs that are not addressed in Sections IV and VI of the Consent Order. (Section IV is discussed in Section I.2.5 of this appendix; Section VI is discussed in Section I.2.7.) The Consent Order sets forth requirements for identifying, investigating, and taking corrective action (if necessary) at any SWMU or AOC discovered after the effective date of the Consent Order, or any newly discovered releases from existing SWMUs or AOCs. Furthermore, the Consent Order presents requirements for addressing SWMUs and AOCs located in aggregate areas[27] (NMED 2005).

As required by the Consent Order, a list has been submitted to NMED identifying all aggregate areas and the SWMUs and AOCs within each aggregate area. Investigative work plans must be prepared for these aggregate areas. Following completion and submittal of the investigations, NMED may require corrective measure evaluations for any SWMU or AOC in any aggregate area. Investigation work plans for each aggregate area must be submitted in accordance with Consent Order schedules. Aggregate-area-specific investigation reports must be submitted by the dates specified in approved investigation work plans (NMED 2005).

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[27] *The Consent Order defines an aggregate area as an area within a single watershed or canyon made up of one or more solid waste management units (SWMUs) or Areas of Concern (AOCs) and the media affected or potentially affected by releases from those SWMUs or AOCs, and for which investigation or remediation, in part or in entirety, is conducted for the area as a whole to address areawide contamination, ecological risk assessment, and other factors.*

The required list of aggregate areas was submitted in 2005 (LANL 2005n). All SWMUs and AOCs, except for canyons identified as AOCs,[28] were assigned to an aggregate area to ensure addressing cumulative impacts of all potentially collocated releases in the corrective action process. The SWMUs and AOCs were assigned to the aggregate areas based on factors such as operational history, potential historical risk, and physical location. Aggregate area boundaries were based mainly on boundaries of grouped subwatersheds, but were adjusted to maximize integration, consistency, and efficiency. The 29 aggregate areas within the eight major watersheds of the Rio Grande River and one watershed of the Jemez Mountains, are listed in **Table I–22** (LANL 2005n). The 29 aggregate areas contain hundreds of PRSs, many of which are described in other sections of this analysis.

Several work plans for these aggregate areas have been submitted to NMED, including those addressing the DP Site Aggregate Area at TA-21 (LANL 2004e); the Guaje, Barrancas, Rendija Canyons Aggregate Area at TA-00 (LANL 2005j); and the Pueblo Canyon Aggregate Area (LANL 2005g). In addition, the Bayo Canyon Aggregate Area Investigation Work Plan and the Middle Mortandad-Ten Site Canyon Aggregate Area Investigation Report have been submitted to NMED (LANL 2005m). Aggregate area Investigation Work Plans have also been submitted for Middle Los Alamos Canyon Aggregate Area, Upper Los Alamos Canyon Aggregate Area, and Cañon de Valle Aggregate Area.

Table I–22 Aggregate Areas and Watersheds

Watershed	***Aggregate Area***	***Watershed***	***Aggregate Area***
Los Alamos	Guaje, Barrancas, Rendija Canyons	Pajarito	Twomile Canyon
	Bayo Canyon		Starmer, Upper Pajarito Canyon
	Pueblo Canyon		Lower Pajarito Canyon
	Upper Los Alamos Canyon		Threemile Canyon
	Middle Los Alamos Canyon	Water	Cañon de Valle
	DP Site		Potrillo, Fence Canyons
	Lower Los Alamos Canyon		S-Site
Sandia	Upper Sandia Canyon		Upper Water Canyon
	Lower Sandia Canyon		Lower Water, Indio Canyons
Mortandad	Upper Mortandad Canyon	Ancho	North Ancho Canyon
	Middle Mortandad, Ten Site Canyons		South Ancho Canyon
	Lower Mortandad, Cedro Canyons	Chaquehui	Chaquehui Canyon
	Upper Cañada del Buey	Frijoles	Frijoles Canyon
	Middle Cañada del Buey	Lake Fork	TA-57 (Fenton Hill)
	Lower Mortandad, Cañada del Buey		

TA = technical area.
Source: LANL 2005n.

I.2.7 Continuing Investigations

Section VI of the Consent Order requires continued investigation of the SWMUs listed in **Table I–23**. Investigations of these sites were planned or ongoing at the time the Compliance Order was originally issued in November 2002. Hence, many Consent Order requirements for the listed SWMUs have already been met.

[28] AOCs that are canyons were not assigned an aggregate area and are being investigated pursuant to Section IV.B of the Consent Order.

Table I–23 Solid Waste Management Units Requiring Continuing Investigation

SWMU	*Description*
3-010(a)	Used for disposal of vacuum oil from Building TA-3-30 pump repair area
16-003(o)	Known as the fish ladder, the former outfall from Building TA-16-340
16-008(a)	Inactive, unlined pond 200 feet (61 meters) in diameter
16-018 (MDA P) and TA-16-387	SWMUs included with MDA P closure, including a former barium nitrate pile, the TA-16-386 and TA-16-387 and the septic tank drain field and outfall
16-021(c) and 16-003(k)	Collectively the outfall, drainage, and associated sumps and drain lines from the active explosives machining building, TA-16-260
21-011(k)	Outfall for industrial wastewater from Buildings TA-21-35 and TA-21-257
TA-35	The Middle Mortandad-Ten Site Aggregate Area
TA-49, Areas 5, 6, and 10	SWMUs associated with historic hydrodynamic studies at MDA AB
53-002(a and b)	Impoundments that have received sanitary, radioactive, and industrial wastewater from several TA-53 facilities
73-001(a-d) and 73-004(d)	Airport landfill, comprising five SWMUs: main landfill, waste oil pit, bunker debris pits, debris disposal area, and a septic system
73-002	Ash pile from a former incinerator next to the Los Alamos County Airport

SWMU = solid waste management unit, TA = technical area, MDA = material disposal area.
Source: NMED 2005.

I.2.7.1 Solid Waste Management Unit 3-010(a): Vacuum Oil Disposal Area

SWMU 3-010(a) within TA-3 (South Mesa Site) was used between 1950 and 1957 for disposal of vacuum oil from the pump repair area within Building TA-3-30. The disposal site is 40 feet (12 meters) long by 15 feet (4.6 meters) wide and is on a hillside on the west side of Building TA-3-30. Consent Order investigations are meant to determine the extent of groundwater contamination, determine sources and flow directions, any connection between the shallow groundwater and deeper zones, and other contaminants (NMED 2005). The Groundwater Investigation Report for SWMU 03-010(a) was submitted to NMED on 31 August 2005. The report defined the nature and extent of chemicals of potential concern in soil and tuff, and concluded that the shallow groundwater body beneath this site and SWMU 03-001(e) (a former waste storage area) was of limited extent, and most likely recharged from stormwater runoff. Among other studies, quarterly groundwater monitoring will be conducted at the sites for two years to better understand the sources of the groundwater and to determine temporal trends of the contaminants of potential concern and their potential for natural attenuation (LANL 2006h).

I.2.7.2 Solid Waste Management Unit 16-003(O): Fish Ladder Site

Covering 2,410 acres (975 hectares), TA-16 is in the southwest corner of LANL. TA-16 is bordered by Bandelier National Monument south of New Mexico (NM) 4 and by Santa Fe National Forest west of NM 501. TA-16 is bordered to the north and east by TA-8, -9, -11, -15, -37, and -49. The northern border of TA-16 is Cañon de Valle (LANL 2003l). TA-16 was established to develop explosives, cast and machine explosives, and assemble and test explosives for nuclear weapons. This mission continues (LANL 2003l).

SWMU 16-003(o) comprises six inactive high explosive sumps and an outfall associated with the explosives synthetics building (Building 16-340), the largest of five structures that produced plastic-bonded explosive powders from the early 1950s until October 1999. Between 1951 and 1988, explosive-contaminated wastewater was untreated before discharge. Starting in the early 1980s and lasting through 1998, various methods were used to reduce volatile organic compound concentrations in effluent. Although most volatile organic compounds were distilled during processing, the remaining solvents were discharged. The effluent historically discharged to a permitted outfall that was removed from the LANL National Pollutant Discharge Elimination System (NPDES) permit effective July 20, 1998 (LANL 2005c, NMED 2005).

The Consent Order requires continuing investigation to fully characterize the vertical and lateral extent of sediment and groundwater contamination by these contaminants and other metals (NMED 2005). The investigation report for the Fish Ladder Site was submitted to NMED on January 31, 2006, and was approved on October 25, 2006. Phase II investigations are ongoing.

I.2.7.3 Solid Waste Management Unit 16-008(a): Inactive Pond

Consolidated Unit 16-008(a)-99 comprises the footprints of former high explosive process buildings; former materials storage buildings; and sumps, drain lines, and outfall systems. Most structures were built in 1950 for machining high explosive. After 1970, the buildings were used for storage until, by 1991, they were all removed from service. The structures were removed in 1996 (LANL 2005c).

One SWMU (16-008(a)) is an inactive, unlined pond 200 feet (61 meters) in diameter. The pond received liquids from sumps and drain lines from process buildings. The discharge began as early as 1949; lasted until the mid-1950s; and contained explosives, barium, uranium, volatile organic compounds, machining oils, nickel, and cadmium. The area contains runoff and occasionally dries up in the summer (LANL 2005c, NMED 2005). The Consent Order requires continued investigation to fully characterize the vertical and lateral extent of surface, vadose, and groundwater contamination (NMED 2005).

The Investigation Work Plan for SWMU 16-008(a) and associated sites was submitted to NMED on March 31, 2004, and approved by NMED on June 28, 2004.

I.2.7.4 Solid Waste Management Unit 16-018 (Material Disposal Area P) and Technical Area 16-387

SWMUs incorporated into NMED-required closure activities for MDA P (SWMU 16-018) include the former barium nitrate pile (SWMU 16-016(c)); the TA-16-386 flash pad (SWMU 16-010(a)); the TA-36-387 flash pad (SWMU 16-019(b)); and the septic tank drain field and outfall (SWMU 16-006(e)) (NMED 2005).

MDA P was a 1.4-acre (0.57-hectare) waste pile near the south rim of Cañon de Valle. In 1995, LANL submitted a closure plan to NMED proposing to clean-close MDA P. NMED approved the closure plan for MDA P on February 20, 1997, and approved the closure plan for the TA-16-387 flash pad on April 28, 2000 (NMED 2005). Contamination was removed as described in Section I.3.3.1.3.1. A closure certification report for MDA P and the TA-16-387 flash pad was submitted to NMED on January 31, 2003. On April 30, 2003, NMED requested its reformatting and resubmittal. One of the four documents composing the reformatted closure report was submitted to NMED on July 9, 2003 (NMED 2005).

The Consent Order requires submittal of the remaining three documents composing the closure report for MDA P (NMED 2005). All three documents were submitted in 2003. The MDA P closure certification report was approved by NMED, and no further actions are required under the Consent Order.

I.2.7.5 Solid Waste Management Units 16-021(c) and 16-003(k): 260 Outfall

Operating since 1951, Building 16-260 processed and machined HE (LANL 2002c). Machine turnings and HE washwater were flushed to building sumps and routed to the TA-16-260 outfall. Liquids from the outfall drained to a settling pond 40 feet (12 meters) away (**Figure I–18**) (LANL 2003l). The settling pond was 50 feet (15 meters) long and 20 feet (6.1 meters) wide. Pond overflow flowed through the drainage channel for 300 feet (91 meters) before dropping to a lower drainage channel that continued to the bottom of Cañon de Valle (LANL 2003l). EPA permitted the outfall in the late 1970s. The last NPDES permitting effort occurred in 1994, the outfall was deactivated in November 1996, and the outfall was removed from LANL's NPDES permit in January 1998. Liquids once routed to the outfall are now treated in the TA-16 wastewater plant that was completed in 1997 (LANL 2003l).

Consolidated SWMU 16-021(c)-99 includes:

- SWMU 16-003(k), comprising 13 sumps in the HE machining building (TA-16-260) plus 1,200 feet (366 meters) of associated drain lines (concrete troughs) that ran 200 feet (61 meters) to the outfall east of the HE machining building

- SWMU 16-021(c), comprising the upper draining channel fed directly by the outfall, the settling pond and associated surge beds beneath the settling pond (see below), and the lower drainage channel leading to the bottom of Cañon de Valle

During 2000 and 2001, an interim measure removed contaminated soil from the settling pond and channel (LANL 2003l).

The 260 Outfall has three areas of contamination (LANL 2003l): an outfall source area (excluding the settling pond and surge beds); outfall settling pond and surge beds; and canyon springs and alluvial system. The outfall source area refers to the drainage channels. Fewer than 100 cubic yards (76 cubic meters) of residual contaminated soil remains within the outfall source area (LANL 2003l). The settling pond has underlying surge beds at depths below ground surface of 17 and 45 feet (5.2 and 14 meters). The canyon springs and alluvial system refers to sediments, springs, surface water, and alluvial groundwater in Cañon de Valle and in Martin Spring Canyon (LANL 2003l).

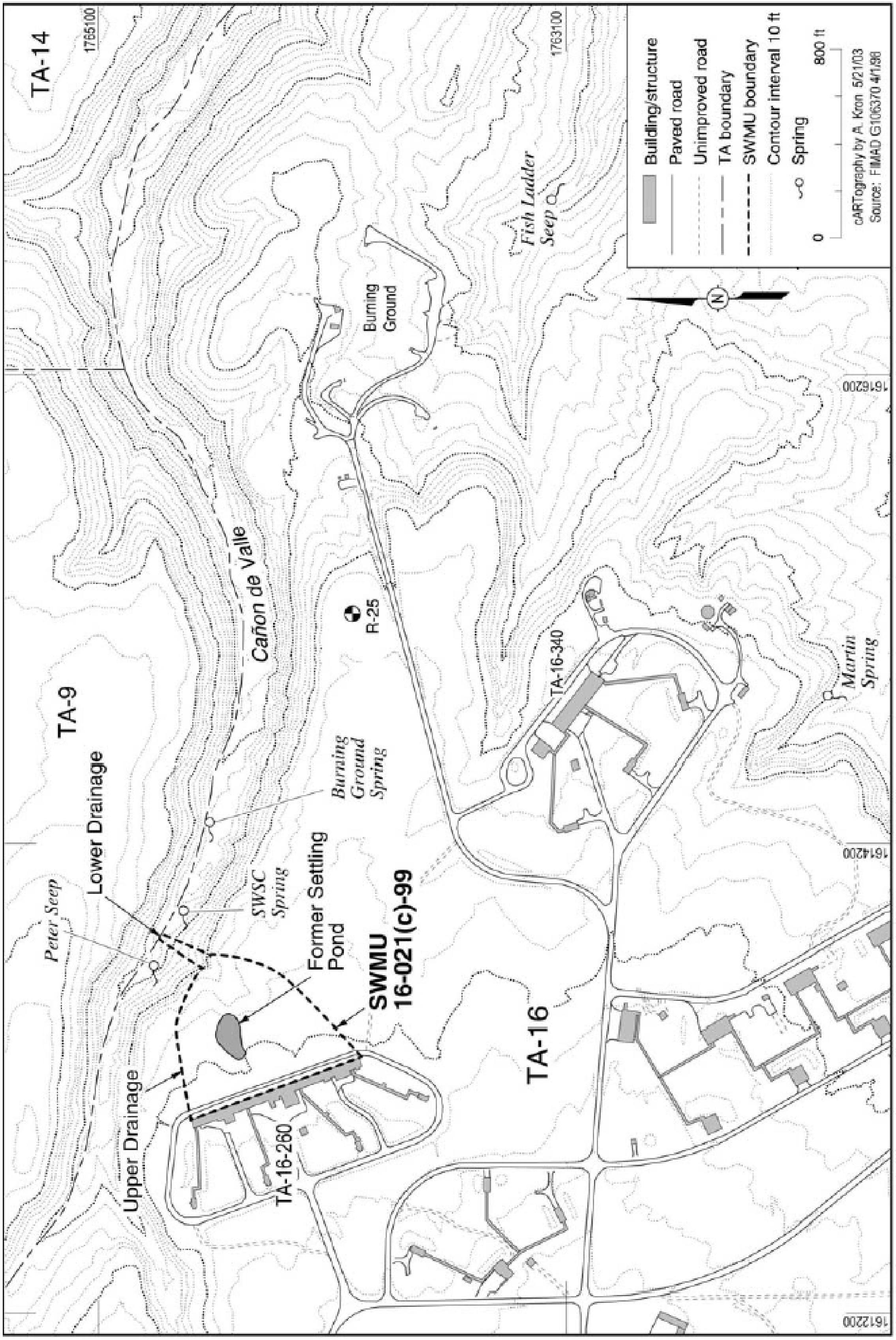

Figure I–18 260 Outfall Within Technical Area 16

Both the outfall and the drainage channel below the outfall are contaminated with high explosive and barium. Known contaminants include barium, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), TNT (2,4,6-trinitrotoluene), and HMX (octahydro-1,3,5,7-tetranitro-3,5,7-tetrazocine). Suspected contaminants include other high explosive compounds, inorganic chemicals, volatile organic compounds, semivolatile organic compounds, and uranium. The 17-foot (5.2-meter) surge bed beneath the settling pond contains detectable levels of RDX, HMX, and TNT. The 45-foot (24-meter) surge bed contains detectable levels of RDX and HMX (LANL 2003l).

Several site investigations have been conducted as summarized in the Corrective Measures Study Report (LANL 2003l) and the Phase III RFI Report, issued in September 2003 (LANL 2003g) and revised in September 2004 (LANL 2004g).

NMED selected a final remedy for the surface and alluvial system on October 13, 2006. The investigation report for intermediate and regional groundwater was approved by NMED on November 29, 2006; and additional groundwater investigations are ongoing to support the intermediate and groundwater corrective measure evaluation.

The land adjacent to the outfall is dedicated to continued LANL operations (LANL 2003l).

I.2.7.6 Solid Waste Management Unit 21-001(k): Technical Area 21 Outfall

SWMU 21-011(k) was an NPDES-permitted outfall. The SWMU includes a drainage pipe and an outfall ditch that routed wastewater north over the south rim of DP Canyon and into the canyon itself. The outfall received industrial effluent from the wastewater treatment plant in Building 21-35 from 1952 until 1967 and from the wastewater treatment plant in Building 21-257 from 1967 until the early 1990s (LANL 2002f).

SWMU 21-011(k) was investigated in 1988, 1992, and 1993. A 1996 interim action removed the contaminated soil from the hillside (LANL 2002f). A November 2000 gamma spectrometry for the site was followed in March 2001 by collection of samples that identified remaining hotspots (LANL 2002f). A voluntary corrective measure was prepared that included the following actions: (1) excavate and dispose of the outfall drain line and other waste; (2) excavate and solidify contaminated tuff and sediment; (3) place solidified material in a cell excavated near the center of the SWMU; (4) place and compact clean fill over the entire site; and (5) conduct site inspections and radiation surveys (LANL 2002f). However, plans for the voluntary corrective measure were modified to eliminate the onsite solidification of waste. The remedy was implemented in 2003 (LANL 2003i). The Voluntary Corrective Measure Report for SWMU 21-011(k) was submitted to NMED on October 31, 2003, and approved by NMED on August 9, 2005.

I.2.7.7 Technical Area 35 (Middle Mortandad–Ten Site Canyon Aggregate Area)

TA-35 (Ten Site) is used for nuclear safeguards research and development; reactor safety research; optical science and pulsed-power system research; and metallurgy, ceramic technology, and chemical plating activities. TA-35 is on a finger mesa between Mortandad Canyon and Ten Site Canyon within the Mortandad Canyon Watershed.

Contaminants have been released from outfalls, air stack emissions, and cooling water and septic system discharges. From 1951 until 1963, the wastewater treatment facility discharged effluent into Ten Site Canyon. Spills occurred from leaks in pipelines, structures, and container storage areas. Potential contaminants include metals, PCBs, volatile organic compounds, and radionuclides (NMED 2005).

On March 29, 2002, a Sampling and Analysis Plan (LANL 2002e) was submitted that integrated most of the PRSs into one aggregate. Originally 102 PRSs were within TA-35. Fifty-four PRSs were SWMUs and 48 were AOCs. Of the 102 PRSs, 32 have been recommended or approved for no further action, leaving 70 PRSs, of which 65 will be investigated.[29] The PRSs addressed in the Sampling and Analysis Plan are listed in **Table I–24**, where the first column indicates whether the PRS is part of a consolidated unit and the second column indicates the PRS number. The third column describes the PRS, while the fourth column describes the subarea within TA-35 within which the PRS is located (LANL 2002e).

Table I–24 Potential Release Sites Considered in the Middle Mortandad–Ten Site Aggregate Sampling and Analysis Plan

Consolidated Unit	*Potential Release Site*	*Potential Release Site Description*	*Subarea within the Aggregate*
	35-002	MDA X	Mesa top
35-003(a)-99	35-003(a)	Wastewater Treatment Facility	Mesa top
	35-003(b)	Wastewater Treatment Facility	Mesa top
	35-003(c)	Wastewater Treatment Facility	Mesa top
35-003(d)-00	35-003(d)[a]	Wastewater Treatment Facility	Pratt Canyon
35-003(a)-99	35-003(e)[a]	Wastewater Treatment Facility	Pratt Canyon
	35-003(f)	Wastewater Treatment Facility	Mesa top
	35-003(g)	Wastewater Treatment Facility	Mesa top
	35-003(h)	Wastewater Treatment Facility	Mesa top
35-003(j)-99	35-003(j)	Wastewater Treatment Facility	Mesa top
	35-003(k)	Wastewater Treatment Facility	Mesa top
35-003(d)-00	35-003(l)[a]	Wastewater Treatment Facility	Pratt Canyon
35-003(a)-99	35-003(m)	Wastewater Treatment Facility	Mesa top
	35-003(misc)	Industrial waste lines	Mesa top
	35-003(n)	Wastewater Treatment Facility	Mesa top
	35-003(o)	Wastewater Treatment Facility	Mesa top
	35-003(p)	Wastewater Treatment Facility	Mesa top
35-003(d)-00	35-003(q) [a]	Wastewater Treatment Facility	Pratt Canyon
	35-003(r)	Outfall	Pratt Canyon
	35-004(a)	Storage areas	Mesa top
	35-004(b)	Storage areas	Mortandad slope
25-004(g)-00	35-004(g)	Container storage area	Ten Site slope
	35-004(h)	Container storage area	Mesa top
35-014(g)-00	35-004(m)	Container storage area	Ten Site slope
35-008-00	35-008	Surface disposal and landfill	Mortandad Slope

[29] PRSs 35-013(a), 35-013(b), 35-013(c), 35-006(g), and 35-016(h) are not being investigated in the Sampling and Analysis Plan because they are outside the watershed aggregate boundary or are within active buildings and have been deferred until decommissioning occurs (LANL 2002e).

Consolidated Unit	***Potential Release Site***	***Potential Release Site Description***	***Subarea within the Aggregate***
	35-009(a)	Septic system	Ten Site slope, mesa top
35-004(g)-00	35-009(b)	Septic system	Ten Site slope, Ten Site Canyon
	35-009(c)	Septic system	Mortandad slope
	35-009(d)	Septic system	Pratt Canyon
	35-009(e)	Septic system	Ten Site slope
35-010(a)-99	35-010(a)	Sanitary lagoon	Ten Site Canyon
	35-010(b)	Sanitary lagoon	Ten Site Canyon
	35-010(c)	Sanitary lagoon	Ten Site Canyon
	35-010(d)	Sand filters	Ten Site Canyon
	35-010(e)	Release from sand filter	Ten Site Canyon
	35-011(d)	Underground storage tank	Mesa top
	35-014(a)	Operational release	Mesa top
35-003(j)-99	35-014(b)	Leaking drum	Mesa top
	35-014(d)	Operational release	Mesa top
35-008-00	35-014(e)	Oil spill	Mortandad slope
35-016(i)-00	35-014(e2)	Oil spill	Mortandad slope
	35-014(f)	Soil contamination	Mesa top
35-014(g)-00	35-014(g)	Soil contamination	Ten Site slope
	35-014(g2)	Soil contamination	Ten Site slope
	35-014(g3)	Soil contamination	Ten Site slope
	35-015(a)	Soil contamination	Mesa top
35-003(j)-99	35-015(b)	Waste oil treatment	Mesa top
35-016(a)-00	35-016(a)	Drains and outfalls	Ten Site slope
	35-016(b)	Outfall	Ten Site slope
335-016(c)-00	35-016(c)	Outfall	Ten site slope
	35-016(d)	Outfall	Ten site slope
	35-016(e)	Outfall	Mortandad slope
	35-016(f)	Storm drain	Mortandad slope
35-016(i)-00	35-016(i)	Drains and outfalls	Mortandad slope
	35-016(j)	Storm drain	Ten Site slope
35-016(k)-00	35-016(k)	Drains and outfalls	Pratt Canyon
	35-016(l)	Storm drain	Pratt Canyon
	35-016(m)	Drains and outfalls	Pratt Canyon
35-014(g)-00	35-016(n)	Storm drain	Ten Site slope
	35-016(o)	Drains and outfalls	Mortandad slope
	35-016(p)	Outfall	Mortandad slope
35-016(a)-00	35-016(q)	Drains and outfalls	Ten Site slope
	35-017	Steam blowoff outfall from reactor	Ten Site slope
	35-018(a)	Transformer	Mesa top
	C-35-007	Soil contamination	Ten Site Canyon

MDA = material disposal area.
[a] These potential release sites are consolidated with mesa top potential release sites but also have a canyon component.

Among the PRSs in Table I–24 is MDA X (PRS 35-002) near the southeast corner of Building TA-35-2 on the south side of Ten Site Mesa. MDA X is the former site of the reactor from the Los Alamos Power Reactor Experiment No. 2 (LAPRE-II). After being decommissioned in 1959, the reactor was buried in place. But in 1991, MDA X was remediated as an interim action. MDA X was recommended for no further action in the Addendum to the Operable Unit 1129 RFI Work Plan (LANL 1999b).

NMED approved the sampling and analysis plan on June 9, 2003. A supplemental sampling and analysis plan addressing the remaining sites in the Middle Mortandad-Ten Site Canyon Aggregate Area was submitted to NMED on March 31, 2004, and approved on June 29, 2004. The sampling and analysis plan, and supplement, was implemented and the Investigation Report for the Middle Mortandad-Ten Site Canyon Aggregate Area was submitted to NMED in September 2005. Additional investigations for the Middle Mortandad-Ten Site Canyon Aggregate Area are ongoing.

I.2.7.8 Technical Area 49: Areas 5, 6, and 10

The Consent Order requires additional investigation of potential contamination at Areas 5, 6, and 10 within TA-49. Details about the activities conducted in these areas, the likely contamination present, their current configurations, and past investigations are discussed in Section I.2.5.3.

I.2.7.9 Solid Waste Management Unit 53-002 (a and b): Impoundments

SWMU 53-002(a) includes two impoundments (northeast and northwest), each 210 by 210 by 6 feet deep (64 by 64 by 1.8 meters deep), that were built in 1969 and received sanitary, radioactive, and industrial wastewater from TA-53 facilities. The impoundments occasionally overflowed to a channel draining east into a tributary of Los Alamos Canyon. A third impoundment (southern impoundment, SWMU 53-002(b)) was built in 1985 and measured 305 by 148 by 6 feet deep (98 by 45 by 1.8 meters deep). In 1989, the southern impoundment was restricted to radioactive liquids, while the other two impoundments received sanitary wastewater. All three impoundments are now inactive. As part of an interim action, the sludge and liners were removed from all three impoundments, and characterization samples were collected from the perimeter around each impoundment and from drainage channels leading from the southern impoundment (NMED 2005). The investigation and remediation report for the impoundments was submitted to NMED on January 29, 2004, and approved on July 25, 2006. NMED issued a Certificate of Completion on September 13, 2006.

I.2.7.10 Solid Waste Management Unit 73-001 (a-d) and 73-004 (d): Airport Landfill

The Airport Landfill consists of 5 SWMUs: a main landfill (73-001(a)), a waste oil pit (73-001-b)), bunker debris pits (73-001(c)), a debris disposal pit (73-001(d)), and a septic system (73-04(d)). DOE began operations in 1943. Trash collected from the townsite and from other locations was burned on the edge of a hanging valley. Burning continued until 1965, when Los Alamos County assumed operation. Operation ceased on June 30, 1973. From 1984 to 1986, the western portion of the landfill was removed and taken to the debris disposal pit. This allowed construction of airport hangers and tie-down areas (LANL 2001b, NMED 2005). RFI activities occurred between 1994 and 1997 (LANL 1992e). An RFI report was submitted to NMED, and NMED agreed with the proposed remedy on December 8, 1999 (NMED 2005).

The Sampling and Analysis Plan for the Airport Landfill disposal areas describes the main landfill as covering 12 acres (4.9 hectares) and having a volume of 489,500 cubic yards (374,000 cubic meters). The west and south sides of the main landfill coincide with the edges of the asphalt tie-down area and the asphalt taxiway. The north site extends roughly to the chain-link security fence along the north side of the airport, and the east side extends to the end of the hanging valley. The debris disposal area consists of two, roughly parallel trenches dug to a maximum depth of 35 feet (11 meters). The debris disposal area covers 5 acres (2.0 hectares) and has a volume of 126,000 cubic yards (96,000 cubic meters) (LANL 2001e).

Subsequently, data needed to design a final cover for the landfill were collected, and an interim measure removed debris from landfill drainages. A closure recommendation was issued in June 2005. The preferred alternative is to leave the waste in place and install a MatCon (Modified Asphalt Technology for Waste Containment) asphalt cover and retaining wall at the main landfill and an evapotranspiration cover at the debris disposal area (LANL 2005i, DOE 2005b).

I.2.7.11 Solid Waste Management Unit 73-002: Incinerator Ash Pile

SWMU 73-002 is an ash pile from a former incinerator at TA-73. The ash pile is next to the Los Alamos County Airport. The incinerator equipment and stack were removed before 1973. An ash and surface disposal area is on the north-facing slope below the canyon rim (NMED 2005). The pile is several hundred feet northwest of the airport. The pile is 150 feet (46 meters) wide and 150 feet (46 meters) below the mesa top (LANL 2005e). RFI activities were conducted in 1996 and 1997. The RFI results were submitted in 1997 to NMED in a Phase II sampling and analysis plan. The plan was approved on February 28, 2000 (NMED 2005).

The Consent Order requires investigations to fully characterize the extent of contamination and the potential for migration of contaminants through fractures (NMED 2005). The investigation and corrective action work plan for SWMU 73-002 was submitted to NMED in May 2005 and approved in September 2005. Remediation of the ashpile is now complete and the Investigation Report for Consolidated Unit 73-002-099 and Corrective Action of Solid Waste Management Unit 73-002 at Technical Area 73 was submitted to and approved by NMED (LANL 2008a).

I.2.8 Additional Material Disposal Areas

MDAs in this section will be addressed as part of the aggregate area investigations.

I.2.8.1 Technical Area 8: Material Disposal Area Q

Also known as the GT or Anchor West Site, TA-8 is at the western end of LANL and is used for dynamic tests. MDA Q is within a 0.2-acre (0.8-hectare) site on Pajarito Mesa, in an area called the Gun-Firing Site (PRS 8-002), which once contained naval guns used to develop the Little Boy atomic weapon. Two concrete anchor pads for the gun mounts and two target sand butts remain (LANL 1999b).

MDA Q is a burial ground (SWMU 8-006(a)) that received waste in 1946 from the naval gun experiments, possibly including parts from Little Boy tests (LANL 2005c). The MDA occupies an irregularly shaped area having dimensions of 270 by 260 feet (81 by 78 meters) (LANL 1999b). Within this area, burial occurred in a pit of uncertain size. Investigations in the early 1990s suggested a size of 30 by 30 feet (9.1 by 9.1 meters) (LANL 1993d). Later investigations indicated that the disposal area covered a larger area (LANL 1993d). The MDA Core Document cites a 0.2-acre (0.8-hectare) area (LANL 1999b).

Radioactive contamination was absent in a gun mount unearthed in 1947. In 1994, copper and lead were found above background values in surface soil samples. No radioactive contamination was found (LANL 2005c).

I.2.8.2 Technical Area 9: Material Disposal Area M

TA-9 (Anchor East Site) is on the western edge of LANL. The site is used for explosives research. MDA M is on Pajarito Mesa southwest of Pajarito Canyon. MDA M (SWMU 09-013) consists of a 3.2-acre (1.3-hectare) circular surface MDA and a small disposal area 750 feet (229 meters) northwest. The main disposal area is surrounded by an earth berm that is eroded from surface runoff. MDA M was a dump for construction debris and other wastes. From 1960 through 1965, the site received nonhazardous wastes from construction at other sites. MDA M has been inactive since 1965 (LANL 2005c).

In 1996, all wastes were removed and the site surveyed. Twenty-six verification samples were analyzed for organic and inorganic chemicals, radionuclides, PCBs, and asbestos. All contaminants were either not detected or were below recommended cleanup levels. The site access road was regraded and revegetated, and the main disposal area was scarified, graded, tiered, and seeded to control soil movement and erosion. The report for the 1996 expedited cleanup recommended no further action (LANL 2005c).

I.2.8.3 Technical Area 15: Material Disposal Area N

MDA N (SWMU 15-007(a)) is within a 0.28-acre (0.11-hectare) site within TA-15. MDA N is a pit containing remnants of structures from R Site that had been exposed to explosive or chemical contamination. (If radioactive contamination is present, it is probably at a low level given nearby office buildings.) The MDA is shown in the RFI Work Plan for Operable Unit 1086 work plan as a 30- by 290-foot (9.1- by 88-meter) rectangle (LANL 1993c). A later report estimated the size as 300 by 100 feet (91 by 30 meters) (LANL 2005c). Opened in 1962, MDA N may have received waste from demolishing the control room and darkroom (Building 15-7) used to support Firing Point C (and probably D) (LANL 1993c). A 1965 aerial photograph showed it to be closed (LANL 2005c). The pit is covered and vegetated (LANL 1999b).

Little is known about use of hazardous materials. A 1989 aerial survey did not find radioactive materials. Neither high explosives nor uranium were handled. It is unknown how photographic chemicals were disposed (LANL 1993c).

I.2.8.4 Technical Area 16: Material Disposal Area R

TA-16 is described in Section I.2.7.2.

MDA R (SWMU 16-019) is an 11.5-acre (4.7-hectare) site on the edge of the mesa on the south side of Cañon de Valle. It is north of the explosives processing facility (Building 260). MDA R is an high explosive burning ground and disposal area that was used from 1945 until 1951. The MDA covers an area of 600 by 900 feet (180 by 270 meters), although the contaminated area is probably smaller (LANL 1999b).

A later document (LANL 2005c) reports an area of 2.27 acres (0.92 hectare). The MDA consists of three U-shaped, 75-square-foot (7.0-square-meter) bermed pits that were fenced and encircled by a road (LANL 1993f). During construction of the 260 Line, the berms and surface soil were graded northward into Cañon de Valle. Debris was pushed northward over the edge of the burning ground toward the canyon floor. Debris was held back by a natural barrier of wood and tress created by clearing the area for Building 16-260 in 1951. The area was covered with grasses and pine trees before the 2000 Cerro Grande Fire. Suspected contaminants are barium, high explosive, lead, asbestos, and organic chemicals (LANL 2005c). A geophysical survey suggests that the depth of waste at MDA R is shallow (LANL 1999b).

After the Cerro Grande Fire, 800 cubic yards (611 cubic meters) of clean soil was excavated and staged, as well as 1,500 cubic yards (1,147 cubic meters) of contaminated soil and debris. A runon diversion channel was built and erosion-control materials installed. The MDA was sampled in September 2000 to determine the nature and extent of contamination (LANL 2005c).

I.2.8.5 Technical Area 33: Material Disposal Areas D, E, and K

TA-33 (Hot Point Site) is near the southeast boundary of LANL. It spans the boundary of the Chaquehui Canyon and Ancho Canyon Watersheds. TA-33 was used from 1947 to perform experiments in underground chambers, on surface firing pads, and at firing sites where guns shot projectiles into berms. Weapons experiments ceased in 1972. A high-pressure tritium facility operated from 1955 until late 1990 (LANL 1999b). The TA is used for experiments that require isolation or do not need daily oversight.

I.2.8.5.1 Material Disposal Area D

MDA D (SWMUs 33-003(a) and (b)) is on the east end of the TA. MDA D consists of two underground chambers: TA-33-4 (SWMU 33-003(a)) and TA-33-6 (SWMU 33-003(b)). Built in 1948, the chambers were octagonal (18 by 18 by 11 feet high [5.5 by 5.5 by 3.4 meters high]), with the tops of the chambers 30 feet (9.1 meters) below grade. Access was via a 46-foot-deep (14-meter-deep) elevator shaft (Rogers 1977). The chambers were used for initiator tests using polonium-210 (138-day half-life), milligram quantities of beryllium, and large quantities of high explosive. Chamber TA-33-4 was used once in 1948. Chamber TA-33-6 was used in 1948 and April 1952. The second test destroyed the chamber. Debris ejected into the air spread over the mesa. The crater around the chamber was filled with recovered debris and covered with soil (LANL 1999b).

The Rogers report summarizes information indicating that the underground chambers may be contaminated with explosive residue, uranium-235, and possibly trace amounts of other uranium isotopes, polonium, and cobalt-60 (Rogers 1977).

A 1995 Phase I RFI report for the MDA recommended no further action for SWMU 33-003(a) because no release to the environment was apparent. A 1997 Phase I report recommended no further action for SWMU 33-003(b). The report recommended deferring evaluating ecological risks until a risk method had been developed (LANL 2005c).

I.2.8.5.2 Material Disposal Area E

On the south edge of the TA, MDA E is on a point formed by Chaquehui Canyon and one of its tributaries. Consolidated Unit 33-001(a)-99 (MDA E) consists of four waste disposal pits (SWMUs 33-001(a) through (d)) and an underground test chamber and shaft (SWMU 33-001(e)). The test chamber and shaft were last used in 1950, and the disposal pits ceased receiving waste in 1963. The consolidated unit covers 140 by 220 feet (43 by 67 meters) and is fenced (LANL 2005c). The four pits[30] have the following dimensions, based on contemporary engineering drawings (LANL 2005c):

- 33-001(a): 20 by 60 feet (6.1 by 18 meters);
- 33-001(b): 20 by 50 feet (6.1 by 15 meters);
- 33-001(c): not determined; and
- 33-001(d): 20 by 100 feet (6.1 by 30 meters).

The pits are probably shallow, each about 6 to 7 feet (1.8 to 2.1 meters) deep (Rogers 1977).

All four pits contain beryllium and uranium. A report by the U.S. Geological Survey referenced by Rogers (Rogers 1977) states that the area contains several hundred kilograms of depleted uranium. Pits 1 and 2 were reported to contain 240 curies and 60 curies, respectively. Pits 1 and 2 may contain hazardous wastes (LANL 1999b). Pit 3 contains a can of beryllium dust immersed in kerosene. Dates of construction cannot be confirmed. When disposal ceased in 1963, the pits were filled and compacted (LANL 2005c).

The underground chamber and shaft were built from November 1949 to February 1950. The octagonal chamber was 14 feet (4.3 meters) wide and 11 feet (3.4 meters) high and had concrete walls, floor, and ceiling. The adjacent shaft was 48 feet (15 meters deep). The chamber was used to conduct tests using explosives, beryllium, and tungsten. The chamber collapsed during an April 1950 experiment and was abandoned (LANL 2005c).

Sampling programs in 1982 and 1983 found tritium, cesium-137, and uranium. The RFI work plan indicated that subsurface contaminants were not being released from the pits and chamber (LANL 2005c).

I.2.8.5.3 Material Disposal Area K

MDA K (Consolidated Unit 33-002(a)-99) is in the northern part of the TA. The consolidated unit is in an unfenced area comprising a 3-acre (1.2-hectare) footprint (LANL 2005c). The six SWMUs composing the consolidated unit have a smaller footprint. The RFI Work Plan for Operable Unit 1122 estimates a size of 1 acre (0.4 hectare) (LANL 1992f). All former SWMUs

[30] Two additional pits were constructed but were backfilled, apparently without being used for waste disposal. Rogers (Rogers 1977) reports slightly different dimensions for the pits, based on a contemporary engineering drawing: Pit 1 = 15 by 75 feet (4.6 by 23 meters); Pit 2 = 15 by 45 feet (4.6 by 14 meters); Pit 3 = 5 feet (1.5 meters) in diameter; Pit 4 = 15 by 100 feet (4.6 by 30 meters).

are associated with the Tritium Facility (Building 33-86), which operated from June 1955 until 1990. The former SWMUs consist of a septic system (SWMU 33-002(a)), two sumps (SWMUs 33-002(b) and -002(c)), an outfall (SWUM 33-002(d)), a roof drain (SWMU 33-002(e)), and a surface disposal area (SWMU 33-002(f)) (LANL 2005c). SWMUs (33-002(a-e)) were remediated in 2005 as part of an accelerated corrective action at TA-33. The remedy completion report for this accelerated corrective action was submitted to NMED on March 2, 2006, and was approved with a Certificate of Completion on August 31, 2006.

The history and origins of waste within the surface disposal area (33-010(f)) are unknown. The surface disposal area comprises two groups of debris at the southeast corner of the MDA. One group of debris is 15 feet (4.6 meters) square, and it is 50 feet (15 meters) from a second 10- by 20-foot (3.0- by 6.1-meter) group of debris. Materials include pieces of concrete and concrete culvert, piles of tuff and cured asphalt, rusted metal cans, rebar, strapping bands, and other debris (LANL 2005c).

I.3 Description of Options

I.3.1 Overview of Options

To predict the impacts of carrying out future corrective measure decisions, three broad-scope options are considered for purposes of NEPA:

1. **No Action Option**. Environmental investigations and restoration efforts are assumed not to be carried out in accordance with the Consent Order. The LANL environmental restoration project would continue at a pre-Consent Order level, but no extensive corrective measures would be conducted for major PRSs.

> The No Action Option is considered in this appendix because such an action is required by NEPA. DOE is legally required to carry out the provisions of the Consent Order.

2. **Capping Option**. The Consent Order would be implemented. For this appendix it was assumed that environmental investigations would take place in accordance with the Consent Order, LANL MDAs would be stabilized in place, and several other PRSs would be remediated annually.

   Stabilizing MDAs in place means placing final covers over them and conducting certain other environmental restoration activities such as remediating the volatile organic compound plumes existing in soil at some MDAs. The General's Tanks within MDA A would be stabilized in place using a grout mixture. Transuranic waste in subsurface storage at MDA G would be removed, processed, and shipped to WIPP. Because a small volume of the stored transuranic waste in subsurface shafts within MDA G may be difficult to retrieve, an option to leave this stored waste in place would be considered. If this option were pursued, a performance assessment pursuant to 40 CFR Part 191 may be required. If such an assessment is required, the assessment results may indicate the need for additional waste stabilization or MDA final cover modification.

   Remediating additional PRSs would include contamination removal at sites such as Firing Sites E-F and R-44 and the 260 Outfall. Other remediation activities could include surge bed grouting, contaminated sediment natural flushing, use of permeable reactive barriers, pump and treat system installation, or other measures.

For MDAs A, B, T, U, C, L, G, and AB, it was assumed that remediation would be completed by the dates presented in Table I–2. For other MDAs and PRSs, it was assumed that remediation would be completed in compliance with appropriate Consent Order schedules, including those for aggregate areas. It was assumed that remediation of these MDAs and PRSs would occur from FY 2007 through FY 2016.

3. **Removal Option**. The Consent Order would be implemented. For this appendix it was assumed that environmental investigations would take place as they would for the Capping Option. In addition, LANL MDA waste and contamination would be removed. All transuranic waste stored at MDA G would be removed and shipped to WIPP along with all other transuranic-contaminated material disposed of before 1970. Remediation of additional PRSs would again occur by various methods as discussed for the Capping Option. Remediation of MDAs or PRSs was assumed to be completed by the same dates assumed for the Capping Option.

   The projected annual waste volumes and other environmental impacts are conservative. If extensive removal of waste and contamination from the MDAs were required, then for a variety of programmatic, funding, safety, and regulatory compliance reasons, the remediation process may extend beyond FY 2016, provided that a revised schedule is approved by NMED. If this were to occur, annual waste volumes and other impacts associated with the Removal Option would be smaller.

Environmental impacts associated with these three options are expected to bound those that could result from eventual implementation of MDA and PRS corrective actions. Remediation decisions will be made for specific MDAs and PRSs rather than groups, and may prescribe a combination of corrective measures. For example, some waste within an MDA may be removed and the remainder may be stabilized in place.

For all options, appropriate safety and environmental surveillance and maintenance would continue at LANL to maintain compliance with DOE and external criteria and standards, including those for nuclear environmental sites (Section I.3.2.3).

I.3.2 Continuing Environmental Restoration Work

Since LANL's environmental restoration project was established in 1989, progress has been made in characterizing and remediating LANL PRSs. Some of the numerous environmental investigations conducted by LANL have generated solid and liquid wastes. Additional wastes have resulted from implementing corrective measures. Projections of future waste generation are difficult. One reason is that waste generation rates depend on regulatory decisions yet to be made that would establish the scope of specific environmental restoration activities. Because the kinds of investigations conducted under the Consent Order will be basically the same as those previously performed (for example, well drilling), it was assumed that waste from environmental investigations would be encompassed by those in existing LANL forecasts (see Section I.3.2.1).

I.3.2.1 Existing Waste Forecasts

Estimates of waste generation from LANL's environmental restoration project were presented in the 1999 *Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory, New Mexico (1999 SWEIS)* (DOE 1999a). Updated projections are in the August 17, 2004, *Information Document in Support of the Five-Year Review and Supplement Analysis for the Los Alamos National Laboratory Site-Wide Environmental Impact Statement (DOE/EIS-0238)* (LANL 2004f). The 2004 LANL information document provides 10-year forecasts of radioactive and nonradioactive waste generation at LANL. These forecasts are in two parts:

- Forecasts of wastes from several LANL sources, including the environmental restoration project and LANL operations. The forecasts are derived from a June 2003 report (LANL 2003c) that was attached to the 2004 LANL information document (LANL 2004f) as Appendix G.

- Forecasts of waste from a separate decontamination, decommissioning, and demolition (DD&D) project that would generate wastes from demolishing several LANL structures (LANL 2004f).

The focus of this appendix is on waste that could be generated from LANL's environmental restoration project.[31] Projections of environmental restoration project waste from the June 2003 report (LANL 2003c) as updated for years 2006 through 2008 by a subsequent report (LANL 2004i), are presented in **Table I–25** for FYs 2006 through 2012. For transuranic waste and mixed transuranic waste, the revised forecast projected an annual minimum of 52 cubic yards (40 cubic meters) of transuranic waste and an annual maximum of 105 cubic yards (80 cubic meters) of transuranic waste (LANL 2004i). The larger estimate is reflected in the table.

Table I–25 Projections of Los Alamos National Laboratory Environmental Restoration Project Wastes from Fiscal Year 2006 through Fiscal Year 2012

Waste	*Fiscal Year*						
	2006	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***
Chemical - hazardous waste [a] (tons)	7,591	1,644	1,165	162.7	0	38.4	27.6
Low-level radioactive waste (cubic yards)	1,295	989	3,640	4,175	31	0	0
Mixed low-level radioactive waste (cubic yards)	6.5	129	196	20	0	303	89
Transuranic waste (cubic yards)	100	100	100	0	0	0	0

[a] Resource Conservation and Recovery Act (RCRA) waste, Toxic Substances Control Act (TSCA) waste, New Mexico State special solid waste, and waste not otherwise suitable for sanitary landfill disposal.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; tons to metric tons, multiply by 0.90718.
Sources: LANL 2003c, 2004i.

The Consent Order requires the investigation and remediation of numerous potential release sites and areas of concern. Implementing the Consent Order may cause generation of larger quantities

[31] *Wastes potentially generated from DD&D of LANL structures are addressed in Appendix H, Section H.1, for structures in TA-18 and in Section H.2 for structures in TA-21. Waste estimates from recovery and shipment of stored transuranic waste at Area G of TA-54 are addressed in Section H.3. Waste estimates from combined LANL sources are addressed in the main body of this SWEIS.*

of environmental restoration waste than previously projected. Because investigations are ongoing and many corrective action decisions remain to be made, it is not possible to precisely define the types and quantities of wastes that would be generated from actions taken under the Consent Order. Bounding estimates were therefore made.

It was assumed that MDAs A, B, T, U, AB, C, G, and L would be remediated in conformance with their remedy completion report due dates.[32] For other MDAs, it was assumed that their remediation would start in FY 2007 and continue through FY 2016. Total quantities of wastes that may be generated under each option (capping or removal) were estimated and averaged from FY 2007 through FY 2016. For the remaining PRSs, waste generation rates from some representative PRSs were estimated, and an average annual waste generation rate was assumed starting in FY 2007 and continuing through FY 2016. This waste was added to that projected in Table I–25.

The waste types assumed for this appendix are listed in **Table I–26**. Nonliquid wastes are grouped into four types: solid waste, chemical waste, low-level radioactive waste, and transuranic waste. Solid waste refers to solid waste suitable for disposal into a solid waste landfill. Chemical waste is meant to be a general description for chemical or hazardous wastes that contain hazardous constituents regulated under RCRA or TSCA, are regulated as a special waste by the State of New Mexico pursuant to the New Mexico Solid Waste Act of 1990, or otherwise fail to meet waste acceptance criteria for sanitary landfill burial.

Table I–26 Waste Types Considered

Waste Types	*Waste Subtypes*
Nonliquid Wastes	
Solid waste	–
Chemical waste	–
Low-level radioactive waste	Low-activity
	Mixed low-activity
	Alpha
	Mixed alpha
	Remote-handled
	Mixed remote-handled
Transuranic waste and mixed transuranic waste	Contact-handled
	Remote-handled
Liquid Wastes	
Industrial	–
Hazardous	–
Radioactive	Low-level
	Mixed low-level

Low-level radioactive waste was assumed to be radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring

[32] *This assumption is conservative for MDA U because NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (see Section I.2.5.2.4 of this appendix).*

radioactive material. Low-level radioactive waste was divided among six subtypes. This distinction was made to enable assessment for transportation impacts in this appendix and was not meant to represent official DOE waste classifications.

Low-activity low-level radioactive waste contains radionuclides in concentrations that do not exceed the Class A limits of 10 CFR Part 61 and have surface radiation levels smaller than 200 millirem per hour. Mixed low-activity low-level radioactive waste has similar radioactive properties but also meets the definition of RCRA hazardous waste. Alpha low-level radioactive waste contains alpha-emitting transuranic isotopes in concentrations between 10 and 100 nanocuries per gram; this waste is assumed to be contact-handled. Mixed alpha low-level radioactive waste is similar radiologically but also meets the definition of RCRA hazardous waste. Mixed remote-handled low-level radioactive waste has surface radiation levels that exceed 200 millirem per hour. Much of this waste may also exceed Part 61 Class A limits. Mixed remote-handled low-level radioactive waste is similar material but also meets the definition of RCRA hazardous waste.[33]

Transuranic waste is not separated into mixed and nonmixed subgroups. Both mixed and nonmixed transuranic waste can be shipped directly to WIPP, provided that wastes having the RCRA characteristics of ignitability, corrosivity, or reactivity are treated. Transuranic waste is separated into contact-handled and remote-handled transuranic waste, where remote-handled transuranic waste containers have surface radiation levels exceeding 200 millirem per hour.

Liquid wastes would be generated in small volumes; for example, from equipment decontamination. Liquid low-level radioactive waste contains small concentrations of radioactive isotopes regulated by DOE under the Atomic Energy Act of 1954. Mixed low-level radioactive liquid waste is similar in radioactive properties but also meets the definition of RCRA hazardous waste. Hazardous liquid waste meets the definition of RCRA hazardous waste. Industrial liquid waste is process water that does not meet the definition of hazardous waste.

I.3.2.2 Investigations

The Consent Order requires investigations to fully characterize the nature, extent, fate, and transport of contaminants that have been released to air, soil, sediment, surface water, and groundwater. For example, the investigations of the canyon watersheds must address canyon alluvial sediments, surface water monitoring and sampling, and groundwater monitoring and sampling, focusing on the fate and transport of contaminants from the point of origin to each canyon watershed drainage system, and, if necessary, to the regional aquifer and the Rio Grande. The Consent Order requires the construction of new wells, the abandonment of some existing wells, and environmental sampling. Newly constructed wells include alluvial wells, intermediate wells, and regional aquifer wells. Requirements for specific LANL TAs are often prescribed in terms of individual MDAs. The investigations for each MDA must typically include a survey of disposal units, drilling explorations, soil and rock sampling, sediment sampling, vapor monitoring and sampling, intermediate and regional aquifer groundwater well installation, and

[33] *This grouping of different low-level radioactive waste subtypes contains simplifications. For example, some alpha-low-level radioactive wastes may require remote handling. However, there is insufficient information for further meaningful subgroupings.*

groundwater monitoring (NMED 2005). These investigations would involve similar if not identical technologies that have long been used at LANL.

Investigations of PRSs must be conducted in accordance with work plans to be submitted to and approved by NMED. Investigations for most PRSs will be conducted in accordance with work plans for the aggregate areas containing these PRSs, and the details of the work plans will depend on the known and inferred characteristics of the PRSs within each aggregate area. Three example work plans are those addressing the DP Site Aggregate Area at TA-21 (LANL 2004e); the Guaje, Barrancas, Rendija Canyons Aggregate Area at the townsite (LANL 2005j); and the Pueblo Canyon Aggregate Area (LANL 2005g). The objectives of the work plans are to characterize the nature and extent of contamination, if any, and to determine the need for corrective action. Investigations may include (but are not necessarily limited to) geodetic and geophysical surveys, radiological surveys, surface and near-surface soil sampling, sampling soil and tuff from boreholes, and confirmation sampling of soil or tuff after conducting a remedial action. A phased approach will be used that will be tailored to each PRS, including site reconnaissance, screening, characterization, excavation, confirmation sampling, and evaluation of survey screening and sample data. This approach allows for acquisition of confirmation data and review of results before demobilizing the investigation program for that PRS.

In May 2005, LANL staff submitted an Interim Facility-Wide Groundwater Monitoring Plan to NMED. Four modes of water will be monitored: base flow, alluvial groundwater, intermediate perched groundwater, and regional aquifer groundwater. Monitoring within LANL boundaries will take place in seven major watersheds or water shed groupings. Monitoring outside LANL boundaries will be conducted in areas that LANL operations have affected, and, to provide baseline information, areas that LANL operations have not affected. Monitoring data will be reported in accordance with Consent Order schedules (LANL 2006h).

Any investigation-derived waste generated during the site investigation process will be managed in accordance with all applicable EPA and NMED regulations, DOE orders, and LANL implementation requirements. Investigation-derived waste may include drill cuttings, contaminated personal protective equipment, sampling supplies, plastic, and decontamination fluids. Some field investigations may also displace environmental media such as groundwater, surface water, surface and subsurface soils, rocks, bedrock, and gravel.

I.3.2.2.1 Well Installation

Exploratory and monitoring well borings must be drilled using the most effective, proven, and practicable method for recovery of undisturbed samples and potential contaminants. Methods to be used must be approved by NMED (NMED 2005). Monitoring wells are typically constructed by advancing a boring with a drilling rig, installing a well casing and screen, and backfilling the annulus between the casing and the wall of the borehole (Hudak 1996). Based on drilling conditions, the borings may be advanced using one of the following methods: hollow-stem auger, air rotary, mud rotary, percussion hammer, sonic, dual-wall air rotary, direct-push technology, cryogenic, and cable tool. Drilling techniques will be selected and used that minimize collateral disturbance and investigation-derived waste. NMED prefers hollow-stem auger or direct-push technology drilling methods if vapor-phase or volatile organic compound contamination is known or suspected. Air rotary drilling is preferred for borings intersecting the regional aquifer. The type of drilling fluid used must be approved by NMED (NMED 2005).

Each of these drilling methods are summarized below.

Hollow-stem auger. A hollow-tem auger may be used to install monitoring wells in unconsolidated or poorly consolidated materials, but is inappropriate for solid rock. No drilling fluids are required (Hudak 1996).

Air rotary. Rotary drilling uses circulating fluids to remove drill cuttings and maintain an open hole as drilling progresses. In the air rotary method, air is forced down the drill pipe and back up the borehole to remove drill cuttings. Air rotary is often discouraged for environmental investigations because of the difficulty of yielding representative samples (Hudak 1996).

Mud rotary. Mud rotary drilling, like water rotating drilling, requires the introduction of fluids through the drill pipe to maintain an open hole, to provide drill bit lubrication, and to remove drill cuttings. Mud rotary drilling is often used instead of water drilling when the subsurface properties make it difficult to maintain an open borehole (Hudak 1996).

Dual-wall air rotary. The dual-wall reverse-circulation rotary method employs a double-walled drill pipe. Air (or water) is forced down the outer casing and circulated up through the inner pipe. Cuttings are forced to the surface through the pipe (Hudak 1996).

Percussion hammer. This drilling technique uses compressed air to hammer a series of short, rapid blows to the drill rods or bits and also simultaneously applies a rotating motion. Drill cuttings are flushed to the surface by compressed air (TH 2005).

Sonic. Resonant sonic drilling uses a combination of mechanically generated vibrations and limited rotary power to penetrate soil. The drill head, attached to the drill pipe, uses two counter-rotating, out-of-balance rollers, causing the drill pipe to vibrate in resonance. The vibration and weight of the drill pipe, along with the downward thrust of the drill head, permit penetration of the geologic formation without adding drilling mud or lubricating fluid. The technique is adaptable to any slant angle and virtually any geologic formation and typically produces no cuttings or secondary waste streams (NCDENR 2005, CPEO 2005).

Direct-push technology. Direct-push technologies use hydraulically powered machines that drive small-diameter tools directly into the surface. This technology generates little to no investigation-derived wastes and can be mounted on relatively small vehicles, allowing for use at sites that are difficult to access and minimizing collateral disturbance to surrounding soil and vegetation (ICON 2005, Fugro 2005).

Cryogenic. Cryogenic drilling replaces ambient air with cold nitrogen liquid or gas—as cold as 320 ^{o}F (degrees Fahrenheit) (-196 ^{o}C [degrees Celsius])—as the circulating medium. The nitrogen stream freezes moisture in the ground surrounding the borehole, thus stabilizing it (DOE 1998b).

Cable tool. The cable tool drilling method uses a heavy string of drilling tools that are repeatedly lifted and dropped within a borehole. The drill bit breaks and crushes consolidated rock into small fragments and loosens unconsolidated material. The reciprocating action of the tools mixes the crushed and loosened rock particles with water to form a slurry. A sand pump or bailer removes the slurry (Hudak 1996).

I.3.2.2.2 Well Purging

Procedures for purging monitoring wells before sampling must be approved by NMED. The Consent Order requires temporary storage of purged groundwater and decontamination water until proper characterization and disposal can be arranged. Disposal methods must be approved by NMED (NMED 2005).

I.3.2.2.3 Test Excavations

Site investigations may include test excavations, including trenches and test pits in areas of contamination. Test excavation programs have been conducted at LANL PRSs. Future test excavation programs should cause small areas of temporary surface disturbance, generally in areas such as MDAs that have already been changed from natural conditions. Test excavations will result in temporary removal, stockpiling, and return of uncontaminated soil and material, as well as generation of small volumes of waste.

I.3.2.3 Maintenance of Nuclear Environmental Sites

Some of the PRSs addressed in this appendix are nuclear environmental sites, which are inactive waste handling or disposal areas that contain sufficient radioactive material to be classified as hazard category 2 or 3 according to DOE Standard thresholds (DOE 1997b). These nuclear environmental sites are listed in **Table I–27**. LANL staff perform routine inspections and maintenance at these sites to maintain compliance with 10 CFR Part 830. LANL staff has developed a documented safety analysis for surveillance and maintenance of the sites (LANL 2004l).

Consistent with the surveillance and maintenance documented safety analysis implementation plan, all nuclear environmental sites have been initially inspected. Results of those inspections indicated the need for several actions, which are ongoing. The work elements required to address these findings fall into several distinct categories of similar actions:

- General maintenance
- Boundary marking
- Baseline radiological survey
- Erosion control studies and maintenance efforts
- New fencing

Table I–27 Hazard Categories and Descriptions of Nuclear Environmental Sites

Nuclear Environmental Site [a]	*Associated PRS*	*Description*	*Hazard Category*
TA-21 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 Wastewater Treatment Plant	35-003(a)-99	Areas of residual contamination associated with leakage from, and removal of, components of former Wastewater Treatment Plant	3
TA-35 Pratt Canyon	35-003(d)-00	Areas of residual contamination associated with discharge from former Wastewater Treatment Plant	3
TA-49 MDA AB	49-001(a)-00	Shaft areas 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

PRS = potential release site, TA = technical area, MDA = material disposal area.
[a] An additional site is outside the LANL boundary in Bayo Canyon.
Source: LANL 2004l.

General Maintenance. Activities may include mowing, debris clearing, foliage removal, and fence repair. Tasks such as mowing, clearing brush, removing debris, and removing small trees are performed to maintain site surface characteristics and to limit combustible materials. Equipment used includes 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. Repairing existing fences involves minor site preparation, such as light scraping and removal of vegetation. Small hand- and power tools may be used.

Boundary Marking. The disposal units that comprise the inventory driving the nuclear facility categorization are being demarcated. Activities may include general surveying, placement of posts, and placement of temporary barriers such as orange construction fencing. General surveying is usually conducted by a surveyor and assistant. Some surveying equipment (for example, tripods, survey rods) slightly intrudes into the subsurface to provide a firm base for instruments. The depth of penetration in typical soils is less than 3 inches (7.6 centimeters). Personnel use pin flags, flagging, and wooden or metal stakes to mark locations and may pound stakes 1 foot (0.3 meter) or deeper into the subsurface. General surveying may require the installation of permanent benchmarks using hand- or battery-operated rock drills to make small holes in bedrock and cementing the benchmarks in the drilled holes. 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.

Baseline Radiological Survey. Baseline radiological surveys are being performed at several sites. The goal of a baseline survey is to establish surface radiological conditions at a specific point in time. If future inspections indicate significant physical changes such as biodegradation, erosion, or burrowing animals, the impacts of these changes can be evaluated by performing radiological surveys in the areas of changed condition. Survey equipment includes a wide array of devices that are generally small, handheld, and self-contained. To 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 nuclear environmental site boundaries. Survey personnel may work in areas of dense vegetation or rough terrain and along parking lots and roadways near traffic. Survey instruments may be mounted on all-terrain vehicles.

Erosion Control Studies and Maintenance. Erosion control measures may include installation and maintenance of check dams, straw wattles, or surface basecoarse or earthen berms.

New Fencing. New fence construction can include digging holes, placing concrete, setting posts, and using a "come along" or other light equipment to stretch fencing. 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; or electric or pneumatic cutting drills and saws.

I.3.3 Remediation of Material Disposal Areas

The MDAs contain a variety of radionuclides or hazardous constituents within wastes that have been disposed of in pits, trenches, and shafts. To evaluate alternative corrective measures, potential corrective measure technologies would be screened to eliminate those that prove infeasible to implement, rely on technologies unlikely to perform satisfactorily or reliably, or do not achieve corrective action objectives within a reasonable time. Conceptual models would be established and the likely performance of the MDAs would be evaluated against the corrective measure objectives established for the corrective measure process.

The purpose of this section is not to preclude this screening process, but to identify a range of corrective measure technologies that might be suitable. At any MDA, a number of corrective measure technologies may be used. For example, portions of MDAs may be removed and portions may be stabilized in place. Some MDAs may require treatment of volatile organic compound plumes.

I.3.3.1 Corrective Measure Technologies Possibly Suitable for Material Disposal Areas

Corrective measure technologies continue to be developed, for example as part of DOE's Environmental Remediation Science Program. One information source of environmental remediation technologies is the Federal Remediation Technologies Roundtables Remediation Technologies Screening Matrix and Reference Guide (FRTR 2005). Each of the MDAs presents a unique mix of challenges for remediation. Nonetheless, possible treatment technologies can be grouped as follows:

- *Stabilization in place* – containment and in situ treatment technologies
- *Removal* – excavation/removal and ex situ treatment technologies

I.3.3.1.1 Possible Containment and in Situ Treatment Technologies Associated with the Stabilization in Place Option

Contamination would be treated in situ or contained in place by installing a final cover. Possible technologies are listed in **Table I–28.**

Table I–28 Possible Technologies for Containment and in Situ Treatment

Category	*Subcategory*	*Technology*
Containment	Vertical barriers	Slurry walls
		Rock-grout mixing
		Synthetic membrane
	Deep-surface horizontal barriers	Deep-surface horizontal barriers
	Near-surface horizontal barriers	Soil-grout mix
		Vitrification
	Surface barriers	Asphalt cover
		Compacted clay cover
		Multilayer cover
		Evapotranspiration cover
		Biotic barriers
In Situ Treatment	Biological treatment methods	Microorganisms
	Physical treatment methods	Soil gas venting
		Soil vapor extraction
		Pneumatic fracturing
		Electrokinetic soil treatment
		Vitrification
		Compaction with conventional equipment
		Dynamic compaction
		Waste stabilization
		Thermal treatment

Vertical Barriers

Vertical (lateral) barriers could be installed around the perimeters of the disposal units, including:

- *Slurry walls*. A slurry wall is formed by placing cement grout or similar materials into narrow, deep trenches or in a series of adjacent open boreholes surrounding the perimeter of a group of disposal units.

- *Rock-grout mixing*. Rock-grout barriers are formed by drilling adjacent deep shafts around the perimeter of a group of disposal units and then mixing the cut rock with injected grout as the shaft is drilled.

- *Synthetic membrane*. A geosynthetic liner or similar membrane can be placed in a vertical trench, thereby forming a barrier that impedes or restricts the lateral movement of contaminants.

These barriers are principally meant to prevent lateral movement of contaminants from disposal units. Assuming that vertical barriers were combined with an effective cap, the two technologies would act essentially as an upside-down box over the waste. This would reduce the potential for human or bio-intrusion.

Vertical barriers were considered as stabilization alternatives for the nine waste disposal shafts at MDA H. Under one alternative, a vertical sidewall barrier would be constructed at a predetermined depth and width around the entire perimeter of MDA H. Concrete caps would be placed above the shafts and the surface covered with an evapotranspiration cover. Under a second alternative, which was selected as a partial corrective remedy by NMED (NMED 2007a), interlocking boreholes filled with grout would surround each of the 6-foot shafts. A concrete cap would be installed (DOE 2004b). A third alternative was the deep-surface horizontal barrier discussed below.

Deep-Surface Horizontal Barrier

A horizontal barrier could be installed underneath disposed waste to reduce the downward aqueous-phase movement of contaminants. Such a barrier was selected by NMED for encapsulation of the nine disposal shafts at MDA H (LANL 2003b, NMED 2007a). A wall would be constructed around each disposal shaft by drilling interlocking shafts around each disposal shaft that would be filled with cement slurry. At the bottom of each disposal shaft a bottom seal would be constructed using a three-fluid ("Kajima") system. An injector assembly would be lowered to the bottom of one or more shafts. As the injector assembly rotated, it would direct high-energy jets of water against the tuff. An air jet producing an aureole of compressed air concentric about the jet would augment the effectiveness of the water jet. At the same time, cement grout would be injected into the void and the surrounding soil through a second nozzle. A mixing radius of over 6 feet (1.8 meters) can be achieved (LANL 2003b).

The Kajima system may not be effective for all disposal units considered in this appendix. Most MDAs are much larger than MDA H, comprising pits and trenches covering large surface areas in addition to shafts.

Near-Surface Horizontal Barrier

These technologies provide horizontal barriers above disposed waste to reduce vertical infiltration of water into waste and to reduce the potential for intrusion by plants, animals, or humans. Technologies include a soil-grout mixture and vitrification:

- *Soil-grout mix*. A soil-grout mixture would be emplaced over the tops of the disposal units. The mixture could range in thickness up to several feet. After the mixture hardens, it would restrict infiltration or intrusion.

- *Vitrification*. Electrical resistance would heat several feet of soil above disposed waste to temperatures high enough to melt the soil. This melted area would cover the entire surface of a disposal unit.[34] When the melted soil or rock cools, a glasslike mixture would cover the tops of the disposal units. The glass mixture would be theoretically impenetratable against water infiltration and biological intrusion.

A soil-grout mix may be more generally suitable to the MDAs considered in this appendix. Vitrification would subject the top layers of waste within the MDAs to high levels of heat, possibly causing unsafe reactions.

Surface Barriers

These technologies comprise barriers placed over the tops of disposal units to restrict infiltration of water, erosion, or biointrusion. Possible barriers may include asphalt covers, compacted clay covers, multiple-layer covers, evapotranspiration covers, and biotic barriers.

Asphalt covers. A layer of asphalt would be placed over the tops of the disposal units. Asphalt layers have been placed over portions of disposal units at MDA AB (Area 2), MDA L, and MDA B. Investigations at Area 2 of MDA AB have shown that moisture has been trapped beneath its asphalt layer. Absent the asphalt, the moisture may have evapotranspired. Also, if portions of the asphalt collapse from settling or subsidence of the underlying waste and backfill, the holes produced in the asphalt can act as a funnel for infiltration.[35]

Compacted clay cover. A 1- to 3-foot (0.3- to 0.9-meter) layer of compacted clay would be placed over the tops of disposal units. Because clay, when effective, has a very low permeability and therefore resists water infiltration, a clay cap has been recommended or used at numerous waste disposal sites. But in arid and semiarid environments the clay can dry and crack, leading to comparatively large rates of infiltration through the cracks. And to the extent that the underlying waste and soil is structurally unstable, leading to subsidence and differential settling, the barrier provided by the compacted clay may be disrupted.

Multiple-layer cover. Multiple-layer covers consist of layers of different geologic and synthetic materials. They have been proposed for several radioactive waste disposal sites and are being used at RCRA landfills. The Corrective Measures Study Report for MDA H cites cases where multiple-layer covers at RCRA landfills were damaged through settlement that compromised the continuity of the cover's discrete layers. The clay layer at the bottom of a differentially settled area at a landfill may be breached. Also, a geomembrane may tear if enough settlement occurs. The drainage layer above the barrier layer can funnel moisture to the low area where infiltration occurs at the breached portions of the clay layer (LANL 2003b).

Evapotranspiration cover. Evapotranspiration covers are designed to enhance soil water storage capacity by retaining infiltrated water until it can be evaporated by solar radiation and transpired by shallow-rooted plants. Two types of evapotranspiration covers have been investigated: monolithic evapotranspiration covers and evapotranspiration covers having capillary barriers. Monolithic evapotranspiration covers consist of a single, vegetated soil layer having a site-specific mix of soil texture, soil thickness, and vegetation. Evapotranspiration covers having

[34] *See the In Situ Physical Treatment section for a brief discussion on applying vitrification to waste in an entire disposal unit. In this case, vitrification is used for long-term waste stabilization.*
[35] *The asphalt layer at MDA AB was removed in 1999 and an evapotranspiration cap installed (LANL 1999a).*

capillary barriers include an interface between an upper fine-textured soil and lower coarse-textured material.[36] The capillary barriers are placed below the water storage zone to provide additional protection against downward water flow (INEEL 2000).

Unlike clay covers, evapotranspiration covers do not rely on low hydraulic conductivity. Mechanisms that increase the hydraulic conductivity of evapotranspiration covers (that is, drying out) do not significantly affect their performance. Hence, evapotranspiration covers—particularly monolithic covers—may be less susceptible to loss of function from subsidence and differential settlement than either a compacted clay cap or a multiple-layer cap. Evapotranspiration caps have been developed explicitly for landfills in arid and semiarid environments. Case studies addressing the use of evapotranspiration caps at landfills covering a range of climatic conditions have been summarized in a technology overview by the Interstate Technology and Regulatory Council (ITRC 2003a). Research has been ongoing about use of evapotranspiration caps at LANL disposal units since the early 1980s (Breshears, Nyhan, and Davenport 2005; Nyhan 2005).

Biotic barriers. These barriers control the intrusion of plants or animals into disposal units. One approach would be to place layers of hard, long-lasting natural materials such as cobble-sized rocks or pea gravel. These barriers discourage penetration by burrowing animals and, depending on design, can potentially discourage penetration by deep-rooting plants.

Research has been performed on burial of herbicides (or other plant poisons) within discharge units at depths below those associated with desirable types of local, shallow-rooted plants. Plants having roots that grow into the herbicide layer are killed. The efficacy of this technology is limited to the secretion period of the discharge units.

At MDA AB, chain-link fencing has been placed on the surface of a disposal cover. Although vegetation readily grows through the fencing, intrusion by burrowing animals is discouraged (LANL 1999b).

In Situ Biological Treatment

These technologies use processes that feed on organic material. The technologies have been effective in treating low-level concentrations of radionuclides in wastewater, but have not been demonstrated at radioactive waste disposal sites (LANL 2003b).

In Situ Physical Treatment

Several technologies may help remediate or physically stabilize waste disposal sites, including those described below.

Soil gas venting. Boreholes are drilled into the soil and left open, allowing release of subsurface vapors and gases to the atmosphere or a treatment system. Soil gas venting may be used to

[36] Under unsaturated conditions, water in the small pores of the fine-textured soil is held at high tension and will not flow into the large pores of the coarse-textured soil where the water tension is low. For the water to flow out of the soil and into the coarse-textured material, it must be at sufficiently low tension. Tension decreases as the soil approaches saturation. Once breakthrough occurs, water will drain into the coarse material at a rate largely controlled by the hydraulic conductivity of the overlying soil (INEEL 2000).

remove an underground source of volatile organic compounds or to reduce volatile organic migration. It is less effective when volatile organic compound concentrations are in the parts-per-billion range. It has been postulated for release of tritium in a gaseous or vapor form (LANL 2003b).

Soil vapor extraction. A force is applied to underground gases or vapors to accelerate their removal from soil. Forces have included: (1) air pressure injected into one or more wells; (2) a vacuum pulling the gas or vapor from one or more wells; or (3) a steep diffusion force that removes gas or vapor from an area. The extracted gas or vapor may be directed to a treatment system. The technology is less effective for volatile organic compounds when volatile organic compound concentrations are in the parts-per-billion range (LANL 2003b).

Pneumatic fracturing. A fluid is injected at high pressure to create open fractures in an area where a contaminant plume exists. The opened flow paths allow access to the contaminated media for removal or treatment. The technology injects large amounts of water, which may accelerate contaminant movement. If the contaminant includes explosives, the technology might promote their detonation (LANL 2003b).

Electrokinetic soil treatment. This technology continuously removes ionic or charged species from soils. A low-intensity direct current is produced between ceramic electrodes that are divided into a cathode array and an anode array. Charged species are mobilized toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Chlorides, cyanides, fluorides, nitrates, negatively charged organic compounds, and other anions move toward the anode. Contaminants that migrate toward the polarized electrodes may be removed. If the contaminant includes explosives, the technology may promote their detonation. Effectiveness is reduced for waste having a moisture content smaller than 10 percent (LANL 2003b, FRTR 2005).

Vitrification. In situ vitrification uses an electric current to melt soil or waste at temperatures from 2,900 to 3,650 degrees F (1,600 to 2,000 degrees C). Most inorganics are immobilized within the vitrified glass and crystalline mass, and most organics are destroyed by pyrolysis. Water vapor and organic combustion products are captured and drawn into a treatment system. Vitrification leaves a chemically stable, leach-resistant crystalline material similar to obsidian or basalt (FRTR 2005). In situ vitrification has been demonstrated at LANL by treating a small portion of one absorption bed at MDA V (LANL 2003e, 2004j).

Compaction with conventional equipment. Decreased infiltration and percolation through a disposal unit cover (by reducing porosity and thus permeability) can be achieved using commercially available equipment. Equipment may include sheepsfoot rollers, rubbertire rollers, smoothwheel rollers, vibrating baseplate compactors, and crawler tractors. Soil to be compacted would be applied in 6- to 12-inch (15- to 30-centimeter) lifts and several passes made to compact each lift to the desired density. The depth of compaction can range from 0 to 6 feet (0 to 1.8 meters) (NRC 1981).

Dynamic compaction. This technology compacts and consolidates waste in place. It may greatly reduce settling and subsidence over time. It has potential use at pits and trenches where the surface area is large relative to the disposal unit depth. A heavy weight is raised above a disposal unit and dropped, compressing the area underneath the weight. The weight is lifted, moved to cover an adjoining area of the disposal unit, and dropped. This process is continued until all the area over the disposal unit is compressed. The voids created by the process are backfilled and compacted. The technology has drawbacks: for maximum effectiveness, compaction should extend to the bottom of the disposal units. If the compactor breaks through the cover placed over the waste, contamination may be ejected. (Significant ejection of material might be avoided by making repeated compacting runs over the same area, each time filling in voids after each compacting effort.) The physical shock may destroy the integrity of any buried waste container. It may drive moisture from the disposal unit into the surrounding soil matrix (NRC 1981).

Waste stabilization. Wastes can be stabilized using a lance to inject a grout mixture (or similar) into the waste zone. The process to be employed, and the grout formulation, would be developed through a test program. The grout could be mixed at a conveniently sited batch plant, delivered to the work site by truck, and fed into pumps that deliver the grout to an injection lance using high-pressure lines. The injection lance would be driven into the waste using technology such as a rotary percussion drill to the maximum depth of the waste, or until refusal. As grout is forced out of jet nozzles located in the tip of the lance, the lance is rotated as it is withdrawn. After the lance is retracted, it is decontaminated and moved to the next location. Care is needed to minimize the return of grout to the surface. Another concern is ground heaving. Properly performed, the technique can increase the density of the disposed waste without any increase in waste volume. In addition to waste stabilization, the technique reduces the permeability of the waste, and provides encapsulation and chemical buffering (INEEL 2002c).

In situ grouting has been analyzed and tested at several DOE sites as summarized in an Idaho National Laboratory report (INEEL 2002c). Grout consisting of Portland cement, epoxy, hematite grout, paraffin grout, and other proprietary formulations have been investigated or considered (INEEL 2002c). In situ grouting is an option for stabilization of the trenches, pits, and shafts at the Idaho National Laboratory surface disposal area (INEEL 2002a). A variation was considered for encapsulation of the LANL MDA H shafts (DOE 2004b).

Thermal treatment. Several techniques have been developed to decompose heat-sensitive contaminants into less-toxic or less-mobile forms. These techniques can be used to heat a contaminant into a vapor phase, and in so doing, enhance its extractability. Heat may be generated using microwave, radiofrequency, thermal radiation, or other methods. But if the contaminants include reactive or explosive materials, this technology might promote undesirable chemical reactions (LANL 2003b).

I.3.3.1.2 Possible Removal, Ex Situ Treatment, and Disposal Technologies

A decision to remove waste or contaminated soil results in an interlinked series of operations:

- Excavation;
- Material characterization;
- Material classification;
- Treatment and packaging; and
- Storage or disposal of the material.

The first three operations are addressed in Section I.3.3.1.2.1; the last two are addressed in Section I.3.3.1.2.2. Some case studies are summarized in Section I.3.3.1.2.3.

I.3.3.1.2.1 Removal Technologies and Operations

Removal activities must be conducted in a manner that ensures worker and public safety, minimizes the spread of contamination, and minimizes possible negative effects on biological, cultural, and operational resources. Typical removal activities are listed in **Table I–29.**

Table I–29 Typical Removal Activities

Activity	*Typical Subactivities*
Planning	Engineering and operations Material disposition Safety assessments and plans Biological and cultural assessments and resource protection plans Stormwater pollution prevention plans Best management practices for erosion control NEPA reviews Readiness reviews
Permits and authorizations	National Pollutant Discharge Elimination System General Permit Regulatory corrective action approval NEPA documentation Safety authorization Other authorization
Preliminary work	Site preparation (establish roads and equipment; material; and waste storage, handling, and decontamination areas and reroute utilities) Remove buried pipes or lines or overheads (ensure utilities, if needed) Establish environmental and safety monitoring networks Perform tests and further develop equipment and procedures (test excavations, etc.) Perform surface and subsurface tests and sample collections to determine the extent of contamination
Operations	Excavation Contamination control Sorting Media characterization Material characterization Material classification Packaging for transport Safety and environmental monitoring
Finish work	Backfilling Final cover, if needed Cleanup and remediation
Closeout	Final sampling and monitoring Regulatory approval

NEPA = National Environmental Policy Act.

After the planning, authorization, and site preparation phases are completed, excavation would commence and continue until the operational objectives are met. Overburden over the contaminated material, or uncontaminated material excavated near the contaminated material, would be stockpiled for return to the excavation when contamination removal is completed.

Removal operations can be differentiated into:

- *Standard removals*: Those that can be safely and relatively quickly conducted using standard construction equipment

- *Specialized removals*: Those requiring more extensive planning and effort and use of specialized procedures and equipment

Standard, usually small-scale, removals have taken place at several DOE sites. Procedures for radiation and industrial safety, contamination control, waste characterization, and classification are well established. Waste equipment commonly used for such removals is listed in **Table I–30** (INEEL 2002b).

Table I–30 Equipment Commonly Used for Standard Removals

Equipment	*Description*	*Comments*
Backhoe	Tracked or wheeled excavators used for digging small areas, having a typical bucket size of 2 cubic yards (1.5 cubic meters). Auxiliary equipment can include clamshell buckets, drum grapplers, dippers, loader buckets, and hammers.	Useful for trench digging and area excavation up to 45 feet (13.7 meters) deep. Linear reach less than 100 feet (30 meters).
Front-end loader	Tracked or wheeled excavators capable of digging, lifting, dumping, and hauling. Bucket size is up to 20 cubic yards (15 cubic meters).	Useful for excavating large areas having short travel distance needs (< roughly 300 feet [91 meters]).
Bulldozers	Tracked vehicle having a blade or bucket for surface work.	Useful for removing surface layers, clearing surface debris, and general earthmoving. Less useful for retrieval of buried waste.
Trencher	Wheeled excavator capable of excavating and grading. Commonly called a ditch witch, it can use auxiliary equipment such as a backhoe, backfill blade, or an auger.	Useful for small-scale digging.
Vacuum/soft trencher	Vacuum removes soil without disturbing large debris. Can use jetted air to loosen soil before vacuum removal.	Potentially useful for loose soil removal at dig face. Not useful for retrieving buried waste.
Soil skimmer	Removes thin layers of soil in a controlled manner.	
Skid-steer loader	Small excavator similar to a front-end loader. Often called a Bobcat.	

Source: INEEL 2002b.

Specialized removals require more extensive planning and effort and use of specialized procedures and equipment such as remote-control excavators or excavators designed to protect the operators from external radiation or airborne contamination hazards. An Idaho National Laboratory report (INEEL 2002b) provides 13 case histories of demonstrations where (mainly) DOE sites have: (1) used remote excavators and end-effectors; (2) modified standard equipment so a person in a sealed environment could operate the equipment; and (3) faced conditions similar to those at the Idaho National Laboratory subsurface disposal area. Another reference surveys commercially available remote-control machines for excavation and recovery of buried ordnance (LLNL 2002). Appendix G of the Sandia Mixed Waste Landfill Corrective Measures Study Final Report reviewed excavation of a portion of the landfill using robotics (SNL 2004). Examples of specialized excavators and ancillary equipment are listed in **Table I–31** (INEEL 2002b).

Example measures for controlling contamination during excavation are listed in **Table I–32** (adapted from INEEL 2002b).

Table I–31 Examples of Specialized Excavators and Other Equipment

Equipment	***Comments***
Remote Excavators	
Brokk	Remote controlled excavator with a telescoping arm. Available with several end-effectors for hammering, cutting, and scooping wastes. The largest BROKK can reach about 13 feet (4 meters) below ground surface (bgs). Used at Hanford for retrieval of high-dose debris and at Idaho National Laboratory for demolition.
Kiebler Thompson	Remote-controlled excavator with a telescopic boom capable of three-dimensional movement. Available with several end-effectors. The largest machine can reach about 16 feet (5 meters) below ground surface. Similar to the Brokk.
T-Rex	A tele-operated, heavy-lift, long-reach excavator used to retrieve boxes, drums, and containers using a front-shovel excavator. Controls can be operated up to 1,250 feet (381 meters) away. Developed at Idaho National Laboratory.
HERMES	A tracked computer controlled excavator with a hydraulic manipulator. The system (Hybrid Remote Robotic Manipulation and Excavation System [HERMES]) was developed by Boissiere Engineering and Applied Robotics (BEAR), Inc., and used for exhuming LANL's MDA P.
Modified Standard Equipment	
Sealed, pressurized cabins	Standard construction equipment with cabin modifications. Can supply air to the operator either using filtered air intakes or externally supplied air. Possibly useful for environments where the inhalation hazard is high.
Shielded cabins	Standard construction equipment with cabin modifications. The walls and cabin windshield would be shielded for use in high external radiation environments.
Remote Cranes	
Cooperative Telerobotics Retrieval System	System consists of a 80-foot-wide (24-meter-wide) girder, two trolley assemblies with vertically telescoping masts, two manipulators, and a 5-ton (4.5 metric ton) remotely operated hoist. Presently at Idaho National Laboratory.
RoboCrane	Cable-driven platform for a parallel link manipulator. Provides load control via teleoperative, graphic offline programming, and hybrid control modes.
Remote End-Effectors	
Safe excavation	High-pressure probe dislodges compacted and other hardened materials using air-jet/vacuum end-effecter system. Vacuums up soil.
Tentacle, highly manipulative	Teleoperated manipulator and bellows actuator. Used with a crane and manipulator. Load capabilities less than 4,000 pounds (1,814 kilograms).
Schilling Tital II	Manipulators deployed by crane for selective retrieval of barrels from soil. Basic components include hydraulic system, positioning system, electronics module, and mechanical interface.
Confined sluicing end-effector	Water jet designed for waste tank cleanout. Uses high-pressure water jets to cut material into small pieces and evacuates with a vacuum jet pump. Captures slurry water. Creates additional waste.
Innovative end-effector	Consists of a thumb, an attachable integrated transfer module, and a shovel assembly. Capable of soil retrieval and dust-free waste dumping.

MDA = material disposal area.
Source: INEEL 2002b.

In situ soil remaining after excavation must be characterized to determine whether it is sufficiently contaminated to warrant removal. Screening levels would be determined for the removal based on expectations about the future use of the site and upon established health, safety, or environmental protection criteria. Soils that do not exceed the screening levels would be left in place. Characterization techniques to be used, and their implications on operations, will depend on the contaminant under consideration; its in situ concentration; and operational or environmental factors.

Table I–32 Example Contamination Control Options

Options	*Description*
Confinement	Confinement structures made from plastic, metal, or other materials can enclose a piece of equipment, a work area, or a site and thereby prevent the spread of airborne contaminants. Enclosures used at a site or work area have ranged from lightweight, portable units to substantial structures.
Ventilation and vacuum systems	These systems use laminar airflow at a dig-face within enclosures to direct dust to filters. Vacuums remove loose particulates from equipment and structures and collect dust and debris.
Foams, sprays, misters, fixatives, and washes	These options can be used to control odors, volatile organic compounds, dust, and other emissions; create a barrier between work surfaces and the atmosphere; settle loose airborne contamination; and decontaminate personnel and equipment.
Electrostatics	Electrically charged plastic and electrostatic curtains form barrier walls against spread of contamination from enclosed areas. Curtains can be used upstream of emission filtering systems to neutralize charged dust particles.
In situ stabilization	Used before excavation to fix contamination into the soil and waste matrix and thereby minimize its dispersion into the air or surface water. Processes include injection of grout, resin, or polymer; vitrification; or ground-freezing.

Source: INEEL 2002a.

Excavated material must be similarly characterized in terms of its radionuclide or hazardous content to enable decisions about its further disposition. Soil or other materials that do not exceed screening levels may be recycled, disposed of as solid waste, or used as backfill. Contaminated material can be considered waste or decontaminated, if feasible and cost effective, and the decontaminated material reused, recycled, or disposed of.

Requirements for the subsequent disposition of the waste depend on the waste's classification. Wastes containing RCRA hazardous constituents must be treated according to regulatory-prescribed methods. DOE classifies wastes containing radionuclides as low-level radioactive waste if the concentrations of alpha-emitting transuranic isotopes (having half-lives exceeding 20 years) do not exceed 100 nanocuries per gram of waste.

As site preparation and excavation proceeds, site survey and monitoring programs would be conducted to ensure worker health and safety and to detect movement of radioactive or hazardous constituents from the work area to the environment.

After removal is complete, the site must be restored. An excavation at an MDA would be backfilled with soil, compacted, and revegetated. There would be an investigative effort to confirm that the corrective action objectives of the removal had been achieved. Appropriate after-action reports would be prepared for submittal and approval.

I.3.3.1.2.2 Treatment and Disposal Options

Following removal, wastes may require treatment and perhaps specialized packaging before their further disposition. Treatment options for wastes containing RCRA hazardous constituents include (LANL 2003b):

- *Neutralization*. Reactive materials can often be neutralized. Acids can be neutralized using bases and vice versa. Lithium compounds can be neutralized through reaction with water.

- *Thermal treatment*. Burning to destroy the explosive compounds can treat HE. This technology has long been used at LANL.

- *Cement stabilization*. Some materials may require stabilization before disposal as hazardous or mixed waste. This technology has long been used.

- *Debris treatment*. Treatment standards for materials meeting the RCRA definition of debris are specified in 40 CFR 268.45 and New Mexico Administrative Code 20.4.1.800. Microencapsulation is authorized for treating lead or lead-containing debris.

Some of the wastes possibly recovered from MDAs may be compressed gas cylinders.[37] Gas cylinders may present a physical hazard if they are recovered still pressurized and a chemical hazard depending on the gases contained within the cylinders. Gases in recovered cylinders may be toxic or reactive. Gases may be caustic or acidic, for example, or unstable. For example, hydrogen cyanide and ethylene oxide can undergo exothermic polymerization, while gases such as hydrogen bromide can react with moisture. Pyrophoric liquids may be stored in nonpressurized gas cylinders.

Recovered cylinders may be safely opened and the contents either recovered or treated. Basically, the recovered cylinder is placed within an explosion-resistant pressure vessel configured with various cutting tools and perhaps an inert-gas environment. (Recovered cylinders can be transported to a treatment facility external to the excavation using overpacks designed to contain the contents of the cylinder if it leaks or fails during transport.) Once the container contents are released within the pressure vessel, the gases or liquids may be transferred to appropriate external reactors or collection tanks. Gases, for example, can be transferred to wet scrubbers for neutralization. Systems are also available to treat cylinders containing biological or chemical weapon material (IES 2005).

Treatment of waste contaminated with high explosives would take place at LANL. Treatment of other RCRA hazardous wastes could take place either at LANL, if treatment capacity exists, or at an offsite location. Radioactive waste would be treated to meet the waste acceptance criteria for the facility receiving the waste.

Onsite Disposal Capacity

Onsite solid waste capacity. Solid waste currently generated by LANL's environmental restoration project is typically sent to an offsite solid waste landfill. However, a municipal solid waste landfill (to be closed) does exist within the LANL boundary (see Section I.4.9).

Onsite low-level radioactive waste capacity. The only operating low-level radioactive waste disposal facility at LANL is at Area G in TA-54. Because of the impending lack of capacity in existing disposal units, and because LANL personnel must complete remediation at MDA G by the end of 2015, LANL is expanding low-level radioactive waste disposal operations into Zone 4 and Zone 6 in TA-54 (see Section I.4.9).

[37] *Because LANL's mission during the period when compressed gas cylinders could have been disposed of was oriented much more to research and development than production of nuclear materials, pressurized containers possibly disposed of in LANL MDAs were probably lecture-size bottles containing no more than 1 pound as a pressurized liquid.*

Offsite Treatment and Disposal Capacity

Offsite treatment and disposal capacity exists for solid waste, hazardous waste, low-level, and mixed low-level radioactive wastes, and transuranic waste. Examples are described below.

Solid waste capacity. The Solid Waste in New Mexico, 2000 Annual Report lists 50 active solid waste landfills, including 3 landfills that accept construction and demolition wastes (NMED 2000).

Hazardous waste capacity. The 2006 U.S. Army Corps of Engineers *Report on Treatment, Storage & Disposal Facilities (TSDF) for Hazardous, Toxic, and Radioactive Waste* provides information about eighteen facilities currently engaged in commercial disposal of RCRA Subtitle C hazardous waste (ACE 2006). Five of these facilities hold a Toxic Substances Control Act permit for disposal of PCB-contaminated materials. Information about six hazardous waste sites near LANL is provided in **Table I–33**.

Table I–33 Selected Hazardous Waste Operations Near Los Alamos National Laboratory

Operator and Location	*Hazardous Waste Operations* [a]	*Waste Groups Accepted* [a]
Clean Harbors Westmorland, LLC Westmorland, CA	Treatment of heavy metals and other wastes; micro-encapsulation; solidification; waste landfill; processing of bulk or drummed wastes; storage before treatment or disposal.	RCRA hazardous waste; naturally occurring radioactive material waste from geothermal operations; Animal and Plant Health Inspection Service soils; and California-regulated wastes.
Clean Harbors Dear Trail, LLC Dear Trail, CO	TSD. Analytical capacity for TCLP, cyanide, alkaline chlorination; chemical reduction; stabilization or solidification; deactivation and neutralization; micro-encapsulation; landfill.	Contaminated process wastewaters; inorganic cleaning solutions; organic and inorganic laboratory chemicals; paint residues; debris from toxic or reactive chemical cleanups; off-spec commercial products.
U.S. Ecology Nevada, Inc. Beatty, NV	Chemical oxidation; stabilization; thermal; micro- and macro-encapsulation.	RCRA hazardous wastes, debris, and solid waste greater than 500 parts per million VOCs; PCBs; non-hazardous solid industrial, commercial, and agricultural chemical wastes; liquids for solidification; bulk or drummed solid waste; household hazardous waste; lab packs; State-regulated hazardous wastes; waste from conditionally-exempt small quantity generators; corrosive wastes and acids; asbestos or asbestos-RCRA debris.
Clean Harbors Lone Mountain, LLC Waynoka, OK	Waste treatment and storage; RCRA hazardous landfill operations; waste water treatment; rail transfer operations.	PCB soil and debris; non-hazardous soil; hazardous soil for direct landfill; hazardous soil for treatment of metals and organics on a case basis; debris for micro- or macro-encapsulation; plating waste; acidic waste; caustic waste; cyanide and sulfide bearing waste; and hazardous and nonhazardous liquids.
Waste Control Specialists Andrews, TX	TSD. Chemical oxidation or reduction; deactivation; macro-encapsulation; neutralization; stabilization; controlled reaction; amalgamation. Can dispose of treated soil. Can shred debris or treat VOC waste; aqueous waste; soil; dioxin, inorganic and organic sludges and solids; paint sludges; PCBs; pesticides; reactive material; solvents; TCLP metals; acids; caustics; oil.	Accepts >2,000 RCRA waste codes and TSCA materials. Most accepted radioactive waste is not disposed of. Can dispose of some exempt radioactive wastes, including some source material; some material containing thorium; some NORM; some materials containing rare earths; depleted uranium used for shielding; and materials exempt from licensing under Texas regulation.

Operator and Location	Hazardous Waste Operations [a]	Waste Groups Accepted [a]
Clean Harbors Grassy Mountain, LLC Salt Lake City, UT	Truck and rail logistics; drain and flush for PCB transformers; solidification & stabilization; repackaging.	PCBs; non-hazardous soils and other nonhazardous industrial wastes; asbestos wastes; hazardous waste for treatment of metals; plating wastes; acidic wastes; caustic wastes; hazardous debris; and non-PCB liquid wastes for solidification and landfill.

TSD = treatment, storage, and disposal; RCRA = Resource Conservation and Recovery Act; TCLP = toxicity characteristic leaching procedure; VOCs = volatile organic compounds; PCB = polychlorinated biphenyl; TSCA = Toxic Substances Control Act; SNM = special nuclear material; CFR = *Code of Federal Regulations*.
[a] The listed information is a summary. Consult hazardous waste operators for specific information about operations, waste groups accepted, and restrictions.
Source: ACE 2006.

Low-level and mixed low-level radioactive waste capacity. Offsite treatment and disposal capacity exists for commercial and DOE disposal of low-level radioactive waste and mixed low-level radioactive waste. Some of the treatment and disposal options that may be considered may include the Chem-Nuclear[38] low-level radioactive waste disposal facility near Barnwell, South Carolina; the U.S. Ecology low-level radioactive waste disposal facility on the Hanford Reservation; the EnergySolutions disposal facility near Clive, Utah; the Waste Control Specialists Facility near Andrews, Texas; and DOE's Nevada Test Site.

Neither the Chem-Nuclear nor the U.S. Ecology facility accepts mixed low-level radioactive waste for treatment or disposal, and both limit (or shortly will limit) the quantities of wastes that may be accepted. After FY 2008, only waste generated by members of the Atlantic Interstate Low-Level Radioactive Waste Compact may be accepted.[39] The U.S. Ecology facility accepts waste only from the eight states composing the Northwest Interstate Compact and from the three members of the Rocky Mountain Compact. Although New Mexico is a member of the Rocky Mountain Compact, waste from DOE generators is not encouraged (WSDOE 2005).

The EnergySolutions disposal facility near Clive, Utah, accepts Class A[40] low-level and mixed low-level radioactive wastes. The facility accepts bulk and containerized materials, and mixed waste for treatment by stabilization, oxidation-reduction, deactivation, chemical fixation, neutralization, and macro- and micro-encapsulation. The wastes managed at the disposal facility may not have an external contact dose rate equal to or exceeding 200 millirem per hour on a manifested container; 500 millirem per year on external, accessible surfaces of individual wastes within a container; or 80 millirem per hour for containers of resin (EnergySolutions 2006).

The Waste Control Specialists Facility near Andrews, Texas, accepts low-level and mixed low-level radioactive wastes for treatment. Low-level radioactive waste disposal is not yet authorized. Treated waste is either returned to the generator or sent to another site for disposal. RCRA hazardous wastes may be disposed of (WCS 2002).

[38] Chem-Nuclear, LLC, is a wholly owned subsidiary of Duratek, Inc., which merged in 2006 with other companies to form EnergySolutions, LLC.
[39] South Carolina Code of Laws, Title 48, Chapter 46, Atlantic Interstate Low-Level Radioactive Compact Implementation Act.
[40] The NRC system in 10 CFR 61.55 for classifying low-level radioactive waste is based on two tables listing waste class concentration limits for short- and long-lived radionuclides. For example, low-level radioactive waste containing alpha-emitting transuranic isotopes having half-lives exceeding 5 years is classified as Class A waste if concentrations do not exceed 10 nanocuries per gram of waste, or as Class C waste if concentrations are greater than 10 nanocuries per gram and less than or equal to 100 nanocuries per gram.

DOE's Nevada Test Site disposes of low-level and mixed low-level radioactive waste from DOE Nevada activities, as well as from approved generators, generally defined as those DOE sites and contractors that have traditionally shipped waste to the Nevada Test Site. (LANL has, in the past, shipped waste to the Nevada Test Site for disposal.)

Transuranic waste capacity. Transuranic waste disposal capacity is available at WIPP near Carlsbad, New Mexico. WIPP currently accepts defense-generated transuranic waste for disposal. Mixed contact-handled transuranic waste is acceptable; however, waste that exhibits RCRA characteristics of ignitability, corrosivity, or reactivity must be treated (DOE 2002, WIPP 2004). WIPP initially received only contact-handled transuranic waste, but the WIPP permit modification for receipt of remote-handled transuranic waste was approved in October 2006.

Transuranic waste must contain alpha-emitting transuranic isotopes, having half-lives exceeding 20 years, in concentrations exceeding 100 nanocuries per gram of waste. Pursuant to the WIPP Land Withdrawal Act, the total capacity at WIPP is 6.2 million cubic feet (0.18 million cubic meters) of transuranic waste. Several restrictions exist for acceptance of remote-handled waste.

I.3.3.1.3 Related Remedial Actions

Section I.3.3.1.3.1 summarizes case histories of removals at MDA P and the Sandia Chemical Waste Landfill. Section I.3.3.1.3.2 summarizes the removal alternative considered for remediation of MDA H. Section I.3.3.1.3.3 presents observations.

I.3.3.1.3.1 Selected Case Histories

LANL MDA P. MDA P in TA-16 operated from 1950 to 1984 and contained detonable HE, HE residues in soil, barium, and asbestos; and low levels of uranium, lead, and cadmium. The closure process began in February 1997 (LANL 2001a), when a clean closure plan was approved by NMED. The volume to be removed was estimated to be 30,000 cubic yards (22,900 cubic meters). But in the fall of 1997, work crews discovered HE ranging from the size of a fingernail to that of a softball. Plans for removal were changed. A remote excavator was acquired, as well as a team of explosive ordinance experts to screen excavated materials for high explosive (LANL 2001d). Excavation resumed in February 1999 and was completed on May 3, 2000 (LANL 2001a). Work crews used high-pressure water to remove debris potentially contaminated with HE (LANL 2001d). Nonremote excavation of contaminated soil beneath the waste pile began after the May 2000 Cerro Grande Fire and was completed in March 2001. Additional material was removed in February 2002 (LANL 2001a).

Material excavated from MDA P included 52,500 cubic yards (40,100 cubic meters) of soil and debris (including hazardous and industrial waste and recycled material); 387 pounds (176 kilograms) of detonable high explosive; 820 cubic yards (627 cubic meters) of hazardous waste with some radioactive contamination; 6,600 pounds (3,000 kilograms) of barium nitrate; 2,605 pounds (1,180 kilograms) of asbestos; 200 pounds (91 kilograms) of mixed waste;

235 cubic feet (6.7 cubic meters) of low-level radioactive waste, and 888 containers of unknown content (LANL 2001a).[41] The high explosive was burned (LANL 2001d).

Sandia Chemical Waste Landfill. This landfill was a 1.9-acre (0.77-hectare) landfill near Albuquerque, New Mexico, that was used for disposal of chemical and solid waste between 1962 and 1985 and as a storage area for hazardous waste drums between 1981 and 1989. Liquid and solid waste disposal was discontinued in 1981 and 1985, respectively. Closure of the landfill was initiated in 1988 (SNL 2003).

The site was prepared for excavation following a 2-month preparation period that included mobilization of equipment and administration trailers. Excavation began in September 1998 and was completed in February 2002, when 52,000 cubic yards (40,000 cubic meters) of soil, solid, hazardous, and mixed waste was removed. Excavation extended to 12 feet (3.7 meters) below ground surface and occasionally to 30 feet (9.1 meters). In addition to soil, excavated debris included compressed gas cylinders, intact chemical containers, partially expended munitions, thermal and chemical batteries, large metal objects (such as tanks or gloveboxes), waste containing radionuclides, asbestos-containing tiles and blocks, and biohazardous waste.

Management of the excavated waste was performed in a matter consistent with its hazard. The 357 compressed gas cylinders—apparently intact—that were recovered were processed in an onsite mobile facility. Of these, 233 were empty. Various combinations of five methods were used to process the remaining cylinders, including (SNL 2003): carbon adsorption; devalving of the containers with or without the use of liquid nitrogen; neutralization of the cylinders using sulfuric acid or sodium hydroxide; recontainerization of solids and liquids from the cylinders for appropriate disposal; and venting of the gases through a carbon scrubber.

Excavation was conducted using a large tracked backhoe (trackhoe) having Lexan windows for shielding against explosion. (Blast-resistant Lexan shielding was placed near the excavation for protection of ground personnel.) Workers were equipped with protective clothing and supplied-air breathing apparatus. The project experienced several delays and work slowdowns over the 3.25-year excavation period because of deficiencies in the rate at which excavated material could be sorted; weather conditions; safety concerns (for example, unexpected encountering of chlorobenzylidene malonitrile, an irritating powder; and an apparently erroneous detection of hydrogen cyanide); space limitations in staging and disposing of material; and other issues. Three different technologies for screening excavated soil and debris were tried. A tent was constructed over the sorting area, and a motorized conveyor belt with a site-built hopper was used to avoid manually handling excavated rock. During the first year of the project, the average excavation rate was 155 cubic yards (119 cubic meters) per 50-hour workweek; thereafter, this rate was raised to about 374 cubic yards (286 cubic meters) per 50-hour workweek.

I.3.3.1.3.2 Material Disposal Area H Removal Alternative

At MDA H (PRS 54-004), nine shafts were used for disposal of classified wastes, receiving weapons components, classified documents and paper, aluminum, plastic, stainless steel, rubber, graphite shapes, weapon mockups, depleted uranium scraps and classified shapes, and other materials (DOE 2004b, LANL 2005c). An investigation program has been completed and the

[41] *Revised waste summaries are in the MDA P Closure Certification Report (LANL 2003h).*

results submitted to NMED, along with an addendum. A Corrective Measures Study Report for MDA H was completed in May 2003 (LANL 2003b) and an environmental assessment in June 2004 (DOE 2004b). The recommended corrective remedy was capping with an evapotranspiration cover, although DOE also addressed the corrective measure alternatives of removal, and partial or complete encapsulation of the shafts. Complete encapsulation was selected by NMED, along with installation of an engineered evapotranspiration cover and a soil vapor extraction system (NMED 2007a).

For the removal alternative, the above documents present conceptual designs for the structural and site changes needed to facilitate removal (see **Figure I–19**) (DOE 2004b). Pre-excavation activities include: modification and provision of utilities; delivery of a construction trailer and portable toilets; construction of a waste sorting and declassification structure, including a storage vault; erection of excavation tenting and moisture protection around the shaft area; installation of an enclosed conveyor system; establishment of an overburden storage area; relocation and expansion of the site security fence; an access road between the sorting and declassification, characterization, and packaging operations; and maintaining an exclusion area.

Waste removal using a crane was considered a safety hazard. Backhoes would not have been able to dig sufficiently deep to recover all waste. Therefore, site excavation was to proceed by removing waste laterally in 5-foot (1.5-meter) lifts: Two trenches would be excavated parallel to the shafts and on both sides to depths of 3 to 5 feet (0.9 to 1.5 meters). The trenches would be dug to within 18 to 24 inches (45 to 60 centimeters) of the shafts but would not breach the shaft or shaft contents. The waste in the top lift would be removed. Then the two trenches would be excavated another 3 to 5 feet (0.9 to 1.5 meters) and the next layer of waste removed. This process would be repeated until all the waste was removed. The trenches would be benched at a distance of 5 feet (1.5 meters) horizontally for every 15 to 20 feet (4.6 to 6 meters) of depth. The tuff adjacent to the shafts would be dug to 62 feet (18.9 meters) below ground surface. The complete, excavated footprint would measure 260 by 120 feet (78 by 36 meters) at the bottom of the excavation and 290 by 150 feet (87 by 45 meters) at the top of the excavation. Roughly 50,000 cubic yards (38,000 cubic meters) of uncontaminated tuff would be removed from the two trenches (DOE 2004b).

Because of the possible hazard of reaction of materials such as lithium hydride, high explosive, and pyrophoric uranium hydride, different options were considered for minimizing the hazard. One option was to perform removal under a tented enclosure using a computer-controlled, remotely operated, tracked hydraulic excavator to remove potentially reactive materials. A second option was to remove the waste by operating the excavator inside an enclosure filled with an inert gas such as nitrogen. This option would maintain an atmosphere having a sufficiently low level of oxygen to manage the possibility of an unwanted reaction with oxygen. Under either option, nonsparking tools and chemical "sniffers" would be used (DOE 2004b).

Wastes removed from the shafts would be conveyed by the conveyor system to the sorting and declassification area where the waste would be checked for hazard (radiation level, fire, explosion potential). Materials requiring declassification would be shredded or crushed to declassify the materials and to reduce volume. The conveyor would be designed to convey the wastes in an inert atmosphere, if needed. The conveyor could consist of a series of units containing gloveboxes terminating in a visual inspection station (see **Figure I–20** [DOE 2004b]).

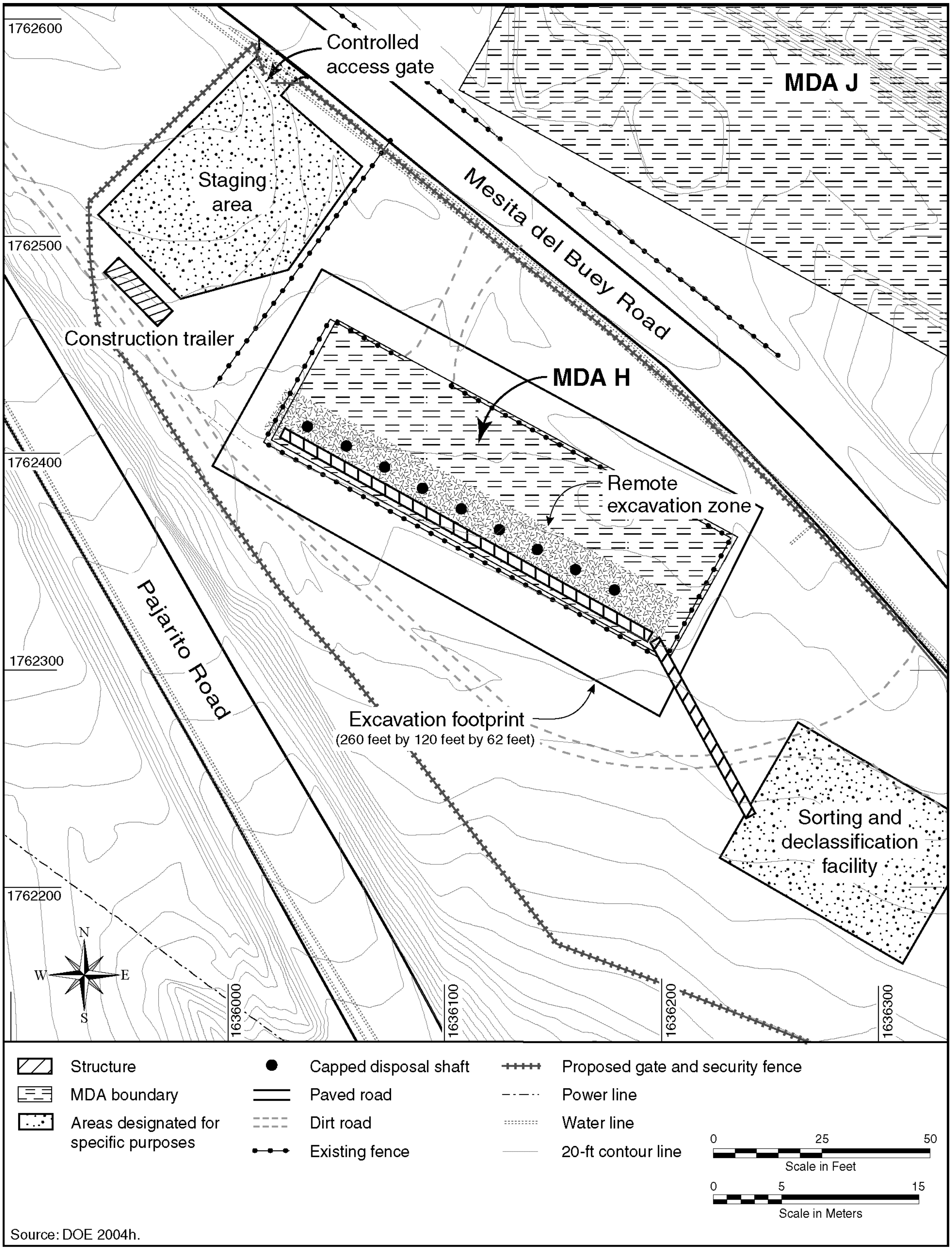

Figure I–19 Closeup View of Conceptual Site Changes to Facilitate Complete Excavation and Removal Corrective Measure Option

Figure I–20 Example of a Remotely Operated Dismantling System and Inspection Station

The inspection station would be remotely controlled, if needed, and contain manipulator arms, tools, and equipment to characterize the wastes and declassify and dismantle materials. Reactive material would be maintained in an inert environment before treatment (for example, high explosive would be safely burned). The enclosed conveyance system would move waste into a packaging and sorting area for placement of the wastes into containers (DOE 2004b).

After excavation and waste sorting is complete, the site would be restored. Stored overburden would be placed back in the hole and additional fill would be trucked in. After grading the filled area, stored topsoil would be reused and the site revegetated (DOE 2004b).

Removal would require 6 months to design and 40 months to implement. Total time for the removal operation would be 48 months. Excavation of the shafts would require 75 to 85 workers during the 48-month implementation period (DOE 2004b).[42]

I.3.3.1.3.3 Observations from Case Histories

Several observations can be made from the above case histories and analyses, including the following:

- Existing case histories are for relatively shallow disposal units. The radiation levels associated with most actual removals have been relatively low.
- Excavation can be dangerous and slow. There can be frequent problems to work around.

[42] *Upgrading the existing cap, or installing an engineered cover, would require 10-12 workers for 5 months. Partial or complete encapsulation of the shafts would require 24 to 38 workers for 12 months (DOE 2004b).*

- Unexpected conditions (such as the need to exhume explosives) can greatly increase the risk of removal, time required to complete removal, and expense for removal.
- Excavation of shafts can require a considerable amount of soil disturbance.

Some additional observations and comparisons can be made for the large LANL MDAs:

- The large MDAs considered in this appendix are generally deeper than those analyzed (except for MDA H).
- The large MDAs considered in this appendix frequently contain transuranic and other radionuclides and often present external radiation hazards.
- The large MDAs considered in this appendix are often nearby other, operating facilities.

I.3.3.2 Options for Remediation of Material Disposal Areas

The two major options for remediation of the MDAs are stabilization in place (Section I.3.3.2.1) and removal (Section I.3.3.2.4). Remediation of any MDA may be a combination of treatment methods.

I.3.3.2.1 Stabilization-in-Place Option

An engineered evapotranspiration cover would be placed over the MDAs using standard construction equipment. Cover placement would include best management practices. Site monitoring and maintenance would be performed thereafter.

Disposal practices at LANL have generally been performed in a manner that has reduced short-term subsidence. At most disposal trenches and pits, waste was placed in layers that were covered with thin layers of tuff and compacted. Much waste was not containerized. This reduced subsidence compared to that from adding backfill and cover to pits or trenches filled with waste. Additional measures to enhance stabilization of the MDAs could include in situ grouting or waste encapsulation, or dynamic compaction. Implementing these measures would invoke tradeoffs such as safety concerns, costs, and the time to install a final cover.

I.3.3.2.1.1 Operational Elements

Operational elements are presented in the text box.

Preliminary site work is assumed to include planning and permitting; demolishing or relocating existing operations, structures, or materials (as needed); rerouting or modifying utilities or pipelines (as needed); mobilization of equipment; and initial site preparation. It is assumed that a management area would be established near the MDA for staging heavy equipment and vehicles. A trailer or similar structure would be temporarily sited for management of operations. The size of the management area may depend on the size of the MDA and the complexity of closure operations, but would probably not, for most MDAs, exceed a few thousand square feet. An area for parking personal vehicles would be needed; in most cases probably in existing nearby parking lots or areas nearby the MDA. Utilities would be made available; for example, by accessing existing utilities in the vicinity of the MDA. Water may need to be delivered by truck at some MDAs. Portable toilets would be installed in the management area, and sanitary waste from the toilets would be trucked to a disposal location either on or offsite.

Capping Operational Elements

- *Design, Planning, and Permitting* – Includes planning for site operations, including equipment and personnel coordination. Includes health and safety plans, site security plans, erosion control plans, and others. Includes permits and authorizations.
- *Demolishing/Relocating Existing Operations, Structures, or Materials* - Includes moving, demolishing, or relocating existing structures or operations.
- *Rerouting/Modifying Utilities, Pipelines, or Similar* – Includes rerouting or modifying water, electrical, telephone, or other underground or overhead lines as needed to preclude damage. Includes removal or rerouting of liquid waste or chemical piping to preclude damage.
- *Mobilization* – Includes mobilization and initial site placement of equipment such as cranes, backhoes, dump trucks, water trucks, and graders. Includes installation of a site management trailer. Includes site storage of equipment and initial mobilization of the workforce.
- *Site Preparation* – Includes explorations needed to determine the specific locations of disposed wastes, and other site-specific studies and tests such as removal of areas of surface contamination. Includes clearing of vegetation. Includes the demolition or removal of asphalt or other hard covers over disposal units. Includes removal and disposal of existing security fencing.
- *Perform Special Activities* – Includes activities unique to a specific MDA. For MDA A, it includes stabilizing the buried General's Tanks.
- *Install Moisture Monitoring System* – Before cover installation, includes the possible placement of moisture detection probes at selected locations, as well as ancillary equipment.
- *Regrading/Evapotranspiration Cover Installation/Revegetation* – Includes placement of the cover, including spreading and fine-grading of topsoil, compaction using heavy construction equipment, watering for dust abatement, and watering of planted areas for vegetation germination at approved levels.
- *Install New Fencing/Gate* – Includes security fencing with a gate large enough for vehicle passage, as well as appropriate signage.
- *Demobilization* - Includes demobilization of equipment such as backhoes, dump trucks, water trucks, and graders. Includes removal of the management trailer.
- *Health and Safety* – Includes development of a site health and safety plan; performing surface sampling confirming nonhazardous site conditions; monitoring site activities; and conforming to standard construction health and safety policies, laws, and procedures.
- *Project Management* – Includes an onsite project manager or foreman, who reports daily site progress, as well as site office support. Includes, as needed, specialists such as an evapotranspiration specialist for confirmation of material placement.
- *Monitoring and Surveillance* – Includes semiannual site visits to repair fencing and covers, eruption control, etc.

Areas may be needed for stockpiling cover materials before emplacement, as well as areas for packaging, characterizing, and storing wastes generated as part of preliminary operations or cover installation. The sizes of these support areas will depend on factors such as operational or impact mitigation considerations (such as minimizing delivery of bulk materials during times of high traffic density), the scope of needed preliminary demolition work, and the expected volumes of wastes to be generated. For example, capping MDAs in TA-21 would be accompanied by operations to remove nearby structures (see Section I.3.3.2.2.1), which would generate wastes requiring temporary management before transport to a disposal facility. Areas for stockpiling cover materials, or overburden removed as part of initial preparation, would be protected from erosion or runon, from airborne dispersion, and from possible cross contamination. Temporary roads may be needed between the MDA and the support areas.

Preliminary site work is also assumed to include removal of fencing to allow for site grading and placement and compaction of cover materials. This fencing may or may not be contaminated. In some cases, it may be reused; in others disposed of as waste. (The latter is conservatively assumed at large MDAs.) But depending on the size of the MDA, only portions of the fence may require removal, and removal might occur as part of the cover placement process as different sections of the MDA are sequentially addressed. For security, temporary fencing could be placed at fence openings and moved as needed.

Several of the MDAs are partially covered by asphalt or concrete. Before capping commences, this material may be removed or broken into rubble and covered. In other MDAs, such as those in TA-21, several buildings or structures may require removal. Removal of buildings and structures in TA-18 and TA-21 is addressed in, Sections H.1 and H.2, respectively, of Appendix H.

Assumptions for packaging and transporting wastes generated from capping MDAs are presented in Section I.3.5.

Capping includes placement of the cover, including spreading and fine-grading of topsoil, compaction using construction equipment, watering for dust abatement, and watering of planted areas for vegetation germination at approved levels. The Capping Option may include the installation of moisture monitoring systems, including moisture detection probes and ancillary equipment, at some of the MDAs (LANL 1999b). Each moisture monitoring system would consist of several Time Domain Reflectometry probes placed at selected locations, and a data collection center at each MDA (or group of adjacent MDAs), including a data logger, remote data access, associated solar equipment to operate the data center, and a tipping bucket rain gauge to monitor precipitation.

Because past site investigations at the MDAs have shown incidents of low levels of contamination in surface soil, capping may be preceded by efforts to remove localized pockets of radioactive or hazardous constituent contamination.

The design of each evapotranspiration cover would be tailored to each MDA based on an analysis of the potential for erosion, runon and runoff, precipitation rate, evapotranspiration, and biointrusion (see, for example, Appendix C of the *MDA Core Document* [LANL 1999b]). At all MDAs, the cover would be a mixture of tuff, gravel, cobbles, and soil amendment or compost. Each cover would be contoured to promote runoff without erosion. Cover thicknesses would be typically larger toward the centers of the footprints of the disposal units. Covers would extend beyond the footprints of the disposal units, and taper at shallow angles.

Because final cover designs for the MDAs are still being developed, a range of average thicknesses was assumed to determine cover material volumes. Consistent with a recent survey of sources for borrow materials for cover materials (Stephens 2005), it was assumed that each cover over each MDA would consist of either 3 feet (0.9 meters) or 8.2 feet (2.5 meters) of crushed tuff or similar material. For either assumed thickness, it was assumed that subgrade fill may be required. It was also assumed that the final cover over each MDA would include additional materials such as cobbles, gravel, topsoil, or soil amendment. It was assumed that the thickness of additional material would be about 10 percent of the base (crushed tuff) thickness.

I.3.3.2.1.2 Closure of Material Disposal Area G within Area G of Technical Area 54

The current schedule for the Consent Order requires submittal of a remedy completion report for MDA G within TA-54 by December 6, 2015. Closure of MDA G will be coordinated with closure of disposal units in the current 63-acre Area G footprint that are not subject to the Consent Order. Existing waste stored within Area G will require recovery, and existing waste management operations will require relocation. Closure of MDA G will be closely coordinated with closure of MDA L, which is addressed in Section I.3.3.2.1.3. The transition of waste management operations from current locations in Areas G and L so that Areas G and L can undergo closure is analyzed in Appendix H, Section H.3.

I.3.3.2.1.2.1 Overview

Area G within TA-54 is used for a variety of radioactive waste management operations. Belowground radioactive waste storage and disposal units are listed in **Table I–34** (LANL 2005k). They include:

- Numerous trenches, pits, and shafts containing radioactive waste subject to corrective action under the Consent Order (MDA G). Early disposal units may contain transuranic isotopes in concentrations exceeding current transuranic waste definitions.
- Two subsurface disposal units subject to closure under RCRA.
- Active disposal units for low-level radioactive waste that do not contain mixed low-level radioactive waste. These disposal units are neither permitted under RCRA nor subject to corrective action under the Consent Order.

Other waste management operations include radioactive waste storage; low-level radioactive waste characterization, verification, and compaction capacity; and capacity for characterizing, processing, and shipping contact-handled transuranic waste. This existing capacity is addressed in a 2005 TA-54 status report (LANL 2005k).

Waste management activities within Area G occur within structures having systems and components designed and constructed in accordance with DOE's systems of hazard and performance categorization (DOE 1993, 1997b). LANL staff conducts operations in a manner that restricts the aboveground inventory of radioactive materials within individual structures and over all of Area G. The limit for all aboveground activity in Area G, including stored waste, is 150,000 plutonium-239-equivalent curies (LANL 2006a).

Table I–34 Belowground Storage and Disposal Units at Area G

Atomic Energy Act-Regulated Storage and Disposal Units		*Corrective Action Storage and Disposal Units* [a]		*RCRA Storage and Disposal Units*
Low-level Radioactive Waste Disposal	*Transuranic Waste Storage*	*Waste Disposal*	*Transuranic Waste Storage*	
Pits 15, 38, 39 Shafts 21, 23, 97, 137, 141-144, 147-149, 161-177, 197, 300, 301, 307, 308, 360-367, 369, 370 Shafts C11, C14, 321, 323, 325, 327, 329, 331, 333, 335, 339, 341, 343, 345, 347, 349, 351, 355, 357 Shafts [b] 309, 311, 313, 317, 319, 337, 353, 359	Shafts 235-243, 246-253, 262-266, 302-306	Pits 1-10, 12, 13, 16-22, 24-30, 32-33, 35-37 Pit 31 Shafts C1-C10, C12, C13, 1-20, 22, 24-96, 99-112, 114, 115, 118-123, 125-136, 138-140, 150-160, 189-192, 196	Pit 9 Trenches A-D Shafts 200-232 Shaft 233 [b] Transuranic waste corrugated metal pipes (stored atop Pit 29)	Pit 29 (below storage of transuranic waste corrugated metal pipes) Shaft 124

RCRA = Resource Conservation and Recovery Act.
[a] Units regulated under RCRA and Corrective Action Requirements are also regulated by DOE under the Atomic Energy Act.
[b] Unused and empty.
Source: LANL 2005k.

Closure of MDA G within the constraints of the Consent Order would occur as waste management operations and facilities are transitioned from Area G as described in Section H.3. This would include the removal of transuranic wastes stored underground. The removal of these operations and facilities will occur in a phased approach, as described in **Table I–35**, that would allow closure activities to begin without waiting for all waste management operations and facilities to be removed (LANL 2005k).

While MDA G is being closed, new low-level radioactive waste disposal capacity would be developed, initially into Zone 4 at TA-54, and then into Zone 6 at TA-54 as needed. Six buildings across from Area L would be removed. A new guard and access station would be constructed. A waste characterization and verification facility would be constructed, as would a new low-level radioactive waste compactor facility (LANL 2005k).

I.3.3.2.1.2.2 Options for Remote-Handled Transuranic Waste

Shafts 200-232 within Area G are 33 1-foot-diameter (0.3-meter-diameter) shafts having carbon steel pipe liners that contain high-activity remote-handled transuranic waste. The environmental impacts associated with removal of this waste from 3 shafts, which would require a temporary facility to be constructed over the shafts, are analyzed in Appendix H, Section H.3.

Another option is to leave the waste in place consistent with health, safety, and environmental analyses in accordance with all applicable regulatory standards. In addition to any analyses performed as part of the Consent Order process, for example, an analysis may be required pursuant to 40 CFR Part 191, EPA's "Environmental Standards for the Management and

Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes." The analysis must provide a reasonable expectation that the following quantitative criteria will be met:[43]

Table I–35 Closure Phases for Existing Area G Footprint

Phases 1 and 2 (Western Portion): Retrieve contact-handled transuranic waste from Pit 9, from Pit 29, and from aboveground storage structures. Characterize and ship 5,500 cubic yards (4,200 cubic meters) of formerly stored and newly generated transuranic waste. Relocate low-level radioactive waste characterization and verification operations. Clean-close or decontaminate and decommission 66 structures. Modify infrastructure such as power lines and fences, as needed. Construct a final cover.
Phases 3 and 4 (Central Portion): Retrieve contact-handled transuranic waste from Trenches A-D and from aboveground storage structures. Retrieve remote-handled transuranic waste from five shafts (shafts 302-306). Characterize and ship 2,600 cubic yards (2,000 cubic meters) of formerly stored and newly generated transuranic waste. Relocate low-level radioactive waste compactor operations. Clean-close or decontaminate and decommission 18 structures. Modify infrastructure, as needed. Construct a final cover.
Phases 5 and 6 (Eastern Portion): Retrieve contact-handled transuranic waste from aboveground storage structures. Retrieve contact-handled transuranic waste from 5 shafts (shafts 262-266). Retrieve remote-handled transuranic waste from 17 shafts (shafts 235-243 and 246-254). Retrieve remote-handled transuranic waste from 33 shafts (shafts 200-232). If necessary, construct a remote-handled facility for waste retrieval and processing for shipment. Alternatively, leave remote-handled waste in place if compliant with a 40 CFR Part 191 analysis. Characterize and ship 5,000 cubic yards (3,800 cubic meters) of formerly stored and newly generated transuranic waste. Construct a transuranic facility outside of Area G for newly generated transuranic waste. Clean-close or decontaminate and decommission 31 structures. Modify infrastructure, as needed. Construct a final cover.

CFR = *Code of Federal Regulations.*
Source: LANL 2005k.

- Containment criterion – A limit on the total quantities of particular radionuclides hypothetically released into the accessible environment over 10,000 years following waste disposal. (Allowable projected releases are scaled to the initial inventory. Because the shafts have a small inventory, allowable projected releases would be very small.)

- Individual protection criterion – An annual dose limit (15 millirem in a year) to individuals in the accessible environment for 10,000 years following waste disposal.

- Groundwater protection criterion – A requirement to project compliance with drinking water maximum contaminant levels in the accessible environment for 10,000 years following waste disposal.

The final configuration of the disposal unit containing the wastes would be designed in compliance with all required analyses and regulatory standards. Further stabilization or containment of the waste, using technologies such as in situ grouting or in situ vitrification, or modifications to the design and installation of the final cover, may be required.

[43] *40 CFR Part 191 also contains qualitative requirements pertaining to the use of active and passive institutional controls, monitoring, resource avoidance, and so forth.*

Additional analyses would be needed to make a decision on this option. It may be noted, however, that possible consequences of leaving contact- and remote-handled transuranic waste in place at LANL were addressed as part of a NEPA analysis prepared in support of disposal of transuranic waste at WIPP (DOE 1997a). This NEPA analysis addressed the consequences of leaving transuranic waste in place as part of a No Action Alternative considered in the *WIPP Disposal Phase Supplemental Environmental Impact Statement (SEIS-II)* (DOE 1997a), based on an analytical model developed by Pacific Northwest National Laboratory (PNNL 1997). *SEIS-II* considered stored and previously buried waste at seven generator-storage sites, including LANL. Stored waste configurations included soil-covered configurations and surface-stored configurations, such as storage in buildings. The analysis considered the consequences that could hypothetically occur assuming that waste at the generator-storage sites would be stored indefinitely into the future, and that loss of institutional control at the generator-storage sites would occur after 2133. Consequences included those that may be experienced by a future inadvertent human intruder into the stored and previously buried waste, and those that may result from long-term release into the environment. The analysis addressed radiological doses and risks, as well as impacts of exposure to chemical carcinogens and noncarcinogens (DOE 1997a).[44] The preferred alternative and decision (63 FR 3624) was to dispose transuranic waste in WIPP. WIPP disposal capacity is expected to be sufficient for disposal of all retrievably stored transuranic waste and all newly generated transuranic waste from the DOE complex over the next few decades, but not sufficient for this waste plus all transuranic waste buried before 1970 across the DOE complex.

Buried waste intrusion scenarios included the driller and gardener scenarios (DOE 1997a):

- *Driller.* A hypothetical intruder drills a well directly through buried or soil-covered waste to underlying groundwater, bringing contaminated soil to the surface that is mixed with topsoil.

- *Gardener.* A gardener farms a garden on the land containing the contaminated soil following the drilling incursion.

Surface-stored waste intrusion scenarios included the scavenger and farm family scenarios (DOE 1997a):

- *Scavenger.* A hypothetical scavenger intruder comes into direct contact with surface-stored transuranic waste over a 24-hour period.

- *Farm Family*. A hypothetical farm family of two adults and two children lives and farms on the land immediately over the former surface-stored transuranic waste area.

Populations and individuals living near the generator-storage sites were assumed to be impacted by long-term environmental release of contaminants. The following two scenarios were used to evaluate impacts on the maximally exposed individual (MEI) of chronic long-term environmental releases (DOE 1997a):

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[44] *The analysis is described in detail in Appendix I of SEIS-II, which is available for viewing at the WIPP Internet site, www.wipp.energy.gov.*

- *Groundwater exposure*. The MEI from a farm family lives 980 feet (300 meters) downgradient of a waste storage area. The family grows and consumes their own crops and livestock and uses contaminated groundwater for drinking water and for watering the crops and livestock. This receptor was considered for long-term release from buried or soil-covered transuranic waste and surface-stored transuranic waste.

- *Air Pathway Exposure*. A hypothetical individual was assumed to be exposed to the maximum airborne contaminant concentration released from a stored transuranic waste site. This receptor, located at least 330 feet (100 meters) from the site but within a 50-mile (80-kilometer) radius, was considered only for long-term releases from surface-stored transuranic waste.

Offsite populations within 50 miles (80 kilometers) of the sites were assumed to be exposed via atmospheric transport of radionuclides or by contamination of surface water (used for drinking water) from releases to the groundwater pathway. (Population exposures from the groundwater-surface water pathway were not considered for LANL.) Long-term releases from both buried or soil-covered transuranic waste and surface-stored transuranic waste were included (DOE 1997a).

Analyses were performed using the modular risk analysis method used in the DOE waste management programmatic environmental impact statement and the GENII and MEPAS computer codes. Site-specific radionuclide inventories were developed for each generator-storage site, and a typical inventory of organic and inorganic constituents was considered for all generator-storage sites. The results of the analysis for a future inadvertent intruder into buried and stored transuranic waste at LANL are presented in **Table I–36**. Maximum lifetime MEI and population impacts calculated for long-term releases to the environment are summarized in **Table I–37**. Noncarcinogenic impacts were determined to have a maximum Hazard Index of 1.7×10^{-3}, principally from mercury through the resuspended soil ingestion pathway (DOE 1997a).

Table I–36 Inadvertent Future Intruder Impact Summary

	Intrusion into Buried Waste				***Intrusion into Surface-Stored Waste***			
	Contact-Handled Waste		***Remote-Handled Waste***		***Contact-Handled Waste***		***Remote-Handled Waste***	
Impact measure	Driller	Gardener [a]	Driller	Gardener [a]	Scavenger	Farmer [b]	Scavenger	Farmer [b]
Dose (rem)	4.5×10^{-3}	41	2.2×10^{-3}	6.1	6.58	2,400	1.39	550
Radiological LCF	2.3×10^{-6}	0.021	1.1×10^{-6}	3.6×10^{-3}	3.3×10^{-3}	1.2	6.9×10^{-4}	0.27
Hazardous Chemical Impacts								
PEL [c]								
Cadmium	9.8×10^{-2}		9.8×10^{-2}		5.2		5.2	
Beryllium	17		17		91		91	
Lead	27		3,000		1,400		160,000	
Mercury	12		12		6.2		6.2	
Hazard Quotient/Index								
Cadmium		0.01		0.01		15		15
Beryllium		0.08		0.08		10		10
Lead		36		3,900		50,000		5.2×10^{6}
Mercury		77		77		100,000		100,000

	Intrusion into Buried Waste				Intrusion into Surface-Stored Waste			
	Contact-Handled Waste		Remote-Handled Waste		Contact-Handled Waste		Remote-Handled Waste	
Cancer Incidence								
Cadmium	1.4×10^{-9}	2.0×10^{-5}	1.4×10^{-9}	2.0×10^{-5}	2.0×10^{-6}	0.02	2.0×10^{-6}	0.02
Beryllium	1.3×10^{-7}	1.0×10^{-4}	1.3×10^{-7}	1.0×10^{-4}	2.0×10^{-4}	1.9	2.0×10^{-4}	1.9

LCF = latent cancer fatality, PEL = permissible exposure limit.
[a] Impact measures for the gardener are totals over 30 years.
[b] Impact measures for the farmer are for the first year of intrusion.
[c] Air concentrations exceeding PEL – that is, "17" means 17 times the PEL.
Note: From the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997a) No Action Alternative 2 Analysis.
Source: DOE 1997a.

Table I–37 Maximum Lifetime Maximally Exposed Individual and Population Impacts after Assumed Loss of Institutional Control

Receptor	Radiological Impacts			Chemical Carcinogenic Impacts	
	Lifetime Dose (rem per 70 years)	Lifetime LCF [a]	Dominant Pathway	Lifetime Cancer Incidence	Dominant Pathway
MEI	0.09	4.5×10^{-5}	Inhalation	2.4×10^{-4}	Resuspended soil ingestion
Population	162	8.1×10^{-2}	Inhalation	2.4×10^{-4}	Resuspended soil ingestion

LCF = latent cancer facility, MEI = maximally exposed individual.
[a] Lifetime LCF is the probability of an LCF for an MEI and the number of LCFs in a population.
Note: From the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997a) No Action Alternative 2 Analysis.
Source: DOE 1997a.

I.3.3.2.1.2.3 Final Stabilization of Area G

Stabilization of the existing 63-acre Area G footprint will proceed in three separate periods. In each of these periods, after removal of structures in the specific area to be covered, the area would be graded and capped. In addition, a soil vapor extraction system would be placed in Area G to remove and treat the volatile organic compound plume at the eastern portion of the MDA (LANL 2005k).

Waste Generation. It was postulated that small quantities of waste would be generated as part of capping MDA G and other disposal units in the existing 63-acre footprint of Area G. These volumes were estimated by assuming that the fencing currently surrounding the MDA is removed and disposed of as waste, and that the concrete and asphalt covering a portion of the site is removed and disposed of as waste. However, the fencing may actually be recycled or reused, and the asphalt and concrete may actually be broken up and buried beneath the final cover. See Section I.3.3.2.2.1 for estimated volumes.

Bulk Materials for Area G Final Cover. The cover for the existing 63-acre Area G footprint is being developed with the support of the updated Area G performance assessment and composite analysis. The final cover would cover all disposal units in the existing footprint, including the active and inactive disposal units that are subject to RCRA closure and the Consent Order (LANL 2005k), and is assumed to cover 65 acres (Stephens 2005). The cover design and thickness will be consistent with a final stabilization analysis that will evaluate alternatives such as stabilization of specific pits before installation of a final cover. The current cover ranges considerably in thickness. A 2002 report proposed increasing the thickness of the interim cover by 4.6 to 7.9 feet (1.4 to 2.4 meters), resulting in a fairly uniform final thickness of about 11.2 feet (3.4 meters) (LANL 2002b).

The current conceptual design for the cover includes the following materials (DOE 2005a):

- Crushed tuff – 514,000 cubic yards (393,00 cubic meters)
- Imported cap material (crushed tuff from another location) – 818,000 cubic yards (625,000 cubic meters)
- Imported clay – 80,000 cubic yards (61,000 cubic meters)
- Imported rock – 167,000 cubic yards (128,000 cubic meters)
- Imported rock armor – 70,000 cubic yards (54,000 cubic meters)
- Imported top soil or soil amendment – 65,000 cubic yards (50,000 cubic meters)
- Pea gravel – 25,000 cubic yards (19,000 cubic meters)
- Surface area for vegetation, mulch, and fertilizer – 80 acres (32 hectares)

This design is assumed to represent the higher end of a reasonable range of possible thicknesses—that is, the thickness of the crushed tuff (514,000 + 818,000 = 1,332,000 cubic yards [1,018,000 cubic meters]) represents a maximum thickness of 8.2 feet (2.5 meters). Again, cover thickness would vary to promote drainage. A thinner cap (about 3 feet [1 meter]) would imply about 487,000 cubic yards (372,000 cubic meters). For this appendix, it was assumed that the additional clay, rock, topsoil, and other material would be roughly similar for either a thin or a thick cover. The minimum and maximum material and shipment requirements assumed in this appendix are listed in **Table I–38**.

Table I–38 Estimated Cover Materials for Material Disposal Area G and Other Area G Disposal Units

Materials	*Thin Cover*			*Thick Cover*		
	In-Place Volume (cubic yards)	*Delivered Quantities* [a]		*In-Place Volume (cubic yards)*	*Delivered Quantities* [a]	
		Cubic Yards	*One-Way Shipments*		*Cubic Yards*	*One-Way Shipments*
Tuff	487,000	643,000	38,000	1,330,000	1,760,000	104,000
Additional Materials	407,000	537,000	32,000	407,000	537,000	32,000
Total	894,000	1,180,000	70,000	1,740,000	2,300,000	136,000

[a] Delivered quantities are based on an assumed 20 percent swell after excavation from a borrow, a density of 1.3 tons per cubic yard, a 10 percent contingency, and an average load per truck of 22 tons.

Note: To convert cubic yards to cubic meters, multiply by 0.76456. Numbers have been rounded.

I.3.3.2.1.2.4 Schedules

The following start and completion dates (and elapsed months) for the three assumed groups of Area G closure phases are used in this appendix (LANL 2005k):

- Phases 1 and 2: 10/1/2010 - 9/30/2011 (12 months);
- Phases 3 and 4: 12/1/2012 – 9/30/2013 (12 months); and
- Phases 5 and 6: 9/29/2014 – 12/28/2015 (16 months).

I.3.3.2.1.3 Closure of Material Disposal Area L within Area L of Technical Area 54

Background. All disposal units in Area L are inactive. Some subsurface disposal units (MDA L) are subject to corrective action under the Consent Order; other subsurface disposal units are RCRA-regulated units subject to RCRA closure and postclosure care. Active waste management operations include storage of mixed low-level radioactive waste and storage and processing of wastes regulated under RCRA or TSCA as described in Section H.3. This waste is managed in container storage units (CSUs) subject to RCRA permitting or interim status requirements.[45] The waste is sent offsite for further processing (as needed) and disposal. Waste management units at Area L are summarized in **Table I–39** (LANL 2005k).

Table I–39 Summary of Waste Management Units at Area L

RCRA Disposal Units	*Corrective Action Disposal Units (MDA L)*	*Aboveground CSUs*	*Lead Stringer Shaft CSUs*
Shafts 1, 13-17, and 19-34 Impoundments B and D	Shafts 2-12 and 18 Pit A Impoundment C	54-215, 54-216, 54-31, 54-32, 54-35, 54-36, 54-58, 54-68, 54-69, 54-70, 54-39, and Area L CSU	Shafts 36 and 37

RCRA = Resource Conservation and Recovery Act, MDA = material disposal area, CSU = container storage unit.
Source: LANL 2005k.

The RCRA disposal units are inactive subsurface units used for hazardous waste disposal after the effective date of the RCRA hazardous waste management regulations. They are subject to RCRA closure and postclosure requirements under 40 CFR Part 264. Some of these disposal units have been previously identified as being subject to corrective action. But under the terms of the Consent Order (NMED 2005), these disposal units are not subject to corrective action but to RCRA closure and postclosure care (LANL 2005k).

In addition to remedial investigations, a pilot study has been conducted to determine the effectiveness of an extraction system for the vapor phase volatile organic compound plume under the site (LANL 2005k, 2006m). A January 2008 Corrective Measures Report to NMED recommended a corrective remedy incorporating an engineered evapotranspiration cover, a soil vapor extraction system, monitoring, and maintenance (LANL 2008a).

Scope of Closure. The intent is to close in a single integrated action those subsurface disposal units regulated under RCRA and those subject to corrective action. Closure would be performed in a manner allowing for continued use of Area L for hazardous and toxic waste treatment and

[45] *Container storage units at MDA L are described in Attachment G of the LANL TA-54 Part B Permit Renewal Application (LANL 2003h).*

storage. To accomplish this, waste management operations would need to be either altered so a smaller area is impacted, or completely removed. These changes to waste management operations are described and analyzed in Appendix H, Section H.3.

Closure activities analyzed in this appendix include capping of the subsurface disposal units and treating the subsurface volatile organic compound vapor plume under the site. One option would be to emplace two separate covers. One cover would envelop the pit and three impoundments and the lines of shafts to the south of Pit A. A second cover would cover the six shafts at the northwest portion of the site. As a second option, a single cover may be installed covering the pits, impoundments, and all shafts except for the lead stringer shafts.

The corrective measure determined by NMED may include removal of some or all of the subsurface units subject to corrective action. In this case, closure and future use plans would require modification.

Waste Generation While Capping. It was postulated that small quantities of waste would be generated as part of capping MDA L. These volumes were estimated by assuming that a portion of the fencing currently surrounding Area L would be removed and disposed of as waste, and that the concrete and asphalt covering a portion of the site would be removed and disposed of as waste. However, the fencing may be recycled or reused, and the asphalt and concrete may be broken up and buried beneath the final cover. See Section I.3.3.2.2.1 for estimated volumes.

Materials for Site Stabilization. The final cover for MDA L is being developed. The 2005 Status Report for TA-54 envisions two 3-foot-thick alternative RCRA covers (LANL 2005k). However, for conservatism, a single large cover was assumed consistent with the 2005 Borrow Source Survey (Stephens 2005).

The Stephens report prepared preliminary designs for MDAs C and L (Stephens 2005). The materials required under this proposal for MDA L are listed in **Table I–40**, assuming two thicknesses of cover. Although the ultimate design for MDA L may differ from that described by Stephens, the range in thicknesses should bound the volumes of bulk cover material that may be required (Stephens 2005). The two thicknesses—i.e., either 3 feet (1 meter) or 8.2 feet (2.5 meters)—refer to the thickness of the fill before addition of topsoil, rock armor, or similar material. Adding this material would add about 10 percent to the final thickness.

Placement of this cover may require removal of a gabion retaining wall that exists along the northern and eastern site boundaries to meet the requirement for cover longevity (Stephens 2005).

Schedules. In its January 2008 Corrective Measures Evaluation Report for MDA L, DOE proposed a DD&D schedule starting in fall 2008 and continuing through 2010; the proposed capping schedule was to start in Spring 2011 and extend through Spring 2012 (LANL 2008a). The actual remediation scope and schedule will depend on decisions made by NMED.

Table I–40 Bulk Materials for Material Disposal Area L Final Cover

Material	*Three-Foot Cover*				*Eight-Foot Cover*			
	In-Place Volume (cubic yards)	*Delivered Quantities* [a]			*In-Place Volume (cubic yards)*	*Delivered Quantities* [a]		
		Cubic Yards	*Tons*	*One-Way Shipments*		*Cubic Yards*	*Tons*	*One-Way Shipments*
Soil rooting medium	5,052	6,669	8,670	394	26,153	34,522	44,879	2,040
Topsoil	1,344	1,774	2,306	105	1,918	2,532	3,291	150
Select fill	2,942	3,883	5,048	229	2,784	3,675	4,777	217
Gravel	134	177	230	10	192	253	329	15
Cobbles	134	177	230	10	192	253	329	15
Angular boulders (1- to 2-foot diameter) [b]	543	717	932	42	555	733	952	43
Soil amendment/ compost [c]	67	88	88	4	96	127	127	6
Total	10,216	13,485	17,504	796	31,890	42,095	54,685	2,487

[a] Delivered quantities are based on assumed 20 percent swell after excavation from a borrow, a soil density of 1.3 tons per cubic yards, and a contingency of 10 percent. Shipments are based on assumed use of trucks containing average individual loads of 22 tons (Stephens 2005).
[b] Angular boulders may be optional on slopes of 25 to 33 percent.
[c] Soil amendment density: 1 cubic yard = 1 ton.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; tons to kilograms, multiply by 907.18.
Source: Stephens 2005.

I.3.3.2.2 Materials Requirements for Stabilizing Additional Large Material Disposal Areas

I.3.3.2.2.1 Site Preparation

Capping would be initiated by suitable site preparation, including removal of existing structures, demolition of fences surrounding the MDAs, clearing of vegetation as needed, and regrading.

Additional work would be needed at MDA T to remove many of the existing structures. Building 21-257 and associated structures (tanks) would be removed under a TA-21 DD&D program (see Appendix H, Section H.2). This would include portions of Buildings 21-005, 21-150, and all of Building 21-286, the aboveground Diesel Tank 21-57, about half of the remaining slab of Building 21-228, and Water Tower 21-342. Removal would include foundations and buried gas and water pipes because they lie within the outer 50 feet (15 meters) of the intended cap (see below). The abovegrade portion of the structures would be removed, and concrete slabs, sumps, and tank pads would be reduced to rubble and left in place along with the below-grade concrete foundations and remaining pipes. Pipes may be filled with a solidifying foam prior to terminating within 50 feet (15 meters) of the cap edge.[46] A 6-inch (0.2-meter) cross-mesa buried gas pipeline located between MDAs T and A would require relocation to the east of MDA A. Approximately 350 feet (107 meters) of pipe would be left in place after filling with solidifying foam. Another 100 feet (30 meters) of the pipe would be removed (LANL 2006a).

[46] *Pipes beyond 50 feet (15 meters) would be removed under remedy programs for other solid waste management units.*

At MDA A, before capping would take place, Water Tower 21-342 and abovegrade Diesel Tank 21-57 would be removed under a TA-21 DD&D program (see Appendix H, Section H.2). Removal would include foundations and buried gas and water pipes because they lie within the outer 50 feet (15 meters) of the intended cap (LANL 2006a).

For both MDA T and MDA A, removal and relocation of the perimeter road would be required, as well as electrical poles.

At MDA C, rather than removing or relocating existing buildings and pipes, retaining walls may be constructed (Stephens 2005).

For the remaining large MDAs, it was assumed that small quantities of wastes would be generated as part of final stabilization. To estimate the volumes of these wastes, it was assumed that as part of site preparation, some or all of the fencing around the MDAs would be removed and disposed of, and that some or all of the concrete and asphalt covering portions of some of the MDAs would be removed and disposed of.

Table I–41 presents the assumed volumes of solid waste produced from site preparation, where the linear footage of fencing removed was estimated based on scale drawings of the MDA sites. Also presented are the estimated volumes of waste, assuming that each 100 linear feet (30 meters) of fence generates about 2,300 pounds (1,040 kilograms) of waste (including mesh, posts, top bars, and concrete footers).[47] Assuming that the bulk density is about the same as common rubbish, then 100 linear feet (30 meters) of fencing would generate about 2.8 cubic yards (2 cubic meters) of solid waste.[48]

Portions of MDAs A, B, L, and G are covered with asphalt or concrete that would be broken up or removed before installation of the site covers. Waste volumes were estimated by multiplying an assumed area removed by an assumed average thickness of 6 inches (15 centimeters). (Much of the concrete and asphalt at the MDAs is probably thinner than 6 inches [15 centimeters]).

- MDA A: Estimated upon assumption of 10 to 20 percent of surface covered with asphalt. Fifteen percent of 1.3 acres (0.53 hectare) is 8,200 square feet (762 square meters).
- MDA B: Estimated from Section I.2.5.2.2 (1,500 by 120 feet = 180,000 square feet [457 by 37 meters = 16,909 square meters]).

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[47] Considered poles, top bar, mesh, concrete, and neglected fittings and gates. Assumed an 8-foot fence, with 10-foot-6-inch (3.2-meter) poles every 10 feet (3 meters). Assumed each pole was embedded in concrete footings 8 inches in diameter and 30 inches deep. From www.hooverfence.com, assumed mesh weighs 561 pounds (254 kilograms) per 100 feet (30 meters), and the weight of a 10-foot 6-inch (3.2 meter) post is 24.3 pounds (11 kilograms). Assumed the density of concrete to be 150 pounds per cubic foot (2.4 grams per cubic centimeter). Rounded addition of posts, top pole, mesh and concrete to 2,300 pounds (1,040 kilograms) per 100 feet (30 meters) of fencing.

[48] From (Reade 2005), the bulk density of common rubbish (garbage) is 480 kilograms per cubic meter (30 pounds per cubic feet).

Table I–41 Solid Waste Generation during Capping of Large Material Disposal Areas

MDA	*Fencing Removed (linear feet)*	*Solid Waste (cubic yards)*
A	1,300	37
B [a]	4,800	140
T	1,500	43
U [b]	700	20
AB	450	13
C	6,900	200
G [c]	9,500	270
L	500	14

MDA = material disposal area.
[a] These volumes are conservatively included for completeness. The current plan is to completely remove the waste in MDA B (see Section I.3.3.2.7 of this appendix).
[b] These volumes are conservative because NMED has issued a Corrective Action Complete with Controls certificate for the SWMUs comprising MDA U (NMED 2006b) (see Section I.2.5.2.4 of this appendix).
[c] Capping MDA G includes capping other disposal units in the existing 63-acre Area G footprint that are not subject to the Consent Order.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; feet to meters, multiply by 0.3048. Numbers have been rounded.

- MDA L: Estimated by scaling from Figure B–1 of the MDA L Historical Investigation Report (LANL 2003m).[49]

- MDA G: Estimated by scaling from Figure B–5 of the Investigation Work Plan for MDA G (LANL 2004c).

Except for MDA L, it was assumed that half could be disposed of as solid waste and half as low-activity low-level radioactive waste. For MDA L, it was assumed that about half would be solid waste and half chemical waste. Waste quantities are listed in **Table I–42**. (See Section I.3.5 for assumptions about shipment of waste to disposal facilities.)

Table I–42 Asphalt or Concrete Removal from Material Disposal Areas

Parameter	*MDA A*	*MDA B*	*MDA L*	*MDA G*
Surface area (square feet)	8,200	180,000	4,300	130,000
Waste volume (cubic yards) [a]	150	3,300	80	2,400
Waste volume (cubic meters): [b]	120	2,500	61	1,800
Solid waste	58	1,300	30	920
Chemical waste [c]			30	
Low-level radioactive waste	58	1,300		920

MDA = material disposal area.
[a] Assuming an average asphalt thickness of 6 inches (15 centimeters) and an average concrete thickness of 6 inches (15 centimeters).
[b] As-shipped volumes would be larger because packaging efficiencies are less than 100 percent.
[c] Includes waste regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or is otherwise unacceptable for sanitary landfill disposal.
Note: To convert square feet to square meters, multiply by 0.0929. Numbers have been rounded.

[49] *Area L is currently entirely covered with asphalt. The only asphalt expected to be removed would be that needed for remediation of MDA L pursuant to the Consent Order. If all asphalt from Area L were to be removed from the 2.6-acre site, then up to an additional 1,050 cubic yards (800 cubic meters) of solid waste would be generated, as would up to an additional 1,050 cubic yards (800 cubic meters) of chemical waste. This would require up to 80 shipments of solid waste and 87 shipments of chemical waste.*

I.3.3.2.2.2 Cover Materials

Cover material assumptions for MDA G and MDA L are provided in Sections I.3.3.2.1.2.3 and I.3.3.2.1.3, respectively. Cover assumptions for other MDAs and landfills are presented below.

Large MDAs. The Stephens report includes preliminary designs for MDA C (Stephens 2005). Materials are listed in **Table I–43**, assuming two thicknesses for fill tuff. Although the ultimate design for MDA C may differ from that described by Stephens, the range in thicknesses should bound the required volumes of bulk cover material. The two thicknesses—that is, either 3 feet (0.9 meters) or 8.2 feet (2.5 meters)—refer to the thickness of the fill before addition of topsoil, rock armor, or other material. Adding this material adds about 10 percent to the final thickness.

Table I–43 Bulk Materials for Material Disposal Area C Final Cover

Material	*Three-Foot Cover*				*Eight-Foot Cover*			
	In-Place Volume (cubic yards)	*Delivered Quantities* [a]			*In-Place Volume (cubic yards)*	*Delivered Quantities* [a]		
		Cubic Yards	*Tons*	*One-Way Shipments*		*Cubic Yards*	*Tons*	*One-Way Shipments*
Soil rooting medium	37,237	49,153	63,899	2,905	117,942	155,683	202,388	9,199
Topsoil	7,943	10,485	13,630	620	8,730	11,524	14,981	681
Select fill	51,544	68,038	88,449	4,020	51,964	68,592	89,170	4,053
Gravel	794	1,048	1,363	62	873	1,152	1,498	68
Cobbles	794	1,048	1,363	62	873	1,152	1,498	68
Angular boulders (1- to 2-foot diameter) [b]	1,094	1,444	1,877	85	2,911	3,843	4,995	227
Soil amendment/ compost [c]	397	524	524	24	436	576	576	26
Total [d]	99,803	131,740	171,105	7,778	183,729	242,522	315,106	14,323

[a] Delivered quantities are based on assumed 20 percent swell after excavation from a borrow, a soil density of 1.3 tons per cubic yard, and a contingency of 10 percent. Shipments are based on assumed use of trucks containing average individual loads of 22 tons (20 metric tons) (Stephens 2005).
[b] Angular boulders may be optional on slopes of 25 to 33 percent.
[c] Soil amendment density: 1 cubic yard = 1 ton.
[d] Does not include retaining walls for Material Disposal Area C.
Note: To convert cubic yards to cubic meters, multiply by 0.7646; tons to metric tons, multiply by 0.907; square feet to square meters, multiply by 0.0929.
Source: Stephens 2005.

Because of the proximity of buildings and buried pipes, retaining walls may be installed at MDA C to terminate the cover edge. Retaining walls would range in length from 1,000 to 1,400 feet (305 to 427 meters) for the 3-foot (0.9-meter) and 8.2-foot (2.5-meter) covers, respectively. The Stephens report estimates material quantities in terms of linear feet for a reinforced concrete option or square feet for a dry-stack rock option. Material quantities are listed in **Table I–44**, along with the average and maximum heights of the retaining walls corresponding to the optional 3- and 8.2-foot (0.9- and 2.5-meter) cover thicknesses (Stephens 2005).

Table I–44 Summary of Material Disposal Area C Retaining Wall Quantities

Material Disposal Area C Cover	*Retaining Wall Dimensions*			
	Length (feet)	*Height (feet)*		*Surface Area (square feet)*
		Average	*Maximum*	
3-foot	1,001	4.6	11	4,571
8.2-foot	1,412	8.7	16	12,333

Note: To convert feet to meters, multiply by 0.3048; square feet to square meters, multiply by 0.0929.
Source: Stephens 2005.

A dry-rock retraining wall was assumed for this appendix. It is a mortarless wall using stacked rocks (or prefabricated reinforced concrete elements, usually L-shaped to enable interlocking successive layers) sloped against the horizontal force of backfill and provided with drain holes to avoid hydrostatic pressure. The depth of a concrete reinforced block often ranges from 1 to 1.5 feet (0.3 to 0.5 meters), depending on variables such as the height of the wall. Assuming 1.5-foot (0.5-meter) blocks, the total wall mass would be 184 pounds per square foot (900 kilograms per square meter) (DCA 2005). This information yields an estimate of about 420 tons (381 metric tons) of concrete reinforced block for the 4-foot (1.2-meter) cover and 1,135 tons (1,030 metric tons) of concrete reinforced block for the 8.2-foot (2.5-meter) cover. Assuming use of 22-ton (20-metric-ton) trucks, this implies (including a 10 percent contingency) 21 to 57 rock retaining wall shipments (one way).

For the remaining MDAs, cover materials were estimated on a nominal cover acreage, an assumed minimum thickness of added tuff of 3.0 feet (0.9 meters), and an assumed maximum thickness of added tuff of 8.2 feet (2.5 meters). Additional cover materials (topsoil, rock, soil amendment, gravel, etc.) were assumed, representing a 10 percent increase in in-place material volume. In addition, subgrade fill would be provided for the MDAs in quantities amounting to about 20 percent of the in-place tuff volume. For cover acreage, LANL expects that MDAs A and T would be capped as a single unit because only 120 feet (37 meters) separate them. LANL indicates that the cap for MDA A would extend 100 feet (30 meters) beyond the limits of the fence surrounding MDA A, thus covering 2.7 acres (1.1 hectares). The cap for MDA T would extend 100 feet (30 meters) beyond the limits of the fence surrounding the MDA, thus covering 6.2 acres (2.5 hectares) (LANL 2006a). The northern edge of the MDA T cap may require riprap (covering about 0.75 acre [0.3 hectare]) to control surface water runoff without erosion (LANL 2006a). For the remaining MDAs, cover acreages assumed for the *Borrow Source Survey* (Stephens 2005) are also assumed here. Material requirements are listed in **Table I–45**.

Current NNSA plans call for complete removal of the waste in MDA B (Section I.3.3.2.7); consequently, the volumes provided in Table I–45 for MDA B are conservative estimates based on assumed capping of all waste and contamination in MDA B. Also, because NMED has determined that the Consent Order requirements have been satisfied for the SWMUs comprising MDA U (NMED 2006b), capping may be unnecessary.

Table I–46 presents the assumed numbers of one-way shipments that would be required for delivery of these materials, assuming that each truck contains 22 tons (20 metric tons) of material and a 20 percent swell factor (Stephens 2005). A 10 percent contingency factor was assumed.

Table I–45 Cover Materials for Selected Material Disposal Areas (cubic yards)

Material Disposal Area	*Cover Area*		*Minimum Cover Thickness (3 feet of tuff)*			*Maximum Cover Thickness (8.2 feet of tuff)*		
	Acres	*Square Feet*	*Tuff*	*Additional Material*	*Total*	*Tuff*	*Additional Material*	*Total*
A	2.7	120,000	16,000	1,300	17,000	43,000	3,600	46,000
B [a]	6.0	260,000	35,000	2,900	38,000	95,000	7,900	100,000
T [b]	6.2	270,000	36,000	3,000	39,000	98,000	8,200	110,000
U [c]	0.2	8,700	1,200	97	1,300	3,200	260	3,400
AB	1.4	61,000	8,100	680	8,800	22,000	1,900	24,000

[a] Estimates for MDA B are based on the assumption that all waste and contamination at MDA B would be capped. Current plans call for complete removal of waste from MDA B. The Capping Option is retained for MDA B for completeness.
[b] Does not include 0.75 acres of riprap comprising 1,210 cubic yards, assuming a thickness of 1 foot.
[c] Estimates for capping MDA U are conservative because NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).
Note: To convert acres to hectares, multiply by 0.4047; square feet to square meters, multiply by 0.092903; cubic yards to cubic meters, multiply by 0.7646. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–46 One-Way Shipments for Delivery of Cover Materials for Selected Material Disposal Areas

Technical Area	*Material Disposal Area*	*Minimum Cover Thickness (3 feet of tuff)*			*Maximum Cover Thickness (8.2 feet of tuff)*		
		Tuff	*Additional Material*	*Total*	*Tuff*	*Additional Material*	*Total*
21	A	1,200	100	1,300	3,300	280	3,600
21	B [a]	2,700	230	2,900	7,400	620	8,000
21	T [b]	2,800	230	3,000	7,700	640	8,300
21	U [c]	91	8	98	250	21	270
49	AB (Areas 1-4)	630	53	690	1,700	140	1,900

[a] Estimates for MDA B are based on the assumption that all waste and contamination at MDA B would be capped. Current plans call for complete removal of waste from MDA B. The Capping Option is retained for MDA B for completeness.
[b] Delivery of riprap for MDA T would entail an additional 72 shipments.
[c] Estimates for capping requirements for MDA U are conservative because NMED has issued a Corrective Action Complete with Controls certification for SWMUs comprising MDA U (NMED 2006b).
Note: Because numbers have been rounded, the sums may not equal the indicated totals.

Small MDAs and landfills. Remediation may be required at several small MDAs and landfills.[50] Assuming that these MDAs are capped in place, the assumed coverage areas of the MDA caps, and capping thicknesses, are listed in **Table I–47**. Cover materials were estimated based on a nominal cover acreage, an assumed minimum thickness of added tuff of 3 feet (0.9 meters), and an assumed maximum thickness of added tuff of 8.2 feet (2.5 meters). Additional cover materials (topsoil, rock, soil amendment, gravel) were assumed, representing an increase in in-place material volume of 10 percent. In addition, subgrade fill was assumed to be provided for the MDAs in quantities amounting to about 20 percent of the in-place tuff volume. For material shipments, each truck was assumed to contain 22 tons (20 metric tons) of material with a 20 percent swell factor. A 10 percent contingency was assumed (**Table I–48**).

[50] Some MDAs are not addressed in this section. MDA M has been remediated and has been recommended for no further action. MDA S is an active 100-square-foot (9.3-square-meter) test plot. MDA W is administratively complete. MDA X has been remediated and recommended for no further action. MDA K has been largely remediated, although two small aboveground disposal areas remain. Capping is not a reasonable option for these disposal areas.

Table I–47 Cover Assumptions for Remaining Material Disposal Areas (cubic yards)

Technical Area – Material Disposal Area	*Assumed Cover Area*		*Minimum Cover Thickness (3 feet of tuff)*			*Maximum Cover Thickness (8.2 feet of tuff)*		
	Acres	*Square Feet*	*Tuff*	*Additional Material*	*Total*	*Tuff*	*Additional Material*	*Total*
06 - F	1.4	61,000	8,100	680	8,800	22,000	1,900	24,000
08 - Q	0.2 [a]	8,700	1,200	97	1,300	3,200	260	3,400
15 - N	0.92 [b]	40,000	5,400	450	5,800	15,000	1,200	16,000
15 - Z	0.23 [c]	10,000	1,300	110	1,400	3,600	300	3,900
16 - R	2.3 [d]	99,000	13,000	1,100	14,000	36,000	3,000	39,000
33 - D	0.11 [e]	4,800	640	53	690	1,700	150	1,900
33 - E	0.7 [f]	30,000	4,100	340	4,400	11,000	930	12,000
36 - AA	0.4 [g]	17,000	2,300	190	2,500	6,300	530	6,800
39 - Y	0.66 [h]	29,000	3,900	320	4,200	11,000	880	11,000

[a] Dimensions uncertain, estimated (LANL 1999b). The Capping Option for this MDA may be unlikely.
[b] Assumed a pit, 40,176 square feet.
[c] Dimensions uncertain. Assumed 10,000 square feet, with some existing material removed.
[d] Dimensions uncertain. Assumed 2.27 acres (LANL 2005c). The Capping Option for this MDA may be unlikely.
[e] Assumed cap is 2,400 square feet to account for depth of chambers.
[f] Assumed one large cap over four pits, a test chamber, and a shaft. Site comprises 0.7 acres.
[g] Assumed two separate trenches, with cap extending to 12 feet around sides of both trenches (i.e., footprint for one trench is 6,656 square feet; footprint for second trench is 10,056 square feet).
[h] Assumed one cap covers northern two trenches, and a second cap covers southern trench. Assumed cap extends 12 feet around all sides of both trench groups (i.e., northern footprint is 17,888 square feet; southern footprint is 11,008 square feet). Does not include any rock armor or other measures to preclude erosion from nearby ephemeral stream.

Note: To convert cubic yards to cubic meters, multiply by 0.7646; acres to hectares, multiply by 0.405; square feet to square meters, multiply by 0.0929. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–48 One-Way Shipments of Cover Materials for Remaining Material Disposal Areas

Technical Area – Material Disposal Area	*Minimum Cover Thickness (3 feet of tuff)*			*Maximum Cover Thickness (8.2 feet of tuff)*		
	Tuff	*Additional Material*	*Total*	*Tuff*	*Additional Material*	*Total*
06 - F	630	53	690	1,700	140	1,900
08 - Q [a]	91	8	98	250	21	270
15 - N	420	35	450	1,100	95	1,200
15 - Z	100	9	110	280	24	310
16 - R [a]	1,000	86	1,100	2,800	230	3,000
33 - D	50	4	54	140	11	150
33 - E	320	26	340	870	72	940
36 - AA	180	15	200	490	41	530
39 - Y	300	25	330	820	68	890

[a] The Capping Option for these material disposal areas may be unlikely.

Note: Because numbers have been rounded, the sums may not equal the indicated totals.

Capping these MDAs may result in generation of waste. Projected waste generation rates for these MDAs are listed in **Table I–49**. Most wastes were from MDAs R and Z. Both MDAs contain debris that is piled above grade, as well as buried debris. It was assumed that the aboveground debris from both MDAs would be removed before capping. This removal waste volume was assumed to be half of the total volume of debris estimated for these MDAs (see Section I.3.3.2.4.3).

In addition to MDAs, other landfills or contaminated areas may require capping. These include the landfill at Area 6 at TA-49 and contaminated soils in Area 12 at TA-49. Capping of the Airport Landfill was completed in 2007 and the landfill remedy completion report was submitted to and approved by NMED (LANL 2006a). Remediation decisions about Areas 6 and 12 of TA-49 have not yet been made.

Table I–49 Waste Generation through Fiscal Year 2016 from Capping Additional Material Disposal Areas

	Solid Waste	*Chemical Waste*	*Low-Level Radioactive Waste*	*Mixed Low-Level Radioactive Waste*	*Total*
Volumes [a] (cubic yards)	14,000	4,400	1,500	190	20,000

[a] In situ volumes. Because much material will be soil and debris, which will "swell" upon removal, and because of packaging inefficiencies, as-shipped volumes will be somewhat larger than in situ volumes.
Note: To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal the indicated totals.

Cover materials estimated for the two TA-49 contaminated areas are summarized in **Tables I–50** and **I–51**.

Table I–50 Cover Assumptions for Technical Area 49 Contaminated Areas (cubic yards)

Landfills and Areas	*Assumed Cover Area*		*Minimum Cover Thickness (3 feet of Tuff)*			*Maximum Cover Thickness (8.2 feet of Tuff)*		
	Acres	*Square Feet [a]*	*Tuff*	*Additional Material*	*Total*	*Tuff*	*Additional Material*	*Total*
Area 6, TA-49 [a]	5	218,000	29,000	2,400	31,000	79,000	6,600	86,000
Area 12, TA-49 [a]	0.3	13,000	1,700	150	1,900	4,800	400	5,200

TA = technical area.
[a] Cover area estimated (Stephens 2005).
Note: To convert cubic yards to cubic meters, multiply by 0.7646; acres to hectares, multiply by 0.405; square feet to square meters, multiply by 0.0929. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–51 One-Way Shipments for Technical Area 49 Contaminated Areas

Landfills and Areas	*Minimum Cover Thickness (3 feet of Tuff)*			*Maximum Cover Thickness (8.2 feet of Tuff)*		
	Tuff	*Additional Material*	*Total*	*Additional Material*	*Tuff*	*Total*
Area 6, TA-49 [a]	2,300	190	2,500	6,200	520	6,700
Area 12, TA-49 [a]	140	11	150	370	31	400

TA = technical area.
[a] Cover area estimated (Stephens 2005).
Note: Because numbers have been rounded, the sums may not equal the indicated totals.

MDA H. Remediation of MDA H has been addressed in corrective measure investigations and evaluations, as well as NEPA analyses (DOE 2004b). The remedy selected by NMED is encapsulation of shafts, installation of an engineered evapotranspiration cover, and installation of a soil vapor extraction system (see Section I.3.3.2.2.4) (NMED 2007a). The final evapotranspiration cover for MDA H (DOE 2004b) would require 2,185 cubic meters (2,860 cubic yards) of bulk materials obtained from onsite or local sources. Assuming a gross material density of 1.3 tons per cubic yard, 22-ton trucks, and 20 percent material swell, transporting 2,860 cubic yards of bulk materials over an estimated period of 5 months would require roughly 200 one-way shipments. Shipments of encapsulation material (grout or micro-concrete) and equipment would also be required. Assuming that remediation occurs during the time period covered in this SWEIS, bulk material volumes and shipments projected in this section could be augmented by those summarized above.

I.3.3.2.2.3 Hydraulic Barriers

An option for some MDAs may be to install hydraulic barriers to restrict lateral movement of moisture and contamination. The design and installation of hydraulic barriers at any MDA would be integrated with the design for its final configuration and would be based on a site-specific analysis that considered the environmental processes affecting the MDA, including surface and subsurface water dynamics. Two example installations are described below.

Using MDA A as an example, a hydraulic barrier could nominally be a high-density polyethylene (HDPE) sheet installed in a slit trench and backfilled with bentonite slurry. The barrier would extend along the north and east sides of the final cap, or about 800 feet (244 meters). The depth of the barrier would range from 20 to 30 feet (6.1 to 9.1 meters), assuming that the barrier is seated 5 feet (1.5 meters) into the bedrock. The average depth may be closer to 20 feet (6.1 meters), because a paleochannel at the west side of the cap forms the deeper limit and has limited lateral extent (LANL 2006a).

Sheet pile cutoff walls are installed by driving interlocking steel or HDPE sheets into the ground. The joints between individual sheets are typically plugged using clay slurry (steel sheets) or an expanding gasket (HDPE sheets). The steel sheets can be driven directly into the ground; the HDPE sheets are driven using a steel backing that is removed once the sheet is in place. Slurry walls can be constructed using a trench backfilled with a slurry mixture of bentonite and native materials, or a vibrating beam, where a steel plate is forced into the ground, and, as the plate is removed, bentonite is injected to fill the space of the beam. A typical slurry wall installed by trenching is 1.5 to 6.5 feet (0.5 to 2 meters) wide. It can be installed to 50-foot (15-meter) depths. Slurry walls using the vibrating beam method are narrower and typically installed at shallower depths (NFESC 2005).

An HDPE barrier installed by trenching may be conservative in terms of materials. An 800-foot (240-meter) wall would require 20,000 square feet (1,900 square meters) of HDPE, assuming an average depth of 25 feet (7.6 meters). Assuming a trench width of 3.3 feet (1 meter), 2,430 cubic yards (1,860 cubic meters) of bentonite and native materials would be needed.

Using MDA T as an example, a hydraulic barrier could again nominally be sheet HDPE installed in a slit trench and backfilled with bentonite slurry. The barrier would extend along the north and west sides of the cap, or 1,150 feet (350 meters). The depth of the barrier would range from 20 to 30 feet (6.1 to 9.1 meters), assuming the barrier is seated 5 feet (1.5 meters) into the bedrock. The average depth may be closer to the 20-foot (6.1-meter) depth, because a paleochannel at the west side of the cap forms the deeper limit and has limited lateral extent (LANL 2006a).

Assuming a length of 1,150 feet (350 meters) and an average depth or 25 feet (7.6 meters), about 28,750 square feet (2,670 square meters) of HDPE sheeting would be required, plus 3,500 cubic yards (2,700 cubic meters) of bentonite and native materials, assuming a trench width of 3.3 feet (1 meter).

I.3.3.2.2.4 Soil Vapor Extraction Systems

Soil vapor extraction systems are contemplated for several MDAs. The investigation work plans to be implemented for these MDAs are intended, in part, to determine the extent of volatile organic compound plumes detected beneath the MDAs (see LANL 2003k, 2003m, 2004c). Alternatives for addressing the plumes will be developed based on these investigations.

An often-used technology for removing soil vapors is an active soil vapor extraction system. A mechanical blower applies a vacuum to a well screened in the vadose zone, causing vapor surrounding the open interval of the well to be drawn to the surface. An active system was constructed and tested near the outer boundary of the volatile organic compound plume under MDA L. Two boreholes were constructed to depths of 215 feet (66 meters) in the immediate vicinity of two source zones. Volatile organic compounds removed from the plume were treated using granular activated carbon to absorb the chemical contaminants. The results from the pilot study will be used to evaluate the potential of soil vapor extraction systems for remediating the MDA L plume and to assess system design criteria. The results of the study will be considered as part of the corrective measure evaluation for the MDA (LANL 2005f, 2006d).

Active soil vapor extraction systems reach a point of limited contaminant flow where the cost per mass of contaminant removed, including operator attention, system maintenance, and a power source, is increased (LANL 1999e). Passive vapor extraction systems become useful as a polishing effort after active systems (or other methods) have reduced existing concentrations, or for situations where the existing concentrations in soil are too low for effective removal using active systems.

Passive soil vapor extraction, also known as barometric pumping, uses differences between atmospheric pressure and subsurface pressures to move contaminants from the vadose zone to the soil surface. Passive soil vapor extraction wells function like active air injection or extraction wells but do not use mechanical pumps. At any time, the atmospheric pressure at the surface and the soil gas pressure in the subsurface are different. If these two zones are connected by a vadose zone well, the pressure differential results in flow either into or out of the well. When atmospheric pressure is higher than subsurface pressure, air flows through wells into the subsurface. But when atmospheric pressure is lower than subsurface pressure, air flows out of the wells into the atmosphere, taking the volatile organic compounds in the gas phase (Initiatives 2001).

The system functions through a series of extraction wells set into the polluted area. Removal efficiency is improved through placement of one-way valves at the tops of the wells, allowing flow only out of the wells. Valves are small and inexpensive. A Baroball® valve is a small housing containing a ping-pong ball in a conical seat, permitting gas flow in one direction and needing minimal pressure (1 millibar) to lift the ball from the seat. Volatile organic compounds flowing out of the well can be captured and treated, commonly by passing the gases through a passive carbon absorption system. Incineration, catalytic oxidation, or condensation may be used depending on the contaminant (Initiatives 2001). Passive soil vapor extraction systems have been used at Hanford (Initiatives 2001) and Savannah River (WSRC 1997, 2000).

Whether active or passive, soil vapor extraction systems are unobtrusive. Although active systems require a source of power, the equipment is portable. Passive systems project only a small distance above the ground. Either system could probably be installed and used without interrupting procedures for final site cover.

I.3.3.2.2.5 Grouting the General's Tanks in Material Disposal Area A

Once used to store solutions containing plutonium, the two 50,000-gallon (189,000-liter) tanks in MDA A contain sludge containing transuranic isotopes (LANL 1991). One option is to solidify some or all of the sludge in place, using a system that achieves a final waste form that is reasonably homogenous. A jet grout system is assumed as a typical decontamination and solidification process. It can wash the interiors of tanks, mix tank contents before removing samples or introducing grout or other stabilization agents, or remove sludge from the tanks. It has been applied to a tank in LANL's TA-50 and to tanks at Oak Ridge National Laboratory. It can be used in tanks having interior obstructions (DOE 1999d).

Pipes are extended from a charge vessel into the sludge and supernatant covering the bottom of a tank. Existing pipes may be used or ones that are inserted. Water is added to the tanks, as needed, as well as chemicals (such as acids) to dissolve the sludge and remove material adhering to surfaces. A jet pump draws a vacuum into a charge vessel, sucking material into the charge vessel. When the mixture reaches a predetermined level in the charge vessel, the jet pump is switched from vacuum to pressure mode. The fluid is forced from the charge vessel into the tank, mixing the contents. The system may be vented to depressurize the charge vessel. The process is repeated until the sludge and supernatant are mixed. Then samples of the mixture can be obtained or grout introduced and mixed with the sludge and supernatant to provide a final solidified waste form. Otherwise, the mixture can be withdrawn, treated, and solidified. Secondary waste streams from jet mixer operations would include small volumes of personal protective equipment, contaminated equipment and hardware, plastic sheeting and containers, and structured steel support and platforms. Decontamination and reuse of some equipment may be possible (DOE 1999d).

Operational Elements. Operational elements for tank grouting include:

- Design, planning, permitting, and developing authorization documents and work orders and providing notifications to regulators or others as needed.
- Training of personnel, as needed.

- Demolishing or relocating existing fences or structures, as needed.
- Identifying utilities such as gas lines, as needed to maintain safety, and, as needed, providing additional utilities (for example, water or electricity).
- Mobilizing equipment.
- Performing preliminary characterization and analyses, including an initial criticality review.
- Preparing the site, including any needed excavations to provide access to the tanks, and installing safety and environmental detection equipment.
- Performing initial entry into the tanks and sampling and stabilizing the atmosphere within the tanks.
- Fabricating and installing equipment into the tanks for mixing, sampling, waste removal, and grouting.
- Sampling and analyzing tank contents and developing grout mix formulations from bench scale testing.
- Stabilizing the tank contents (mixing, grouting, removing, and solidifying material, as needed).
- Managing the small quantities of liquid or solid wastes generated from operations.
- Decontamination of equipment, as needed, and demobilization.
- Final stabilization of the site (for example, backfilling excavations and installing a final cover).

Equipment to be mobilized largely already exists at LANL. The major modules of the system are (AEAT 2004):

- Charge vessel skid (contains the charge vessel, de-mister, jet pumps, piping, and main process valves).
- Control hut (contains a valve rack and the system control panel).
- In-tank charge vessel with wash nozzle module and hydraulic power pack.
- Offgas skid (used to achieve a slight negative pressure on the system, it contains air treatment capacity such as high-efficiency particulate air [HEPA] filters).

After any initial excavation needed to access the tanks, and installation of platforms or scaffolding needed to support equipment, initial operations will focus on accessing the tanks at up to three locations in each tank. All activities will be in accordance with approved documented safety analyses. Because the tanks have been sealed for many years, hydrogen or other gases may have built up within the tanks. The atmosphere within the tanks must be stabilized; depending on the results of sampling and as authorized, the gas may be vented or treated. Following tank atmosphere stabilization, sludge samples will be obtained and analyzed for radioactive and chemical materials. If the sample results indicate RCRA constituents of concern, NMED would be notified and an appropriate path forward negotiated. Next, mixing, sampling, and benchscale testing of grout mixtures will be performed. The grout mixture may contain additives such as fly ash or bentonite. A hot-cell facility may be needed for sampling analysis. Once a final grout mixture is developed, and after any needed additional fabrication or modification of equipment, final stabilization of the tanks will take place consistent with established plans, authorizations, and all safety and environmental reviews and analyses.

Final stabilization of the tank may involve solidification of all material in place or may involve removal of some material and solidifying the remaining material in place.

Assuming that the radioactive material would be all solidified in place, a small concrete batch plant could be installed convenient to the MDA and grout produced as needed. Following these and other preliminary activities, the system would be initially operated to mix the sludge and the supernatant, and then grout would be introduced in a manner achieving a mixture of sludge and grout within the tanks. One approach would be to first mix and solidify the sludge (heel), and then use clean grout to fill the remaining void. The process for each tank could require about 250 cubic yards (190 cubic meters) of grout per tank.

Assuming that the jet grout system is first used to remove most of the sludge from the tank before stabilization, the removed sludge would be treated and solidified. Experience at three 50,000-gallon (189,000-liter) tanks at Oak Ridge National Laboratory demonstrated a removal efficiency ranging from 96 to 98 percent. The ratio of liquid to sludge volume in the material removed from each tank ranged from 2.4 to 9 (DOE 1999d).

The volume of sludge remaining in the General's Tanks is uncertain. Because most of the liquid was removed from the tank, there may be little remaining supernatant. The General's Tanks Characterization Activities Documented Safety Analysis estimates a sludge volume of 3.22 cubic yards (2.46 cubic meters) (LANL 2003j). Assuming that roughly 6 times as much liquid would be added as the original sludge volume, about 22.5 cubic yards (17.2 cubic meters) of mixture would be generated from each tank.[51] Assuming 95 percent removal efficiency, the mixture from the west tank would contain about 45.65 curies of alpha-emitting transuranic isotopes, while the east tank would contain about 11.6 curies. Assuming these mixtures at an increase in volume of about 50 percent results in a final waste volume of about 34 cubic yards (26 cubic meters) from each tank.

It is expected that waste solidification could take place using a mobile waste treatment system temporarily located at the site. Alternatively, existing LANL waste treatment and solidification capacity may be used, depending on the characteristics of the removed sludge. Removed mixture would be pumped from the system charge vessel into containers for safe transfer to the treatment facility.

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[51] A document prepared by AEA Technology indicates that optimum mixing is achieved with a supernatant-to-sludge ratio of about 2 to 1 (AEAT 2004). A 6 to 1 ratio was assumed based on experience at Oak Ridge (DOE 1999d) and because the sludge has been left in place for several years.

Waste from either tank was assumed to be transuranic waste. Assuming use of 55-gallon (208-liter) drums at a 90 percent packing efficiency and 20 percent contingency, the solidified mixture would require about 8 one-way shipments to WIPP, assuming the waste can be contact handled.[52]

The heel left in the tanks after removal would be solidified as discussed above. About the same volume of grout would be required as before.

I.3.3.2.2.6 Schedules

Schedules for capping MDA G and MDA L are provided in Sections I.3.3.2.1.2.4 and I.3.3.2.1.3, respectively. For MDAs A, B, C, T, U, and AB, it was assumed that work periods for stabilization and capping schedules are completed by the schedules for submittals of their respective remedy completion reports. The assumed start and completion dates, and work periods, are listed in **Table I–52**.

Work periods for MDAs A, B, C, T, U, and AB were assumed by extrapolating from published estimates for MDAs G, L, and H (LANL 2005k, DOE 2004b). Work periods would depend on the volumes of capping materials emplaced, operational difficulties and constraints (such as existing nearby structures), economies of scale, funding, and other considerations. For simplicity, a thicker cap was assumed to require the same installation time as a thinner cap.

Stabilization and capping the remaining small MDAs (F, Q, N, Z, R, D, E, AA, and Y) and additional landfills may be carried out, if needed. Consistent with Consent Order schedules, remediation is assumed to start in FY 2007 and continue through FY 2016.

Table I–52 Temporal Assumptions for Capping Large Material Disposal Areas

Material Disposal Area	*Assumed Start of Stabilization and Capping*	*Assumed Completion of Stabilization and Capping*	*Assumed Work Time (months)*
A	1/11/2010	3/11/2011	14
B [a]	2/23/2010	6/23/2011	16
T	6/19/2009	12/19/2010	18
U [b]	5/6/2011	11/6/2011	6
AB	6/1/2014	1/31/2015	8
C	11/5/2008	9/5/2010	22
G	10/1/2010	12/28/2015	40
L	4/30/2010	6/30/2011 [c]	14

[a] Current plans call for complete removal of waste from MDA B. In January 2007, NMED approved the revised Investigation and Remediation Work Plan for MDA B that addresses removal (NMED 2007b). The Capping Option is retained in this Appendix for completeness.
[b] The Capping Option for MDA U is conservatively retained for completeness. NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).
[c] The current schedule for MDA L remediation calls for submittal of a remedy completion report by July 9, 2011.

[52] *This waste was conservatively included for the Capping Option.*

I.3.3.2.3 Sources of Bulk Materials for Stabilizing Material Disposal Areas

Materials required for placing a final cover of the MDAs could include fill material such as crushed tuff, gravel, cobbles and angular boulders, concrete reinforced block or similar dry-stack rock, sand, clay, top soil or rooting media, soil amendment, or compost. Additional bulk materials for stabilizing the MDAs may include barrier wall material such as HDPE sheets and bentonite or similar material. Grout would be needed to stabilize the General's Tanks.

To minimize costs and environmental impacts, bulk materials should be acquired close to the point of use. The *MDA Core Document* (LANL 1999b) and Stephens report (Stephens 2005) documented several sources within and local to LANL for bulk materials such as rocks, clay, or soil amendment. Information from the U.S. Geological Survey and the State of New Mexico confirms the extensive production of nonfuel minerals in New Mexico. The state was a significant producer of construction sand and gravel and dimension stone (USGS 2003). A 2001 reference lists roughly 300 mines, mills, and quarries in New Mexico (Pfeil et al. 2001). Production of masonry cement in 1996 was roughly 100,000 tons (WERC 2002).

The capping material needed in largest quantity is crushed tuff or other fill. The Borrow Source Survey (Stephens 2005) pointed out the potential for stockpiling fill and other material from construction projects, and that two sediment retention and flood control structures built at LANL following the 2000 Cerro Grande Fire could be removed by 2010 as watersheds become revegetated. These structures may provide a source of material for cover construction, perhaps up to 50,000 cubic yards (38,250 cubic meters) (Stephens 2005). But the most significant onsite source would be the existing LANL borrow pit in TA-61.

TA-61 Borrow Pit. Also known as the East Jemez Site, TA-61 is a long, narrow, and relatively small site created from a portion of TA-3 when LANL redefined its TAs in 1989 (LANL 1999d). It contains physical support and infrastructure facilities. In addition to the borrow pit next to East Jemez Road and east of the Royal Crest Manufactured Home Community, TA-61 contains the county landfill, which, when closed, would be the site of a solid waste transfer station.

TA-61 is bordered by TA-43, TA-41, and TA-02 to the north, TA-53 to the east, TA-60 to the south, and TA-3 to the east. Access to TA-61 is via East Jemez Road, a high-traffic publicly used two-lane thoroughfare traversing TA-61 lengthwise in an east-west orientation.[53]

The setting of TA-61 within LANL, and its topography, can be visualized in **Figure I–21**, which shows major physiographic features, the surrounding TAs, and the conceptual geologic model of Operable Unit 1114 (LANL 1993e). The ground slopes upward from east to west. TA-61 is bounded on the north by Los Alamos Canyon and on the south by Sandia Canyon, which is about 400 feet (120 meters) wide and 40 to 140 feet (12 to 43 meters) deep at TA-61 (LANL 1999d). The distance to the regional aquifer is 1,300 feet (396 meters) (LANL 2005a).

[53] *The entrance to the borrow pit is near a steep hill, and there is little room for an acceleration lane (LANL 2003j).*

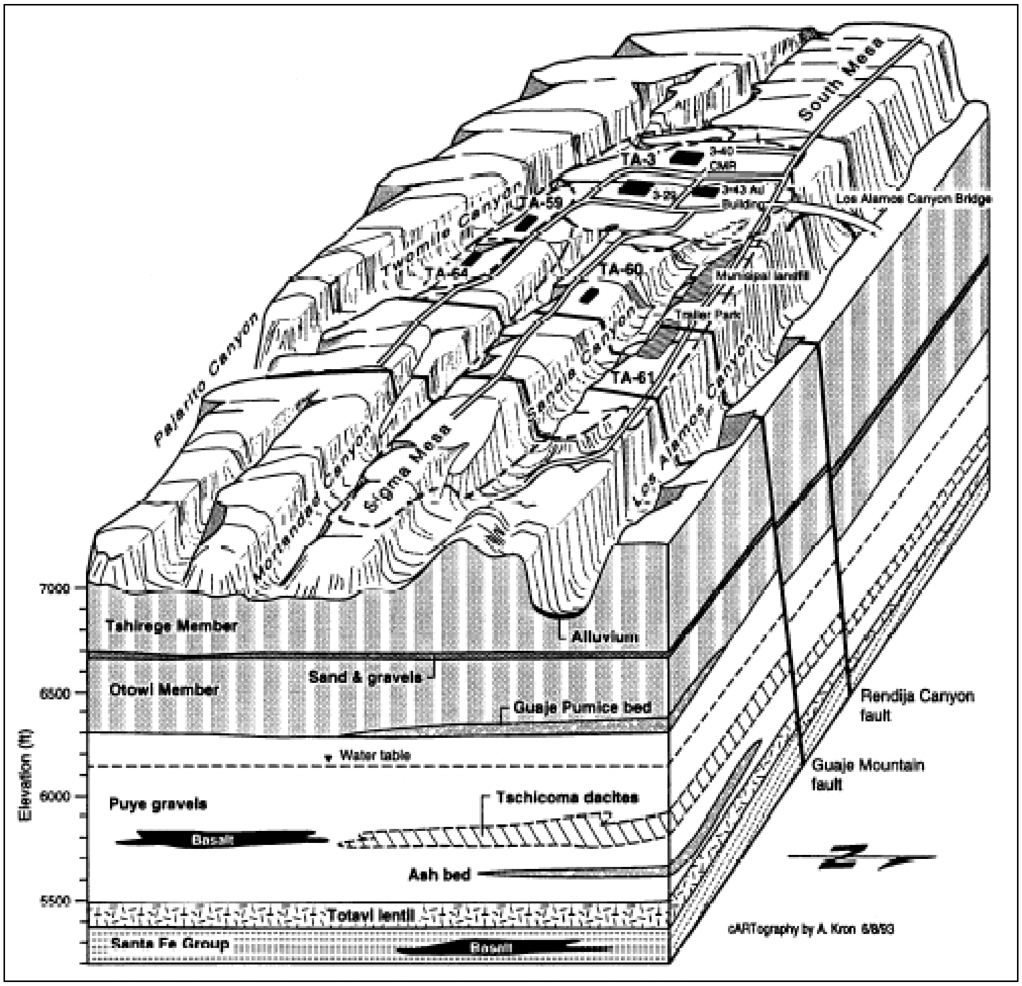

Figure I–21 Conceptual Geologic Model of Operable Unit 1114

Used for soil and rubble storage and pickup, the borrow pit is within a 43-acre (17-hectare) site (LANL 2003a). It is on the south side of East Jemez Road across from its intersection with La Mesita Road, which provides access to the Los Alamos Neutron Science Center (LANSCE). The borrow pit is 2 miles (3.2 kilometers) from the county landfill, a few thousand feet to the east of the trailer park, and across Sandia Canyon from TA-60, Sigma Mesa. A natural gas line is to the west (LANL 2004b, 2005a).

Figure I–22 is an aerial photograph of the triangular-shaped clearing in the forest that comprises the borrow pit (LANL 2003a). Figure I–22 shows the jog in the stream in Sandia Canyon that occurs at the borrow site.[54] **Figure I–23** is a view from within the pit looking to the east (LANL 2003a). The knoll to the left (north) in the figure shields the pit from visibility from East Jemez Road.

[54] *This suggests that if the borrow pit is expanded to the southwest, measures would have to be taken to ensure that drainage does not cause surface water quality problems*

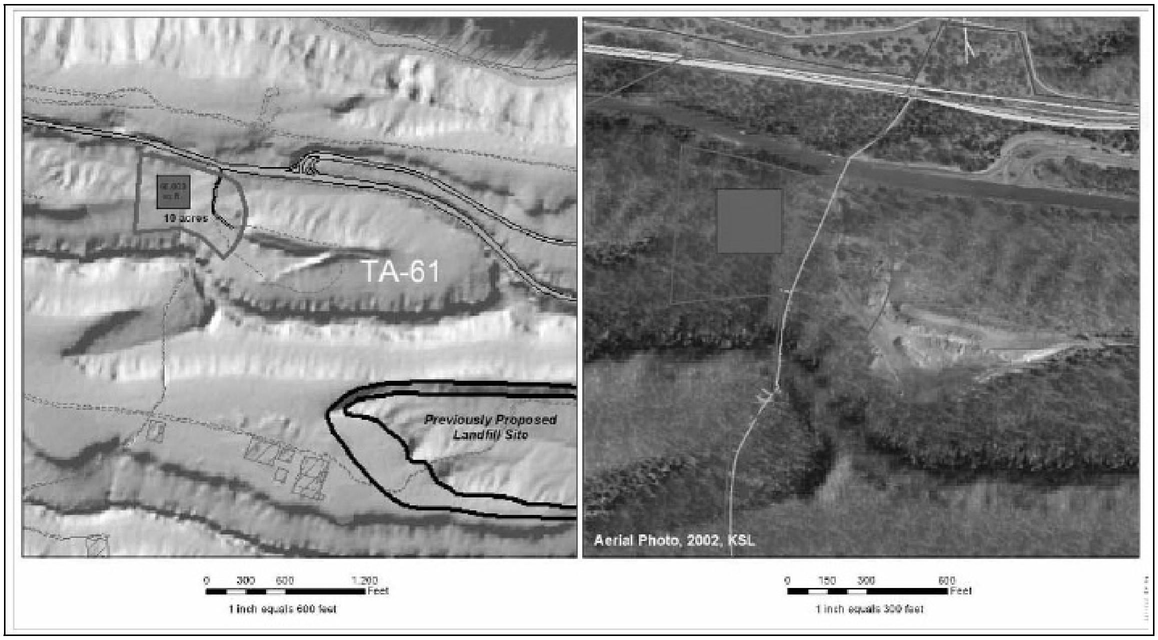

Figure I–22 Aerial Illustrations of Borrow Pit

Figure I–23 View to the East from within the Technical Area 61 Borrow Pit

I.3.3.2.4 Removal Option

Removals are difficult to characterize. Information is still being acquired through corrective measure investigation programs. Simplifying assumptions are made based on studies and experience at LANL and other DOE sites.

I.3.3.2.4.1 Operational Elements

Operational elements associated with removing any of the MDAs are summarized in the text box.

MDA Removal Operational Elements

- *Design, Planning, and Permitting* – Includes planning for site operations, including equipment and personnel coordination. Includes health and safety plans, site security plans, erosion control plans, etc. Includes permits and authorizations.
- *Demolishing/Relocating Existing Operations, Structures, or Materials* – Includes moving, demolishing, or relocating existing structures or operations.
- *Rerouting/Modifying Utilities, Pipelines, or Similar* – Includes rerouting or modifying water, electrical, telephone, or other underground or overhead lines as needed to preclude damage. Includes removal or rerouting of liquid waste or chemical piping to preclude damage.
- *Mobilization* – Includes mobilization and initial site placement of equipment such as cranes, backhoes, dump trucks, water trucks, and graders. Includes installation of a site management trailer. Includes site storage of equipment and initial mobilization of the workforce.
- *Site Preparation* – Includes explorations needed to determine the specific locations of disposed wastes, as well as other site-specific studies and tests. Includes clearing of existing vegetation. Includes the removal of asphalt or other existing covers over disposal units, such as topsoil and the top layer of crushed tuff over the MDAs. Includes removal and disposal of existing security fencing.
- *Perform Special Activities* – Includes activities unique to a specific MDA.
- *Exhumation* – Includes waste exhumation, sorting, characterizing, classifying, packaging as necessary, and shipping for treatment, storage, or disposal.
- *Regrading/Revegetation* – Includes spreading and fine-grading of topsoil, compaction using construction equipment, watering for dust abatement, and watering of planted areas for vegetation germination at approved levels.
- *Demobilization* – Includes demobilization of equipment, including removal of a site management trailer.
- *Health and Safety* – Includes developing a site health and safety plan; performing surface sampling and confirmation of nonhazardous site conditions; monitoring site activities; and conforming to standard construction health and safety policies, laws, and procedures.
- *Project Management* – Includes an onsite project manager or foreman, who reports daily site progress, as well as site office support. Includes specialists such as explosives experts.

Excavation would be preceded by extensive planning and site investigations to confirm the dimensions of the disposal units and the presence of other contamination and buried objects. Other preliminary site work could include permitting; demolishing or relocating existing operations, structures, or materials (as needed); rerouting or modifying utilities or pipelines (as needed); mobilization of equipment; and initial site preparation. Preliminary work may generate wastes requiring treatment and disposal.[55] It is assumed that a management area would be established near the MDA for heavy equipment and vehicles. A trailer or similar structure would be sited for management of operations. The size of the management area may depend on the size of the MDA and the complexity of removal operations, but, for most MDAs, would probably not exceed a few thousand square feet. An area for parking personal vehicles would be needed; in most cases; existing nearby parking lots or areas nearby the MDA could be used. Utilities would be made available, for example, by hooking up to existing utilities in the vicinity of the MDA. Water may need to be delivered by truck at some MDAs. Portable toilets would be installed in the staging area, and sanitary waste from the toilets would be trucked to a disposal location either on or offsite.

Preliminary work would include development of areas supporting waste removal. The scope and size of support operations would depend on the amount of waste to be removed from the MDAs and the hazards that the waste presents. Support operations could include:

- Capacity for storing and managing exhumed wastes and for decontaminating equipment, as needed
- Capacity for storing bulk materials such as excavation spoils, final cover materials, or demolition debris
- Capacity for preliminary classification of exhumed materials by hazard and staging for further management
- Capacity to process waste as needed for shipment for treatment or disposal
- Capacity to characterize the waste for its organic, inorganic, and radioactive material content

It is expected that this support capacity would be sized to support multiple activities, such as those proposed to support MDA remediation and DD&D at TA-21 (see Section I.3.3.2.7). For large operations, such as that proposed for TA-21, or for removal of large MDAs, support areas could cover several acres. Areas for managing exhumed wastes or stockpiling overburden or other bulk material removed as part of initial preparation would be protected from erosion or runon, airborne dispersion, and possible cross-contamination. There may be a need to construct temporary roads between the MDAs and the support areas.

Excavation and removal of uncontaminated topsoil or tuff can be performed using conventional equipment such as backhoes and bulldozers. On average, the top 3 feet (0.9 meters) of topsoil and existing cover soil was assumed to be removed from the existing MDA covers and

[55] *It was assumed that generation of solid waste, chemical waste, and low-level radioactive waste during site preparation would be the same as that for the Capping Option.*

stockpiled at a location as close as reasonably possible considering topography, best management practices, or the proximity of other facilities. The actual volume of the existing cover soil that would be removed will depend on the thickness of cover over each MDA. Maximum, minimum, and average thicknesses can vary considerably within each MDA and over all MDAs. A 3-foot (0.9-meter) thickness for nearly all MDAs was assumed as an average approximation. It represents all the preliminary work at the MDAs that requires movement of soil.

Some removed material may be contaminated. Soil exceeding screening levels would be disposed of as waste. Otherwise, soil meeting screening levels may still be contaminated. Soil not disposed of as waste was assumed to be stockpiled and returned to the excavation along with additional backfill obtained from a local borrow. After backfilling and compaction, topsoil, and related materials would be imported, and the thickness of this final cover would be about 6 inches (15 centimeters).

Only small portions of an MDA would be excavated and backfilled at one time.

Exhumation may take place within an enclosure such as a tension support dome when the waste contains materials that may present a significant inhalation hazard or when removal would be performed within close proximity to operating facilities at LANL or to members of the public. The enclosure would be moved as needed to each successive work area (see Section I.3.3.2.6).

Material would be excavated using heavy equipment. Depending on the hazard presented by the waste, excavation may be possible using conventional equipment such as tracked backhoes, or may require use of specialized equipment such as remotely operated or heavily shielded excavators. Procedures to screen, sort, and classify the removed material would also depend on the hazard presented by the waste. The rates of excavation, sorting, and classification of contaminated materials can vary greatly, depending on the hazard presented by the materials. Materials presenting an external or inhalation hazard would require more time to excavate, sort, and classify. If the material presents an external hazard, then remote operations may be required. If the material presents an inhalation hazard, then use of high-level personal protection equipment may significantly improve work efficiency.

Excavating many of the MDAs considered in this section would generate large quantities of contaminated materials containing hazardous constituents and radionuclides. The materials may present significant handling hazards (for example, external radiation or inhalation concerns) or may otherwise require special consideration because of security concerns. Procedures and equipment may be needed, for example, to contain exhumed compressed gas cylinders or other problematic wastes awaiting sampling and disposal, treatment of gases that cannot be transferred to another container or be transported on highways, hot-tapping of compressed gas cylinders, or excavation or removal of explosives. Remote-operated, shielded facilities may be needed to characterize, treat, and package wastes having high surface radiation levels.

Excavating shafts may be difficult. Removal of the material in shafts could be conducted in many cases using the trenching approach described in Section I.3.3.1.3.2 for MDA H. Many of the shafts in the MDAs have been drilled to roughly similar depths (about 60 feet [18 meters]). In other cases, cranes or specialized equipment may be required.

Volumes of uncontaminated soil removed and temporarily stockpiled during exhumation depend on the method assumed for exhumation, whether all waste is removed or only portions, the depth of excavation, and the configuration of the site.

Once exhumed, waste must be characterized and classified by type. Different types of waste have significantly different requirements for treatment, packaging, and disposal. It was assumed that recovered high explosives would be safely burned at a suitable location within LANL. For other types of radioactive and nonradioactive solid wastes, the total volume of contaminated material excavated from each MDA was estimated, and then the volume was distributed among the different waste types based on available information. It was assumed that the volumes implied by the nominal dimensions of the pits, trenches, and shafts give the total volume of contaminated material.[56] Backfill placed with the waste when disposed of was conservatively assumed to be contaminated. To assist in waste groupings, radionuclide inventories of the larger MDAs were assessed to provide a sense of radionuclide concentrations and external radiation levels that may be associated with exhumed wastes.

A June 2000 DOE study was used to estimate the volumes of transuranic and alpha-contaminated low-level radioactive wastes that might result from exhuming the MDAs.[57] This DOE study developed its estimates through surveys of DOE national laboratories. Estimates for LANL MDAs are summarized in **Table I–53** (DOE 1999g, 2000a). Note that "alpha-contaminated low-level radioactive waste" does not represent an official DOE classification of waste. Distinctions among low-level radioactive waste subtypes (such as low-activity radioactive waste, alpha-contaminated low-level radioactive waste, and others) were considered in this appendix to enable enhanced analyses of possible impacts of radioactive waste transportation.[58]

After classification and sorting, waste must be treated and disposed of or stored. Solid and chemical wastes would be sent to authorized treatment facilities or landfills. Low-level radioactive waste that is not mixed could be either disposed of onsite or sent to another site. No onsite disposal capacity now exists for mixed low-level radioactive waste.

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[56] The as-built dimensions of the pits, shafts, and trenches, often not documented, may be different from the nominal (design) dimensions. The waste volume and potentially contaminated backfill placed in the disposal units would be actually somewhat smaller than that implied by the nominal disposal unit dimensions, because of ramps and sloping walls within pits and trenches. Also, the waste was not placed all the way to the tops of the disposal units. Assuming the disposal unit dimensions, however, accounts for the likelihood of movement of small amounts of contamination laterally and (particularly) vertically downward outside the nominal boundaries of the disposal units after initial waste displacement.

[57] The great bulk of this transuranic-contaminated material was disposed of before operational distinctions between low-level radioactive and transuranic wastes were made at DOE sites.

[58] The estimated total volume of material that may meet the current definition of transuranic waste (22,100 cubic yards [16,900 cubic meters]) is somewhat larger than that assumed for the 1997 WIPP Disposal Phase Final Supplemental Environmental Impact Statement (about 18,300 cubic yards (14,000 cubic meters) of buried contact-handled transuranic waste and 157 cubic yards (120 cubic meters) of buried remote-handled transuranic waste) (DOE 1997a).

Table I–53 Volumes of Transuranic-Contaminated Materials Estimated to be Within Los Alamos National Laboratory Material Disposal Areas

		Transuranic-Contaminated Material Buried in Pits or Absorption Beds (cubic meters)		*Transuranic-Contaminated Material Buried in Shafts (cubic meters)*		*Total Transuranic-Contaminated Material in Pits, Absorption Beds, and Shafts (cubic meters)*	
Technical Area	*Material Disposal Area*	*Transuranic Waste* [a]	*Alpha-Contaminated Low-Level Radioactive Waste* [b]	*Transuranic Waste* [a]	*Alpha-Contaminated Low-Level Radioactive Waste* [b]	*Transuranic Waste* [a]	*Alpha-Contaminated Low-Level Radioactive Waste* [b]
21	A	700	13,300	–	–	700	13,300
21	B	525 [c]	20,475 [c,d]	–	–	525 [c]	20,475 [c]
50	C	2,600	100,400 [e]	70	70	2,670	100,470
54	G	4,785	179,215	6	1,044	4,791	180,259
21	T	162	2,538	3,610	190	3,772	2,728
49	AB	–	–	4,400	–	4,400	–
21	V [f]	–	4,300 [f]	–	–	–	4,300 [f]
Total		8,772	320,228	8,086	1,304	16,858	321,532

[a] For the DOE study, this material was assumed to meet the current DOE definition of transuranic waste.
[b] For the DOE study, this material was assumed to meet the current DOE definition of low-level radioactive waste, but would contain alpha-emitting transuranic isotopes having half-lives exceeding 20 years and in concentrations between 10 and 100 nanocuries per gram. "Alpha-contaminated low-level radioactive waste" is not an official DOE waste category, but was considered for this appendix to enable enhanced analysis of possible impacts from radioactive waste transportation.
[c] More recent analyses of waste in MDA B (LANL 2006i) suggest that these estimates of transuranic and alpha-contaminated low-level radioactive waste volumes in MDA B may be over-conservative.
[d] The DOE database (DOE 1999g) estimates that 5,000 cubic meters of the alpha-contaminated low-level radioactive waste in MDA B may be mixed waste.
[e] The DOE database (DOE 1999g) estimates that 25,100 cubic meters of the alpha-contaminated low-level radioactive waste in MDA C may be mixed waste.
[f] The transuranic content of this waste was over-estimated. None of the material from MDA V removal (completed in May 2006) exceeded 10 nanocuries of transuranic radionuclides per gram of waste (LANL 2006a).
Note: To convert cubic meters to cubic yards, multiply by 1.308.
Sources: DOE 1999g, 2000a.

I.3.3.2.4.2 Waste and Bulk Material Requirements for Removal of Large Material Disposal Areas

This section summarizes estimates of wastes and bulk material requirements for removal of MDAs A, B, T, U, AB, C, G, and L. Summaries of waste generation and shipment of solid wastes from these MDAs are in **Table I–54**. Summaries of volumes and shipments of bulk materials such as soil and backfill are in **Table I–55**. Summaries for liquid wastes are in **Table I–56**, based on information from LANL (LANL 2006a).

The listed volumes include wastes from preliminary site work such as destruction of fencing and removal of concrete and asphalt slabs over portions of the MDAs. Listed volumes for both wastes and materials are in situ volumes. Shipment estimates for wastes and bulk materials reflect the assumption of 20 percent swell of soil once removed from the ground. This swell assumption is applied to removed waste because much of it will be soil and debris.

Table I–54 Waste Volumes and Shipments for Removal of Material Disposal Areas A, B, C, G, L, T, U, and AB

Material Disposal Area	*Solid*	*Chemical* [a]	*Low-Level Radioactive Waste*						*Transuranic Waste*		*Total*
			Low Activity	*Mixed Low Activity*	*Alpha*	*Mixed Alpha*	*Remote Handled*	*Mixed Remote Handled*	*Contact Handled*	*Remote Handled*	
Volumes (cubic yards)											
A	1,200	440	1,800	130	16,000	1,700	–	–	1,100	–	22,000
B [b]	10,000	3,100	9,800	1,000	20,000	6,500	–	–	690	–	51,000
C	22,000	10,000	22,000	2,700	99,000	33,000	6.6	0.7	3,400	46	190,000
G	1,500	–	620,000	69,000	210,000	24,000	1,200	140	6,300	3.9	940,000
L	54	3,300	–	–	–	–	–	–	–	–	3,400
T	43	–	230	32,000	–	3,600	–	–	4,900	–	41,000
U	20	–	570	12	–	–	–	–	–	–	600
AB	13	1,600	2,900	3,700	–	–	–	–	5,800	–	14,000
One-Way Shipments											
A	95	37	130	10	1,200	140	–	–	120	–	1,800
B [b]	760	260	690	82	1,600	520	–	–	80	–	4,000
C	1,700	850	1,500	220	7,900	2,600	3	1	400	70	15,000
G	110	–	44,000	5,500	17,000	1,900	590	66	730	6	70,000
L	4	280	–	–	–	–	–	–	–	–	280
T	3	–	16	2,600	–	280	–	–	570	–	3,400
U [c]	2	–	40	1	–	–	–	–	–	–	42
AB	1	130	200	300	–	–	–	–	670	–	1,300

[a] Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for disposal in a sanitary landfill.

[b] These volumes and shipments are based on conservative assumptions about the quantities and radiological characteristics of waste from complete removal of waste from MDA B. Most recent projections of waste from MDA B removal are in Section I.3.3.2.7. Total volumes of waste from these more recent estimates are smaller than those presented in this table.

[c] These volumes and shipments are based on conservative assumptions about the waste's resulting from complete removal of MDA U. NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).

Note: Volumes are in situ volumes. As-shipped volumes would be larger because of swell of excavated material and packing efficiencies being smaller than 100 percent. Volumes include waste from preliminary site work such as fencing removal but not DD&D of structures. To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal indicated totals.

Table I–55 Volumes and Shipments of Bulk Materials for Removal of Material Disposal Areas A, B, C, G, L, T, U, and AB

Material Disposal Area	*Cover Removed*	*Additional Soil Removed*	*Total Stockpiled Soil Returned*	*Additional Fill*	*Topsoil*	*Total*
Volumes (cubic yards)						
A	6,100	12,000	18,000	21,000	1,100	58,000
B [a]	19,000	12,000	32,000	48,000	3,200	110,000
C	57,000	340,000	390,000	190,000	9,500	990,000
G [b]	220,000	2,900,000	3,200,000	930,000	36,000	7,300,000
L	4,800	9,500	14,000	3,300	810	33,000
T	–	270,000	230,000	41,000	3,200	540,000
U [c]	480	610	1,100	580	81	2,800
AB	6,800	12,000	18,000	14,000	1,100	52,000
One-Way Shipments						
A	430	840	1,300	1,500	78	4,100
B [a]	1,400	870	2,200	3,400	230	8,100
C	4,000	24,000	28,000	14,000	670	70,000
G [b]	15,000	210,000	220,000	66,000	2,600	520,000
L	340	670	1,000	230	57	2,300
T	–	19,000	16,000	2,900	230	38,000
U [c]	34	43	78	41	6	200
AB	480	830	1,300	990	80	3,700

[a] These volumes and shipments are associated with conservative assumptions about the quantities of waste resulting from complete removal of waste from MDA B. Removal of smaller volumes of waste from MDA B, as projected in Section I.3.3.2.7, should result in smaller volumes of bulk materials moved.

[b] Capping the remain disposal units in the existing Area G footprint following MDA removal is projected, depending on whether a thick or thin cap would be installed, to require from 190,000 to 510,000 cubic yards (140,000 to 390,000 cubic meters) of crushed tuff, and 160,000 cubic yards (120,000 cubic meters) of additional material. One-way shipments of crushed tuff would range from 15,000 to 40,000, with 12,000 shipments of additional material.

[c] The volume and shipments are based on conservative assumptions about removal of waste from MDA U. NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).

Note: To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal the indicated totals.

MDA A

This MDA consists of the two relatively long and narrow Eastern Pits, a large Central Pit, and the two General's Tanks containing contaminated sludge. Challenges include: (1) the uncertain waste inventory; (2) its location between DP East and DP West; (3) the proximity of TA-21 to populated areas; and (4) the General's Tanks.

The same buildings, piping, and other structures assumed to be removed as part of capping MDA A (Section I.3.3.2.2.1) would be removed before site exhumation.

Table I–56 Liquid Waste Volumes and Shipments from Large-Material-Disposal-Area Exhumation

Material Disposal Area	*Industrial*	*Hazardous*	*Low-Level Radioactive*	*Mixed Low Level*	*Total*
Volumes (gallons)					
A	–	–	75	–	75
B [a]	2,000	–	450	–	2,450
C	55	–	–	–	55
G	–	–	–	–	–
L	–	10,000	–	–	10,000
T	–	–	–	–	–
U	–	–	–	–	–
AB	–	–	–	–	–
One-Way Shipments [a]					
A	–	–	1 [b]	–	1 [b]
B [a]	3	–	1 [b]	–	3
C	1 [b]	–	–	–	1 [b]
G	–	–	–	–	–
L	–	13	–	–	13
T	–	–	–	–	–
U	–	–	–	–	–
AB	–	–	–	–	–

[a] More recent estimates of liquid waste from removal of MDA B (Section I.3.3.2.7) are smaller than those presented in this table.
[b] Indicates less than a full shipment.
Note: To convert gallons to liters, multiply by 3.78533.

Pits. The two Eastern Pits are each 125 by 18 by 13 feet deep (38 by 5.5 by 4.0 meters deep). The site was assumed to be initially graded, resulting in the removal of 0.2 acre (0.08 hectare) to an average depth of 3 feet (0.9 meters). About 970 cubic yards (742 cubic meters) of soil would be stockpiled for reuse. Excavation was assumed to resemble a general prismatoid, having walls sloping at angles of 45 degrees. This assumption results in an excavation having dimensions of 82 by 151 feet (25 by 46 meters) on the surface and 56 by 125 feet (17 by 38 meters) at the base of the excavation. The total amount of waste removed (before sorting) was estimated to be 2,200 cubic yards (1,700 cubic meters). In addition, 50 cubic yards (38 cubic meters) of contaminated soil was assumed to be removed from the former drummed storage area[59] (LANL 2006a).

Assuming the distance between the pits is 20 feet (6.1 meters), the total amount of clean soil removed (before bulking) is 2,400 cubic yards (1,900 cubic meters). This material was assumed to be stored and returned to the excavation, along with the material originally removed, and 2,200 cubic yards (1,700 cubic meters) (as compacted) of additional backfill. Topsoil and materials to promote vegetation would total 161 cubic yards (123 cubic meters).

The Central Pit has a depth of 22 feet (6.7 meters) and a total capacity of 18,700 cubic yards (14,300 cubic meters). The waste mass was assumed to have a surface area of 23,000 square feet (2,140 square meters); the length of this surface area (assumed to be a square) was 152 feet (46 meters). About 0.9 acre (0.36 hectare) of soil having an average thickness of

[59] *The soil was contaminated from leaking drums of stable iodine in a NaOH solution.*

3 feet (0.9 meters) would be initially removed (4,360 cubic yards [3,330 cubic meters]). The total volume of waste and soil then excavated would be 24,800 cubic yards (19,000 cubic meters), of which 6,060 cubic yards (4,600 cubic meters) would be soil meeting screening levels. This soil, as well as the top cover initially removed, would be stored and then returned to the excavation after waste removal, along with 18,700 cubic yards (14,300 cubic meters) of additional soil (as compacted in place). Topsoil and other growth media would be added and compacted, sufficient to cover an area of about 0.9 acre (0.36 hectare).

It was assumed that removal of contaminated material from the MDA pits would result in 916 cubic yards (700 cubic maters) of contact-handled transuranic waste and 17,400 cubic yards (13,300 cubic meters) of alpha-contaminated low-level radioactive waste (DOE 1999g, 2000a). These volumes represent in situ volumes and may be overestimates. It was assumed that the transuranic and alpha-low-level waste referenced in the DOE database was entirely contained in the Central Pit. The Eastern Pits were used during the 1940s, while the Central Pit was used during the 1970s, when programs generating transuranic-contaminated wastes were more extensive. Also, the projected total volume of waste from the Eastern Pits is much smaller than the total quantity of transuranic and alpha-contaminated low-level wastes, (18,300 cubic yards [14,000 cubic meters]) projected in the DOE database (DOE 1999g). It was assumed that 10 percent of the alpha-contaminated low-level radioactive waste would be mixed.

The remaining 425 cubic yards (325 cubic meters) of waste from removal of the Central Pit was assumed to be 40 percent solid waste, 15 percent chemical waste, 40 percent low-activity low-level radioactive waste, and 5 percent mixed low-activity low-level radioactive waste. (As reported in 1989 by Gerety, Nyhan, and Olive, the Central Pit in MDA A received waste from operations in TA-21, as well as plutonium-contaminated debris from the demolition of Building TA-21-12, a two-story frame and masonry building, after which it continued to receive waste through 1977 [LANL 1989]). A similar distribution was assumed for the 2,170 cubic yards (1,660 cubic meters) removed from the Eastern Pits. The 50 cubic yards (38 cubic meters) of contaminated soil removed from the former drummed storage area was assumed to be chemical waste. It was added to the chemical waste projected from the Eastern Pits.

General's Tanks. The General's Tanks have each been placed on four concrete piers and buried in two pits. The tanks are parallel to one another and about 20 feet (6.1 meters) apart. An 8-inch (70-centimeter) concrete slab was poured above both tanks (see Figure I–6), and soil was mounded above the concrete slab to about 5 feet (1.5 meters) above grade. A vent extends above one end of each tank. At the other end of each tank, a fill pipe leads to a concrete box on the surface.

Because the tanks are large and may be of questionable structural integrity, it was assumed that the tanks could not be removed intact. Rather, it was assumed that the tanks would be exposed and cut into sections for disposal. Removing the tanks in this manner is expected to be difficult, requiring extensive controls to protect health, safety, and the environment.

To expose the tanks, the soil mounded above the concrete slab above the tanks would be removed, as would the concrete slab. From Section I.2.5.2.1, it was estimated that the slab covers 3,860 square feet (360 square meters), and with the earth cover 10 percent more, for a total of 4.250 square feet (400 square meters). About 790 cubic yards (600 cubic meters) of soil cover would thus be removed and stored, and 95 cubic yards (73 cubic meters) of solid waste would be generated from removal of the concrete slab.

The excavation would likely extend to the bottom of the concrete piers and somewhat to the sides of the tanks. The depth of excavation was assumed to be 14 feet (4.3 meters); the surface area at the base of the excavation was assumed to be 6,000 square feet (560 square meters); and the excavation footprint at the top of the excavation was assumed to be 11,300 square feet (1,050 square meters). After the tanks were removed, the total excavated void would be 4,400 cubic yards (3,370 cubic meters).

Waste from removal of the tanks would include the eight concrete piers (33 cubic yards [26 cubic meters]), the two fill boxes (2.6 cubic yards [2.0 cubic meters]), some piping, contaminated soil, and contaminated metal scrap from cutting apart the tanks. The piping should be very small in volume. Contaminated soil volume was estimated by assuming a 3-foot-thick (0.9-meter-thick) contaminated band around the outsides of both tanks. This volume would be 700 cubic yards (530 cubic meters). It was assumed that all of this waste except for the sectioned tanks would be low-activity low-level radioactive waste.

It was assumed that before the tanks were dismantled, as much contamination would be removed as reasonably practical. In so doing, the inside walls and support structures would be washed using remotely operated equipment and available technologies such as the jet grout system discussed in Section I.3.3.2.2.5. The inventory within the tank would be then fixed in place to minimize dispersion during cutting.

As the tank is cut into sections, the sections would be placed into containers for disposal. Assuming that the tanks have an average thickness of 0.5 inches (1.3 centimeters), and assuming an average steel density of 0.286 pounds per cubic inch, about 54 tons (49 metric tons) of contaminated steel would be generated. This mass was increased by 10 percent to account for internal and ancillary structures, totaling 59 tons (53 metric tons). The tanks were in use for about 30 years before the stored material was removed, and about 30 years have passed since this removal occurred. The distribution of contamination within interior tank surfaces is unknown. Therefore, all of the waste from sectioning the tanks was assumed to be contact-handled transuranic waste. Each standard waste box for WIPP can contain 63 cubic feet (1.8 cubic meters) of waste, having a maximum weight of 4,000 pounds (1.8 metric tons). Assuming 4,000 pounds per box, this implies a transuranic waste volume of about 68 cubic yards (52 cubic meters). However, operational restrictions would probably reduce the amount of waste that could be shipped per container. Consistent with the approach taken for other wastes in this analysis (see Section I.3.5), the as-shipped volume was assumed to be somewhat larger.

The soil initially removed over the top of the tanks would be used as backfill. Some of the soil removed as part of exposing the tanks for dismantlement would be returned as well. About 210 cubic yards (160 cubic meters) of topsoil and other growth media would be spread on top of the backfill.

MDA B

The configuration and inventory of radioactive and hazardous constituents within MDA B is not well known. Additional challenges include: (1) the site is large and relatively close to the Los Alamos community; (2) the only paved road access to TA-21 lies immediately north of and parallels the site; (3) businesses exist on the other side of this road opposite to MDA B; and (4) the topography to the south of MDA B falls off quickly to BV Canyon.

LANL personnel plan an investigation and remediation program at MDA B that will remove all waste. For this appendix, a conservative analysis was performed on the quantities of waste that could result from complete removal of MDA B. This analysis resulted in larger quantities of wastes than those estimated by LANL for the investigation and remediation program (see Section I.3.3.2.7).

From the 2004 Investigation Work Plan for MDA B (LANL 2004d) the total volume of waste from MDA B removal was assumed to be 47,900 cubic yards (35,600 cubic meters). It was assumed that all waste in and about MDA B could be represented as a single trench having dimensions of 2,000 by 52 feet (610 by 16 meters). Assuming an average soil cover of 3 feet (0.9 meters), this corresponds to an average depth of the representative trench of 15.5 feet (4.7 meters) (including 12.5 feet [3.8 meters] of waste and backfill).

Soil was assumed to be removed to a depth of 3 feet (0.9 meters) over an area of 4 acres (1.6 hectares), which covers the footprint of the assumed representative trench (about 2.4 acres [0.97 hectare]) plus a small space (a little over 15 feet [4.6 meters]) around it. This results in an initial top cover removal of 19,400 cubic yards (14,800 cubic meters). A pit was assumed having an average depth of 12.5 feet (3.8 meters), sides sloping back at 45 degrees, a base of about 2,000 by 52 feet (610 by 16 meters), and a top footprint of 2,025 by 77 feet (617 by 23 meters). About 60,100 cubic yards (46,000 cubic meters) of waste and soil would be exhumed, of which 12,200 cubic yards (9,330 cubic meters) would be soil meeting screening levels. This soil would be temporarily stored. The remaining 47,900 cubic yards (36,600 cubic meters) of excavated material was assumed to be waste.

Using the DOE database for buried transuranic-contaminated waste (DOE 1999g, 2000a), it was assumed that complete removal of MDA B would generate 686 cubic yards (525 cubic meters) of contact-handled transuranic waste, 20,240 cubic yards (15,475 cubic meters) of alpha low-level radioactive waste and 6,540 cubic yards (5,000 cubic meters) of mixed alpha low-level radioactive waste. This assumption may be a significant overestimate.[60] A precise determination of the quantities of transuranic-contaminated materials buried in MDA B will result from the MDA B investigation and remediation program described in Section I.3.3.2.7.

The remaining 20,400 cubic yards (15,600 cubic meters) of waste was distributed as follows: 40 percent industrial solid waste, 15 percent chemical waste, 40 percent low-activity low-level radioactive waste, and 5 percent mixed low activity low-level radioactive waste. A relatively large fraction of the waste was assumed to contain hazardous constituents because it was an early

[60] *Average transuranic concentrations within MDA B were estimated based on projected radionuclide inventories, total waste volumes as assumed above, and a density of 1.6 grams per cubic centimeter. The average transuranic concentration was 0.4 nanocuries per gram.*

disposal site (1945 to 1948) used for disposal of all types of waste. The MDA received chemicals from laboratories and may include chemical waste disposal pits.

After waste is removed, the stored clean soil would be returned and backfilled, along with 47,900 cubic yards (36,600 cubic meters) (as compacted) of clean soil from a local borrow and 3,230 cubic yards (2,470 cubic meters) of materials intended to support revegetation.

MDA T

This MDA consists of four absorption beds plus 62 shafts used for disposal of higher-activity waste. The depths of contamination beneath the absorption beds are not well known. Contamination under Absorption Bed 1 has been found at 100 feet (30 meters) below ground surface. The shaft depths range to 60 feet (18 meters) below the ground surface. In addition to these challenges: (1) MDA T is located nearby existing structures in TA-West; (2) several buried pipes and utilities are in the vicinity of MDA T; (3) the North Perimeter Road runs along the northern side of MDA T; and (4) the land slopes steeply down to DP Canyon to the north of MDA T.

Removal would follow actions needed to relocate or remove nearby buildings, structures, and underground piping and utilities at risk (see Section I.3.3.2.2.1). DD&D of buildings and structures in the vicinity of MDA T is addressed in Appendix H, Section H.2.

Although the total volume comprising the four absorption beds is 2,100 cubic yards (1,630 cubic meters), the volume of contaminated material will be larger because water and liquid waste was discharged to the beds. For at least one absorption bed (Bed 1), contamination may extend to a depth of 100 feet (30 meters).

For this appendix, it was assumed that contamination moved vertically from all beds to a depth of 100 feet (30 meters). This assumption was considered conservative because it extends contamination to greater depths than may be realistic for all beds. This assumption results in a total contaminated volume beneath the beds of 35,600 cubic yards (27,200 cubic meters). Using the DOE transuranic waste database, it was assumed that removal of the beds would generate 212 cubic yards (162 cubic meters) of transuranic waste and 3,320 cubic yards (2,538 cubic meters) of alpha-contaminated low-level radioactive waste (DOE 1999g, 2000a). Because the beds received metals and organic and inorganic chemicals, much of this alpha-contaminated low-level radioactive waste may be mixed waste. For conservatism it was assumed that all would be mixed. It was also assumed the remaining 32,000 cubic yards (24,500 cubic meters) of waste would be mixed low-activity low-level radioactive waste.

The total volume of waste to be removed from the shafts was assumed to be equivalent to the envelope volume of the shafts, which is 5,200 cubic yards (3,990 cubic meters).[61] From the DOE database, it was assumed that complete removal of the shafts would generate 4,720 cubic yards (3,610 cubic meters) of transuranic waste and 250 cubic yards (190 cubic meters) of alpha-contaminated low-level radioactive waste (DOE 1999g, 2000a). Because the cement paste

[61] *The shafts were not filled to the top with waste. Nonetheless, use of the envelope volume of the shaft to estimate waste volumes should offset the unknown extent to which contamination may have moved beneath and laterally from the shafts. Because the larger shafts, at least, were lined with asphalt, lateral movement may be small.*

placed in the shafts probably contained most of the same chemicals discharged to the beds, most of both types of waste may be mixed. For conservatism, it was assumed that all would be mixed. It was also assumed that all transuranic waste resulting from shaft removal would be contact-handled transuranic waste.

The remaining waste volume implied by the shaft dimensions, 252 cubic yards (193 cubic meters) was assumed to be 90 percent low-activity low-level radioactive waste and 10 percent mixed low-activity low-level radioactive waste. It was assumed that this waste would consist mainly of contaminated backfill and asphalt.

Excavation of the bed contamination and the shafts was assumed to have base dimensions of 150 by 300 feet (46 by 92 meters) and a depth of 100 feet (30 meters). This size should be sufficient for all absorption beds plus the shafts. The sides for the top 20 feet (6.1 meters) of the excavation, which is soil, were assumed sloped at an angle of 3 horizontal to 1 vertical. The sides for the bottom feet of the excavation, which is rock, were assumed sloped at an angle of 0.5 horizontal to 1 vertical. These assumptions result in a surface footprint of 175,000 square feet (16,300 square meters) and a total removed volume of 266,000 cubic yards (203,000 cubic meters) of soil, rock, and waste (LANL 2006a).[62] Subtracting waste, 225,000 cubic yards (172,000 cubic meters) of uncontaminated soil would be stockpiled. This material would be returned to the excavation along with 40,800 cubic yards (31,200 cubic meters) of additional fill (as compacted) from a local borrow. The top of the excavation would be replanted, requiring 3,240 cubic yards (2,480 cubic meters) of additional material.

MDA U

MDA U consists of two absorption beds, each having lengths of 80 feet (24 meters), widths of 20 feet (6.1 meters), and depths of 6 feet (1.8 meters) below the original ground surface. A portion of the contamination in the absorption beds was removed in 1985 by excavating a 20- by 100- by 4-to 13-foot (6.1 by 30 by 1.2 to 4.0 meter) trench. For this appendix, the remaining contamination was assumed to be a volume of material 60 by 20 by 13 feet deep (18 by 6.1 by 4 meters deep), or 578 cubic yards (442 cubic meters).[63]

It was assumed that the top 3 feet (0.9 meters) of soil would be removed over an area of 2,630 square feet (244 square meters), which covers the 60- by 20- foot (18- by 6.1-meter) area addressed above plus 15 feet (4.6 meters) on all sides. This would result in the initial removal of 480 cubic yards (370 cubic meters) of soil cover. Excavating the waste was then modeled as a pit having a base dimension of 60 by 20 feet (18 by 6.1 meters), a surface footprint of 86 by 46 feet (26 by 14 meters), and a volume of 1,190 cubic yards (910 cubic meters). This volume was assumed to comprise 580 cubic yards (440 cubic meters) of waste and 610 cubic yards (470 cubic meters) of soil meeting screening action levels. This soil would be stockpiled for later return to the excavation.

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[62] *Uncontaminated topsoil (such as that over the shafts) is included in this volume.*

[63] *The 2006 Investigation Report for MDA U concluded that neither additional corrective action nor further characterization was required and that the land use be maintained as industrial (LANL 2006e). NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006a). The Removal Option is herein considered for completeness.*

The waste removed from MDA U was assumed to consist of low-activity and mixed low-activity low-level radioactive waste. This assumption is consistent with that for excavation of MDA V (LANL 2004j), which comprises a set of absorption beds used to receive liquid wastes from a laundry. Similar to MDA V, it was assumed that 98 percent would be low-activity low-level radioactive waste and 2 percent would be mixed low-activity low-level radioactive waste.[64]

After waste removal, the 1,090 cubic yards (840 cubic meters) of removed topsoil and clean soil from the excavation would be returned and compacted. An additional 580 cubic yards (444 cubic meters) (as compacted) of clean soil would be delivered, as would 81 cubic yards (62 cubic meters) of materials to support vegetation.

MDA AB

The hydronuclear and support shafts at Areas 1, 2, 2A, 2B, and 4 in MDA AB contain large inventories of plutonium, uranium, beryllium, and lead and are at depths to 142 feet (43 meters) below ground surface. Shafts at Area 3 in MDA AB have much smaller levels of contamination to depths of 57 to 142 feet (43 meters). Wastes resulting from exhumation of MDA AB were assumed to consist of two groups: concentrated waste from the bottoms of the shafts, and lower-activity material, including surface contaminated metals and other wastes that were placed in dump and test shafts.

Regarding the first group of wastes, because large quantities of lead and beryllium were used in the tests, all of the wastes possibly generated from exhuming the wastes at the bottom of the shafts were assumed to be either mixed waste or chemically hazardous waste. The DOE database on buried transuranic-contaminated material (DOE 1999g, 2000a) estimates that the bottoms of the shafts contain 5,755 cubic yards (4,400 cubic meters) of material that would meet current definitions of transuranic waste. This estimate is consistent with an assumption that the bulk of the contamination is within a radius of about 10 feet (3 meters) from the detonation points in the 37 shafts (LANL 1992b) where plutonium was used in the tests. Regarding the other test shafts, 6 shots used uranium-235, 7 shots used uranium-238, 11 shots used tracers, and 11 shots were containment shots (LANL 1992b). Possible waste volumes from exhuming the contamination from these shots were estimated by determining the volumes represented by 10-foot-radius (3-meter-radius) spheres of contamination at the bottoms of the shafts. The uranium and tracer shot contamination was assumed to be mixed low-activity low-level radioactive waste. The containment shot contamination was assumed to be chemical waste.

Regarding the second group of wastes, it is difficult to project those shafts that may contain contaminated material and the depths to which the material was placed before backfilling.[65] The summed depth of all test shafts is 5,070 feet (1,550 meters). Assuming 6-foot-diameter (1.8-meter-diameter) shafts, on average, a total volume in the shafts of 5,310 cubic yards (4,060 cubic meters) is implied. Assuming that, on average, the bottom half of all shafts would

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[64] The MDA U beds probably received organic and inorganic chemicals, plus acids and oils, implying that much of the waste originally in the beds may have been mixed. However, most of the original contamination has been removed, and the extent to which removal of residual contamination may generate mixed waste is unknown.
[65] Burial depth may be highly variable. Waste was dumped in the test holes and in an unknown number of shallow holes of small diameter.

be contaminated, 2,660 cubic yards (2,030 cubic meters) of low-activity low-level radioactive waste would be generated. It was assumed that 10 percent of this waste would be mixed.

Excavating the waste presents a challenge because of the depth of the contamination and because of the contaminated metal and other materials disposed of in the shafts. Excavation might be accomplished partly using conventional excavators such as backhoes and partly using remote techniques such as suspending excavating tools from cranes.

It was assumed that the top 3 feet (0.9 meters) of soil would be removed over the six main areas composing MDA AB. Assuming a total surface area over these six areas of 1.4 acres (6.6 hectares), the total volume of earth removed would be 6,780 cubic yards (5,180 cubic meters). Assuming that about 3 feet (0.9 meters) around each existing 6-foot-diameter (1.8-meter-diameter) shaft would be removed (that is, 12-foot-diameter (3.7-meter-diameter) shafts would be excavated), then 25,600 cubic yards (19,600 cubic meters) of waste and soil would be removed before sorting between waste and clean soil. This would result in 11,700 cubic yards (8,950 cubic meters) of material meeting screening levels and 13,900 cubic yards (10,600 cubic meters) of waste. The material meeting the screening levels would be placed back into the holes, as well as other stored material. About 13,900 cubic yards (10,600 cubic meters) of clean crushed tuff would be imported from a local borrow, as well as 1,130 cubic yards (864 cubic meters) of materials intended to promote vegetation growth.

MDA C

MDA C is a large disposal area consisting of six large radioactive waste pits, a smaller chemical pit, and 108 shafts. Both the shafts and the pits contain a variety of chemicals, some of which may be reactive. The shafts were usually used for disposal of wastes presenting an external radiation hazard. MDA C is immediately south of structures associated with TA-50 waste management operations.

Removal would follow actions needed to relocate or remove nearby buildings, structures, and underground piping and utilities at risk.

The physical relationship of the various rows of shafts with respect to the pits presents safety concerns. Assuming excavation of Pit 3, which has an as-built depth of 25 feet (7.6 meters), there may be concern about the potential for sidewall collapse leading to exposure of the contamination in Shaft Group 2. Assuming excavation of Pits 1 through 4, there may be concerns about end-wall collapse leading to exposure of contamination in Shaft Group 3. A retaining wall may be needed between Shaft Group 1 and Pit 5, or a wall between Shaft Group 3 and the ends of Pits 1 through 4.

From the nominal dimensions of the shafts and pits, the projected volumes of wastes are:

- Pits: 190,830 cubic yards (145,900 cubic meters)
- Shafts: 198 cubic yards (151 cubic meters)

This results in a total waste generation of about 191,000 cubic yards (146,000 cubic meters).

Assuming a surface area of 11.8 acres (4.8 hectares) (Stephens 2005), a volume of 57,100 cubic yards (43,660 cubic meters) of surface soil would be removed and stockpiled.

Excavation was assumed to occur in two groups: one group is Pit No. 6 and the chemical pit, and the second is the remaining pits plus the shafts. Regarding the first group, assuming the excavation walls slope at angles of 45 degrees from the pits, and assuming an average excavation depth of 25 feet (7.6 meters), removing Pit 6 and the chemical pit would excavate 48,800 cubic yards (37,300 cubic meters) of waste and 17,200 cubic yards (13,140 cubic meters) of clean soil.[66] Regarding the second group, assuming that removal of the pits would include excavating the spaces between the pits, the area covered by the footprint of these pits and shafts would cover 10.5 acres (4.2 hectares). Assuming the soil on all sides of this footprint would be sloped at 45-degree angles, and assuming an average excavation depth of 25 feet (7.6 meters), 318,000 cubic yards (243,000 cubic meters) of clean soil would be excavated along with 142,000 cubic yards (109,000 cubic meters) of waste.

From the DOE database on buried transuranic contamination (DOE 1999g, 2000a), it was assumed that exhuming the MDA C pits would generate about 3,400 cubic yards (2,600 cubic meters) of transuranic waste (including 880 cubic yards [675 cubic meters] of mixed transuranic waste) and 131,240 cubic yards (100,400 cubic meters) of alpha-contaminated low-level radioactive waste, of which 32,810 cubic yards (25,100 cubic meters) would be mixed waste. It was assumed that transuranic waste generated from exhuming pits would be contact-handled waste. Assuming a total waste volume of 191,000 cubic yards (146,000 cubic meters), then the remaining radioactive waste would amount to 54,300 cubic yards (41,500 cubic meters). Exhuming the chemical pit was assumed to generate 2,000 cubic yards (1,530 cubic meters) of hazardous waste. The remaining waste from pit exhumation was assumed to consist of 40 percent solid waste, 15 percent chemical waste, 40 percent low-activity low-level radioactive waste, and 5 percent mixed low-activity low-level radioactive waste. These distributions were assumed because the pits were used mostly in the 1950s, and disposal logbooks as well as other information suggest that the pits were used for disposal of hazardous constituents as well as general trash and demolition waste (see Section I.2.5.4).

From the DOE database on buried transuranic-contaminated material (DOE 1999g, 2000a), it was assumed that exhumation of the MDA C shafts would generate 92 cubic yards (70 cubic meters) of transuranic waste and 92 cubic yards (70 cubic meters) of alpha-contaminated low-level radioactive waste. Similar to the assumptions for waste resulting from exhuming MDA G shafts (see below), it was assumed that half of the transuranic waste would be remote-handled waste. It was assumed that 10 percent of the alpha-contaminated waste would be mixed waste.

The total volume of waste implied by the shaft dimensions is 197 cubic yards (151 cubic meters). Subtracting the transuranic and alpha-contaminated low-level radioactive waste leaves 14 cubic yards (11 cubic meters) of waste. This waste was assumed to be low-level radioactive

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[66] *Assuming a pit having walls sloping at a 1:1 ratio and an average depth of 25 feet (7.6 meters), the surface area on the bottom of the excavation would be 109 by 505 feet = 55,000 square feet (5,110 square meters). The surface area at the top of the excavation would be 159 by 555 feet = 88,245 square feet (8,200 square meters). This provides a conservative estimate of soil and waste that may be removed from the excavation. However, shoring may be required along the northern edge of the excavation to avoid damage to structures, utilities, and piping. Shoring could reduce excavated volumes by roughly 0.5 (25 by 25 by 505 feet) = 160,000 cubic feet (4,530 cubic meters).*

waste. A conservative analysis of the MDA G shafts, which were used during a time that overlapped the use of shafts at MDA C, suggests that up to 50 percent of the originally emplaced waste in MDA G may be remote-handled waste. This estimate was applied to the waste in the MDA C shafts. Therefore, it was assumed that half of the remaining 14 cubic yards (11 cubic meters) of waste from shaft removal would be remote-handled low-level radioactive waste and half would be low-activity low-level radioactive waste. Similar to assumptions for other MDAs, it was assumed that 10 percent of both the remote-handled and low-activity low-level radioactive wastes would be mixed wastes.

After waste removal, the stockpiled soil meeting screening levels would be returned to the excavation, along with 191,000 cubic yards (146,000 cubic meters) of additional backfill and about 9,520 cubic yards (7,280 cubic meters) of material promoting vegetation growth.

MDA G

This MDA is located within Area G, which contains active waste disposal units. Current waste management facilities and operations at Area G will be removed or relocated as addressed in Appendix H, Section H.3. It was conservatively assumed there would be extensive removal of the disposal units in MDA G to bound impacts that may result from MDA G remediation. As an upper-bound case, it was assumed that removal would involve all pits through 37, all four trenches used for transuranic waste storage,[67] and 194 shafts. The total volume of waste to be generated from pit removal was assumed to correspond to the field-measured volumes for the pits as given in the Historical Investigation Report for MDA G (LANL 2004c). (For other MDAs, because field-measured volumes were generally unavailable, envelope volumes implied by nominal pit dimensions were assumed.) The total volume of waste thus assumed to be generated from MDA G removal was 931,000 cubic yards (712,000 cubic meters) from the pits and trenches and 3,880 cubic yards (2,970 cubic meters) from the shafts.

It was assumed that the excavation footprint for MDA G removal could be approximated by a 40-acre (16-hectare) rectangle having sides of 4:1. It was assumed that exhumation would be nominally preceded by removal of the top 3 feet (1 meter) of soil over about 45 acres (18 hectares). Assuming an average excavation depth of 60 feet, and assuming an excavation having walls sloping at 45-degree angles, then exhumation would remove about 3,875,000 cubic yards (2,962,000 cubic meters) of waste and soil. After separating waste, about 2,940,000 cubic yards (2,248,000 cubic meters) of soil meeting screening levels would be removed and stockpiled near MDA G for backfilling into the excavation.

Although disposal operations began at MDA G in 1957, it was used later than most of the other MDAs considered in this section. Therefore, it was assumed that MDA G was not used as a general depository for all types of waste, but was used exclusively for radioactive wastes, some of which contained RCRA-constituents.

From the DOE database on buried transuranic contamination (DOE 1999g, 2000a), it was assumed that removal of the MDA G pits would generate 6,260 cubic yards (4,785 cubic meters) of transuranic waste and 234,400 cubic yards (179,215 cubic meters) of alpha-contaminated low-

[67] *The transuranic waste in Trenches A–D will be removed and shipped to WIPP, as addressed in Appendix H, Section H.3. The backfill in these trenches was conservatively assumed to be contaminated and was thus included in the removal volumes.*

level radioactive waste. The radioactive inventory within the pits composing MDA G was estimated using information from the Area G Performance Assessment and Composite Analysis (LANL 1997). Analysis of this inventory suggested that little, if any, of the transuranic waste that would be generated from MDA G removal would be remote handled. Hence, all was assumed to be contact-handled. About 10 percent of the alpha-contaminated low-level radioactive waste was assumed to be mixed waste. The remainder of the waste that would be generated from MDA G pit removal was assumed to be low-activity and remote-handled low-level radioactive waste.

This remaining low-level radioactive waste consists of originally emplaced waste and backfill that was assumed to be contaminated. An analysis of the originally emplaced waste suggests that up to 107 cubic yards (81.5 cubic meters) of this waste could be remote-handled low-level radioactive waste. The remaining originally emplaced waste and backfill was assumed to be low-activity low-level radioactive waste. Ten percent of the remote-handled and low-activity low-level radioactive waste was assumed to be mixed waste.

From the DOE database on buried transuranic contamination (DOE 1999g, 2000a), it was assumed that removal of the MDA G shafts would generate 7.8 cubic yards (6 cubic meters) of transuranic waste and 1,370 cubic yards (1,044 cubic meters) of alpha-contaminated low-level radioactive waste. A conservative analysis of the radionuclide inventories in the shafts indicated that up to about 50 percent could be remote-handled. Therefore, half of the transuranic waste from postulated removal of the shafts was assumed to be remote handled. About 10 percent of the alpha-contaminated low-level radioactive waste was assumed to be mixed waste.

The remaining 2,510 cubic yards (1,920 cubic meters) of the waste generated from shaft removal was assumed to be low-level radioactive waste. Similar to the assumption above for transuranic waste, it was assumed that half would be remote handled low-level radioactive waste and half would be low-activity low-level radioactive waste. It was assumed that about 10 percent of both types of waste would be mixed waste.

It was assumed that the remaining disposal units within the existing Area G footprint would be capped using either a thin or thick cap as addressed in Section I.3.3.2.1.2.3. But the cap was assumed to cover 25 acres (10.2 hectares) rather than 65 acres (26.3 hectares). Projected volumes and shipments of bulk capping materials are in a footnote to Table I–55.

MDA L

MDA L is a relatively small site once used for disposal of chemical waste. It is contained within Area L, which is currently used for authorized storage of RCRA, PCB, and mixed waste. It was assumed that all waste to be generated from MDA L removal would be hazardous waste. Disposal units subject to corrective action are listed in Table I–39. Decisions about remediation of MDA L disposal units (pursuant to the Consent Order or for other reasons) will be made in the future. For conservatism, it was assumed that all disposal units would be removed. The total waste volume from its pit, impoundments, and shafts was estimated to be 3,280 cubic yards (2,505 cubic meters).

In addition to structures removed as addressed in Appendix H, Section H.3, it was assumed that the fence near the working area would be removed and disposed of as solid waste, and a temporary security fence would be emplaced at a distance from the work area and tied into the remaining fence around MDA L. About 80 cubic yards (61 cubic meters) of asphalt would also be removed, of which half was assumed to be solid waste and half chemical waste. It was assumed that about 1 acre (0.4 hectare) of land would then be removed at a depth of about 3 feet (0.9 meters), resulting in 4,840 cubic yards (3,700 cubic meters) of soil for temporary storage.

Excavation may be difficult, particularly for shafts, because of their proximity to nearby structures and LANL operations. The pits were dug to depths of 10 to 12 feet (3.0 to 3.7 meters), and could possibly be exhumed using standard construction equipment. But the shafts have been drilled to 60-foot (18-meter) depths, and their excavation may require use of cranes. Shoring and specialized removal techniques may be needed. An excavation having sloping walls was assumed for the pit and impoundments. The base was assumed to be 80 by 300 feet (24 by 91 meters), the top footprint 324 by 104 feet (99 by 32 meters), and the depth 12 feet (3.7 meters). This results in a total excavated volume of 12,800 cubic yards (9,770 cubic meters), of which 3,280 cubic yards (2,505 cubic meters) would be waste and 9,500 cubic yards (7,260 cubic meters) would be soil meeting screening levels. This excavated soil would be stockpiled at a nearby location for replacement into the excavation. Additional crushed tuff would be backfilled. A final cover would be emplaced, requiring about 810 cubic yards (620 cubic meters) of material. An alternate proposal involving a larger amount of excavated material was submitted to NMED in January 2008 (LANL 2008a).

I.3.3.2.4.3 Wastes and Materials for Removal of Remaining Material Disposal Areas

Waste volumes from removal of several additional small MDAs are summarized in **Tables I–57**, while shipments are presented in **Table I–58**. Additional materials excavated and returned, as well as additional backfill and cover material, are presented in **Tables I–59** and **I–60**.

Less information exists about these remaining MDAs compared with previous MDAs. Waste volumes from removal of each MDA were assumed to be given by the nominal volumes of all disposal units composing the MDA (length by width by average depth). Unless the MDA includes aboveground debris (MDAs Z and R), it was assumed that 3 feet (0.9 meters) of topsoil would be removed and stored. The waste and soil then removed was represented as a general sigmatoid having walls sloping at 45-degree angles. The waste would be sorted into waste type, and clean soil would be returned along with additional fill from a LANL or local borrow pit. An additional 0.5 feet (15 centimeters) of topsoil, soil amendment, and other material would be delivered and emplaced.

The waste removed from the excavation was assumed to be distributed among different types of waste based on information from LANL (LANL 2006a). Estimates of liquids that may be generated during removal were based on LANL information (LANL 2006a).

Table I–57 Waste Projections for Removing Remaining Material Disposal Areas

Nonliquid Wastes (cubic yards) [a]

Material Disposal Area	Solid Waste	Chemical Waste [b]	Low-Level Radioactive Waste [b]	Mixed Low-Level Radioactive Waste [b]	Total Waste Volume
F [c]	–	–	11,000	–	11,000
Q [d]	3,600	18	–	–	3,600
N [e]	10,000	330	2,700	330	13,000
Z [f]	3,000	1,100	3,000	370	7,400
R [g]	26,000	7,700	–	–	33,000
D [h]	12,000	–	12,000	–	24,000
E and K [i]	1,800	2.2	440	1.1	2,200
AA [j]	1,300	380	2,100	–	3,800
Y [k]	5,300	–	–	–	5,300

Liquid Wastes (gallons)

Material Disposal Area	Industrial Waste	Hazardous Waste	Low-Level Radioactive Waste	Mixed Low-Level Radioactive Waste	Total Waste Volume
F	–	–	–	–	–
Q	–	25	–	–	25
N	–	–	–	100	100
Z	–	55	500	–	555
R	–	5	–	–	5
D	–	–	100	–	100
E and K	–	5	55	–	60
AA	–	–	–	100	100
Y	–	110	100	–	210

[a] In situ volumes reduced to two significant figures. As-shipped volumes would be larger because of swell of excavated material and packaging inefficiencies.
[b] Low-level and mixed low-level radioactive wastes were assumed to be low-activity wastes. Chemical waste was assumed to include material regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
[c] Assumed two pits 50 by 150 by 20 feet (15 meters by 46 meters by 6.1 meters) deep pits and four shafts 6 by 6 by 6 feet (1.8 by 1.8 by 1.8 meters).
[d] Assumed one pit covering 90 by 90 by 12 feet (27 by 27 by 3.7 meters).
[e] Assumed one pit covering 100 by 300 by 12 feet (30 by 91 by 3.7 meters).
[f] Partly above-ground debris pile, about 20 by 200 feet (6.1 by 61 meters), with one side approximately 15 feet (14.6 meters) high and the other side at grade. Unknown depth. Assumed a virtual subsurface disposal facility 20 feet (6.1 meters) deep.
[g] Shallow trash pile, comprising three 75-square-feet bermed pits. Waste was bulldozed into pits and likely spread in the vicinity. Some waste has been removed. Assumed to be 300 by 300 by 10 feet (91 by 91 by 3 meters).
[h] Assumed one large excavation to remove buried chamber and elevator shaft. Assumed a 0.3-acre (0.12-hectare) footprint, 50 feet deep.
[i] For MDA E, assumed Pit 3 has same dimensions as largest of four pits. For the buried chamber, assumed a contaminated footprint (244 square feet [23 square meters]) describing the area of the elevator shaft (48 square feet [4.5 square meters]) and the buried chamber (approximately 196 square feet [18 square meters]). For MDA K, assumed two surface disposal piles 15 by 15 by 12 feet (4.6 by 4.6 by 3.7 meters); and 10 by 20 by 12 feet (3.0 by 6.1 by 3.7 meters).
[j] Assumed two trenches, one 80 by 40 by 15 feet (24 by 12 by 4.6 meters) and a second 120 by 30 by 15 feet (37 by 9.1 by 4.6 meters).
[k] Assumed three pits having dimensions estimated from the RFI Work Plan for Operable Unit 1132 (LANL 1993b).
Note: To convert cubic yards to cubic meters, multiply by 0.76456; gallons to liters, multiply by 3.785, feet to meters, multiply by 0.3048; square feet to square meters, multiply by 0.0929. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–58 One-Way Shipments from Exhuming Remaining Material Disposal Areas

Nonliquid Wastes

Material Disposal Area	*Solid Waste* [a]	*Chemical Waste* [a]	*Low-Level Radioactive Waste* [a]	*Mixed Low-Level Radioactive Waste* [a]	*Total* [a]
F	–	–	790	–	790
Q	270	2	–	–	280
N	760	28	190	27	1,000
Z	230	93	210	30	560
R	2,000	640	–	–	2,600
D	940	–	830	–	1,800
E and K	140	–	31	–	170
AA	100	32	150	–	280
Y	400	–	–	–	400

Liquid Wastes

Material Disposal Area	*Industrial Waste*	*Hazardous Waste*	*Low-Level Radioactive Waste*	*Mixed Low-Level Radioactive Waste*	*Total* [a]
F	–	–	–	–	–
Q	–	1 [b]	–	–	1 [b]
N	–	–	–	1 [b]	1 [b]
Z	–	1 [b]	1 [b]	–	1 [b]
R	–	1 [b]	–	–	1 [b]
D	–	–	1 [b]	–	1 [b]
E and K	–	1 [b]	1 [b]	–	1 [b]
AA	–	–	–	1 [b]	1 [b]
Y	–	1 [b]	1 [b]	–	1 [b]

[a] Low-level and mixed low-level radioactive wastes were assumed to be low-activity wastes. Chemical waste was assumed to include materials regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
[b] The shipment contains less than a full load.
Note: Because the numbers have been rounded, the sums may not equal the indicated totals.

Table I–59 Soil and Similar Materials for Removal of Remaining Material Disposal Areas (cubic yards)

Material Disposal Area	*Soil Cover and Initial Preparation*	*Clean Soil Exhumed*	*Stockpiled Material Returned*	*Additional Backfill*	*Topsoil and Soil Amendment*	*Total*
F	1,700	6,800	8,500	11,000	660	29,000
Q	900	1,000	1,900	3,600	240	7,700
N	3,300	2,200	5,600	13,000	740	25,000
Z	–	4,100	4,100	7,400	400	16,000
R	–	2,300	2,300	33,000	1,900	40,000
D	1,400	27,000	29,000	24,000	850	82,000
E and K	720	9,900	11,000	2,100	520	24,000
AA	760	2,600	3,300	3,800	310	11,000
Y	1,300	3,100	4,400	5,300	480	14,000

Note: To convert cubic yards to cubic meters, multiply by 0.7646. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–60 One-Way Shipments of Soil and Similar Materials for Removal of Remaining Material Disposal Areas

Material Disposal Area	*Soil Cover and Initial Preparation*	*Clean Soil Exhumed*	*Stockpiled Material Returned*	*Additional Backfill*	*Topsoil and Soil Amendment*	*Total*
F	120	480	600	790	47	2,000
Q	64	70	140	260	17	550
N	240	160	390	950	53	1,800
Z	–	290	290	530	28	1,100
R	–	160	160	2,400	130	2,800
D	100	1,900	2,000	1,700	60	5,800
E&K	51	700	750	150	37	1,700
AA	54	180	240	270	22	760
Y	93	220	310	370	34	1,000

Note: Because numbers have been rounded, the sums may not equal the indicated totals.

MDA H. In November 2007, NMED selected a corrective remedy for MDA H involving complete encapsulation of the nine MDA H waste shafts, installation of an engineered evapotranspiration cover, and installation of a soil vapor extraction system (NMED 2007a). Implementation of this corrective remedy could produce small quantities of waste. Although uncontaminated cuttings from boreholes installed as part of the encapsulation process would be stockpiled for use in the evapotranspiration cover, contaminated drill cuttings (if any) would be properly disposed. Routine monitoring and maintenance activities may produce a very small amount of operational wastes (DOE 2004b).

I.3.3.2.5 Schedules for Material Disposal Area Removal

Schedules for removal of eight large MDAs are provided in **Table I–61**. It was generally assumed that, depending on the MDA, roughly 12 to 18 months would be needed to complete a corrective measure evaluation for an MDA. Planning for removal of an MDA would require from 4 to 8 months. Then removal would take place, with the goal of completing operations by the (adjusted) remedy completion dates in the Consent Order.

Table I–61 Temporal Assumptions for Removing Large Material Disposal Areas

Material Disposal Area	*Assumed Start of Removal Operations*	*Assumed Completion of Removal Operations*	*Assumed Work Time (months)*
A	6/11/2009	3/11/2011	21
B	10/1/2008 [a]	10/1/2010 [a]	24 [a]
T	12/19/2008	12/19/2010	24
U [b]	1/6/2011	11/6/2011	10
AB	1/1/2013	1/31/2015	24
C	11/5/2008	9/5/2010	22
G	2/6/2009	12/6/2015	82
L	5/30/2011	6/30/2011	37

[a] This schedule is based on Revision 1 to the 2006 Investigation/Remediation Work Plan for MDA B (LANL 2006i). NMED approved the plan with modifications January 2007 (NMED 2007b).
[b] The Removal Option is conservatively assumed for this appendix, although NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).

The schedules presented in Table I–61 result in conservative estimates of waste generation and environmental impacts and are consistent with Consent Order requirements. However, if removal of a significant quantity of waste is actually contemplated for several MDAs, then schedules for completion of corrective measures at these MDAs may be difficult to meet.

If any or all of the remaining MDAs were removed, schedules would need to be developed consistent with the Consent Order. Removal of some or all of these MDAs was assumed to occur at any time starting in FY 2007 and extending through FY 2016.

I.3.3.2.6 Use of Enclosures for Material Disposal Area Removal

Enclosures may be used for removal of waste from some MDAs. The enclosures would be modular, possibly constructed of fabric over metal frames. Similar enclosures have long been used at LANL for temporary storage of transuranic waste, have been used at Rocky Flats, and are now used at Idaho National Laboratory for retrieval of waste from Pit 4 at Idaho National Laboratory's Radioactive Waste Management Complex. Contamination at the dig face would be controlled using soil fixing agents or other techniques. The enclosures would be held at a slight negative air pressure, and air from the enclosures would be exhausted through an air treatment system incorporating a minimum of a prefilter and one or more HEPA filters.

Enclosures can be conceptually configured to meet the specific situation at any MDA. Enclosure sizes and accessory equipment would be designed on an MDA-specific basis, considering the area to be covered, depth of contamination, types of hazards unearthed at the excavation, topography, other nearby structures, and costs. For some MDAs, a single large enclosure (to be moved as needed) may be cost-effective. For other MDAs, two or more enclosures may be cost-effective.

Fabric-covered domes have been used at LANL to support waste recovery efforts. As part of the LANL Transuranic Waste Inspectable Storage Project, drums of stacked transuranic waste that had been stored under a layer of crushed tuff at Area G were recovered under a fabric-covered dome constructed to meet Performance Category 2 wind-loading and seismic events. The dome was supplied with a ventilation system exhausting to a prefilter and a HEPA filter bank. A dome was not used, however, for subsequent retrievals of stored transuranic waste (LANL 2002d).

A decision about the use of an enclosure for removal of waste from an MDA would depend on the hazards represented by the waste. Like the other aspects of the contemplated removal, the design and use of the enclosure would be subject to review and approval by DOE and NMED. Optimum numbers, sizes, configurations, and relocation schedules would be determined as part of these reviews.

I.3.3.2.7 Material Disposal Area B Investigation and Remediation Program

LANL staff initially planned an investigation, remediation, and restoration program for MDA B that would excavate trenches perpendicular to the length of the MDA as well as numerous test pits. For this purpose, MDA B was divided into 10 study sections as summarized in **Figure I–24** (LANL 2005p). Current plans call for removal of all waste buried in MDA B as addressed in the October 2006 *Investigation/Remediation Work Plan for MDA B, Revision 1* (LANL 2006i). The volumes of waste estimated in this work plan are summarized in **Table I–62** (LANL 2006i). Total waste volumes from the work plan are bounded by those estimated for this SWEIS in Section I.3.3.2.4.2.

Achieving the principal objectives of the MDA B investigation and remediation program (see Section I.2.5.2.2) will require LANL to directly excavate into the MDA B disposal trenches, remove the historical content of MDA B, and remediate the site to residential cleanup levels for chemicals and screening action levels for radionuclides. Following excavation, LANL will prepare a sampling and analysis plan (if necessary) for NMED approval to define and nature and extent of any residual contamination at MDA B. This would be accomplished by sampling directly beneath former waste disposal trenches after the waste was removed, and possibly also by drilling subsurface boreholes (LANL 2006i).

Excavation will be performed inside an enclosure to provide site access control, help control offsite environmental impacts, reduce exposure to the public, and protect the excavation operations from environmental factors. The enclosure will provide access for equipment and waste containers that need to be moved in or out during the excavation. A fresh air circulation system will continuously replace air in the enclosure and eliminate combustion gases at a determined rate. Waste inspection and segregation will be performed inside a separate area of the excavation enclosure or within an additional enclosure (LANL 2006i).

Excavations will be completed using a hydraulic excavator to carefully expose and remove trench contents for inspection, identification, and removal. Excavator attachments such as a grappler or shears may be used. Only a small quantity of waste will be exposed and removed at any time (see Section I.5.12.1). If the proximity of waste trenches to DP Road on the north side precludes side sloping of the excavation, shoring or other methods may be used as needed to ensure excavation stability. Equipment, procedures, and administrative controls will be used to ensure safety and environmental protection during the investigation and remediation program. Several monitoring or remote sensing tools will be used for continuous monitoring for radiation, volatile organic compounds, gases, heat of trench contents, pyrophoric materials, or other hazardous conditions. If warranted, excavated wastes may be transferred to a new container or over-packed (LANL 2006i). For example, compressed gas cylinders, if found in the excavation, may be placed within overpacks designed to safely contain the contents of the cylinder if it leaks or fails during transport (IES 2005).

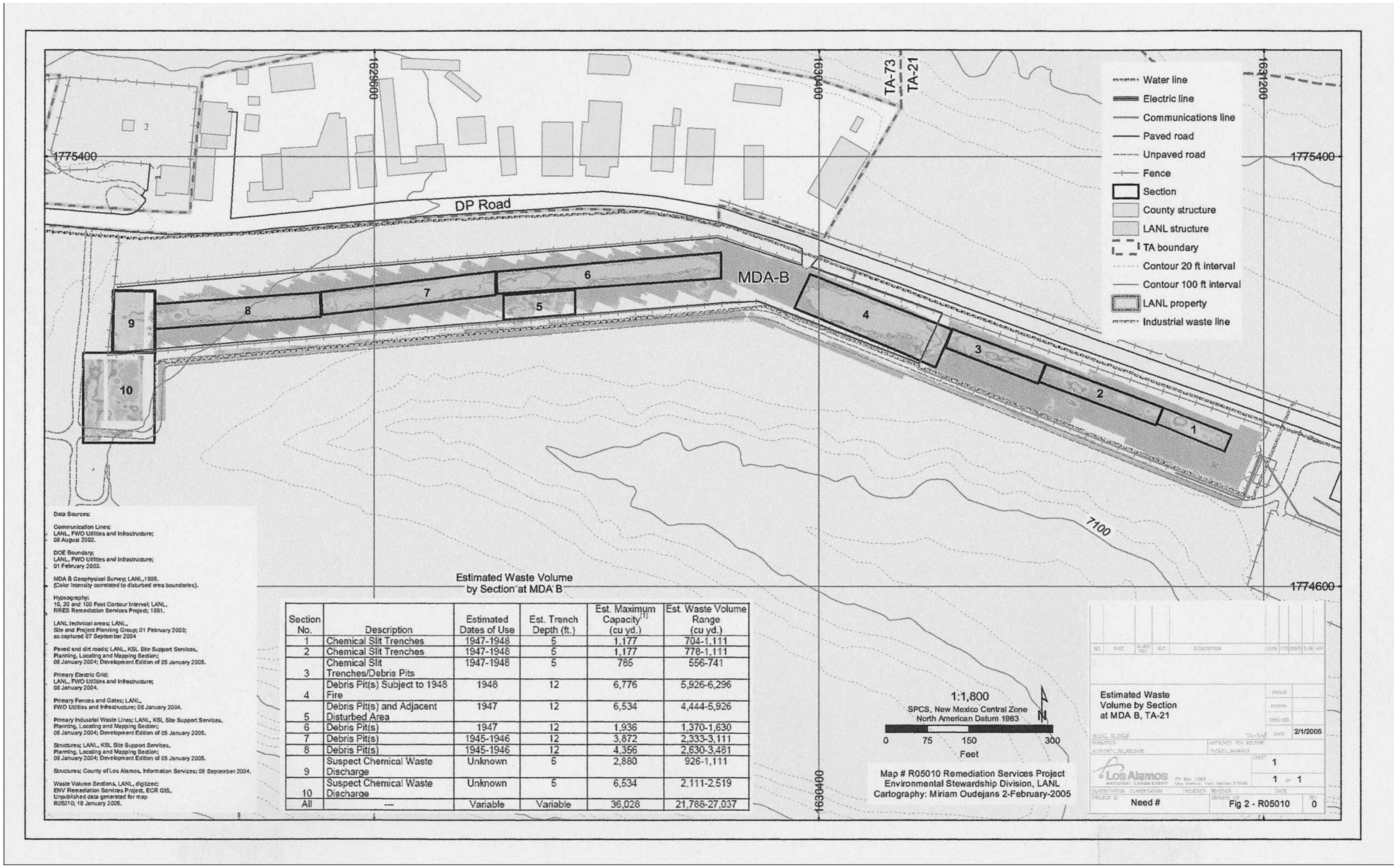

Figure I–24 Material Disposal Area B Investigative Sections

Table I–62 Summary of Investigation-Derived Waste from MDA B Removal

Waste Stream	*Expected Waste Type*	*Estimated Volume (cubic yards)*
Drill cuttings	LLW, MLLW, hazardous, or solid/industrial waste	60
Spent personal protective equipment	LLW, MLLW, hazardous, or solid/industrial waste	20
Disposable sampling supplies	LLW, MLLW, hazardous, or solid/industrial waste	20
Decontamination fluids	LLW, MLLW, hazardous waste, or nonhazardous wastewater	500 gallons
Material from trenches	Solid/industrial	2,590
	RCRA hazardous waste	7,189
	LLW	10,800
	MLLW	4,028
Trench spoils	Return to excavation site if nonhazardous and meets screening criteria; or LLW, MLLW, hazardous, or solid/industrial waste	14,000

LLW = low-level radioactive waste, MLLW = mixed low-level radioactive waste, RCRA = Resource Conservation and Recovery Act.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; from gallons to liters, multiply by 764.54.
Source: LANL 2006i.

Removal operations would include verification sampling; implementation of stabilization and surface water diversion measures; implementation of final restoration measures, including the placement and compaction of backfill; placement of a topsoil and native seed mix; and placement of additional barriers, roads, and paths as needed. Volumes of backfill and other bulk materials (and associated shipments) needed for removal operations are bounded by the analysis in Section I.3.3.2.4.2.

The investigation and remediation program would be integrated with other DD&D and PRS remediation activities at TA-21. Preliminary work would include similar operational elements as those described in Section I.3.3.2.4.1, including (LANL 2006f):

- Clearing and grubbing of vegetative material, debris, and obstructions;
- Installation of new fencing and removal of old fencing;
- Preparation of equipment and material staging areas;
- Modification of existing haul and access roads;
- Construction of a decontamination area;
- Installation of administrative facilities;
- Installation of run-on diversion structures to minimize stormwater impacts to the site and prevent migration of site contaminants;
- Completion of pre-fieldwork surveys, including land surveys, radiological surveys, and biological surveys;
- Collection of supplemental background samples for comparison of underlying tuff contaminant concentrations;

- Installation of area and perimeter monitoring systems, alarms, and communication equipment; and
- Execution of mockup drills and emergency response drills with MDA B site personnel.

A haul road has been created on the southern side of MDA B to divert operations traffic from the DP Road business area. Power will be needed to provide utility power for the enclosure, emergency backup generators, and health-and-safety trailers along that area (LANL 2006i).

It is expected that several temporary support capabilities will be needed for the investigation and remediation program. Support capabilities may include those for definitive identification of waste contents, sorting, temporary storage of waste and excavation spoil, project management, vehicle decontamination, waste processing or analysis, or other needs. It is expected that none of these temporary capabilities would intrude on habitat or buffer areas of protected wildlife. The capabilities may be located partly within the excavation closure and partly or wholly at separate temporary facilities such as those conceptually described below (LANL 2006a). Other permutations of these capabilities may be implemented as needed.

The *Definitive Identification Facility (DIF)* and storage area would encompass an area of a few acres. This storage area would be enclosed within chain-link fencing with a central temporary “Sprung” type dome enclosure as the major feature. The dome would enclose several other temporary buildings, such as a Permacon®-type building[68] that will house the DIF itself. Pre-DIF staging areas within the DIF storage area would store preliminarily hazard-categorized materials awaiting sampling or repackaging by DIF personnel. Post-DIF staging areas would temporarily store materials until verified analytical results determine waste disposition. In all staging areas, hazardous materials would be segregated according to known incompatibilities (for example, oxidizers, flammables, explosives). The DIF would be used to inspect and evaluate containers to determine their contents. Activities could range from removing a “bung” from a drum to sample its contents to “hot-tapping” compressed gas cylinders, which requires drilling into the sides of the containers. Depending upon regulatory controls, gases within some cylinders may be released to the environment (for example, hydrogen), whereas other gases may need treatment or transfer to another container. Exhaust air from the DIF, along with its enclosing dome would be HEPA-filtered and passed through an activated carbon absorption system. Fire protection systems would be used as required to reduce or mitigate accidental releases of hazardous materials to the environment.

The *Waste Processing Facility*, if constructed, would support all MDA and DD&D activities on DP Mesa. This facility would be a chain-link enclosed “yard” or laydown area for the accumulation of waste materials prior to shipment offsite. Some temporary buildings would house administrative activities. Various other structures may be necessary to store RCRA and radioactive materials before shipment. The Waste Processing Facility would be located at the end of DP East and comprise an area of less than 10 acres (4 hectares) of previously disturbed land. The facility would be used to package or repackage waste materials. The Waste Processing Facility would require areas for truck parking, turnaround, and loading by use of cranes, boomtrucks, forklifts, or other suitable heavy equipment. Incompatible materials would be segregated as required and stipulated by regulation. This facility would comply with all

[68] *A Permacon® unit is a type of modular containment system (NFS RPS 2005).*

RCRA regulations as it will function as a treatment, storage, or disposal facility. The Waste Processing Facility would likely include a truck decontamination pad along with a hazardous materials screening area for screening prior to offsite transport. Radioactive materials would be removed as required and shipped to on- or offsite locations for disposal. Roads would be improved or constructed to allow for the additional truck traffic. If the Waste Processing Facility is not constructed, waste processing and packaging would take place within the MDA B area of concern. After waste processing and manifesting, filled waste containers may be staged at other locations within the TA-21 boundary prior to transport and disposal (LANL 2006a).

DP Mesa Field Office and Laboratory Facilities. The facilities would comprise several transportable buildings housing analytical capabilities and offices to support MDA investigation and remediation and TA-21 DD&D activities. It is likely that at least three and maybe four transportable buildings would be required to provide the analytical chemistry capability for organic, inorganic, and radioactive material analysis. A fifth building may be required for administrative activities. The buildings and associated parking areas would fit on less than 2 acres (0.8 hectare) of previously disturbed lands. This facility would provide analytical data of sufficient quality to meet waste disposition manifesting and disposal requirements. It would include a treatment, storage, or disposal facility for RCRA waste accumulation.

Office trailers would be needed to support subcontractor and LANL administration. The area selected would require access using roads that would allow staff to reach work areas without crossing potentially controlled work areas. Extension of utilities from the existing utility grid would be required. To the extent practicable, a centralized area would be developed to minimize support utility requirements. The area of disturbance for administrative support would be limited to less than 2 acres (0.8 hectare).

Spoil Staging Areas. It is expected that clean and suspected-clean soils and construction debris staging areas would be placed as necessary at several locations around the DP Mesa. This would generally take place in locations near the point of their generation or intended use. These spoil piles would be protected from erosion or airborne dispersion by keeping them wet or covered as necessary. Appropriate runon controls would be implemented. These could total many acres in size and would be located in previously disturbed areas when possible, but may require additional land at the east end of DP Mesa.

The total affected area from TA-21 DD&D and MDA remediation is expected to involve about 80 acres (32 hectares) of previously disturbed area and up to 30 acres (12 hectares) of undisturbed mesa top. Another 20 acres (8.1 hectares) of previously undisturbed canyon wall or bottom may also be partially disturbed (LANL 2006a).

I.3.3.2.8 Characterization and Treatment Capacity for Waste from Material Disposal Area Removal

If large-scale removal of waste from the MDAs is required, LANL capacity to characterize and repackage waste may be insufficient. One option to address this problem would be to construct a dedicated facility for waste separation, characterization, treatment, packaging, and staging for shipment. The size, cost, and environmental impacts associated with such a facility would depend on the quantities and characteristics (e.g., radioactive material content) of the exhumed waste, which would depend on remediation decisions to be made in the future. A second option would be to site a number of smaller facilities at strategic LANL locations providing specific services similar to those contemplated for the MDA B investigation and remediation program (see Section I.3.3.2.7). This option could be combined as needed with an upgrade and expansion of existing waste management capacity in TA-54 or other technical areas.

A facility for processing exhumed transuranic waste was considered as part of an early LANL study addressing options for future disposition of buried waste in LANL MDAs A, B, C, G, T, and V (LANL 1981). The facility envisioned in this study would cover 40,550 square feet (3,765 square meters), with an additional 17,570 square feet (1,630 square meters) dedicated to support areas. The envisioned facility would be capable of accommodating remote-handled waste. Its design throughput would be 1 million cubic feet (28,320 cubic meters) of waste over 15 years (1,900 cubic meters per year) (LANL 1981). A facility for treatment of contact handled waste exhumed from Idaho National Laboratory disposal facilities has also been envisioned (INEEL 2002a). Waste would be transferred to the facility from a lag storage area covering 70,000 square feet (6,500 square meters) and capable of storing 6,400 cubic yards (4,900 cubic meters) of waste. Waste introduced into the treatment facility would be handled remotely using manipulators, conveyors, and gloveboxes. The two-story facility was projected to address 18,800 cubic yards (14,400 cubic meters) of waste per year and would have a surface area of 130,000 square feet (12,100 square meters) (INEEL 2002a).

Assuming extensive exhumation, annual waste generation rates from exhuming the LANL MDAs could be on the order of a hundred thousand cubic meters of low-activity low level radioactive waste, several thousand cubic meters of alpha-contaminated low-level radioactive waste, a few hundred cubic meters of high-activity low-level radioactive waste, and up to a few thousand cubic meters of transuranic waste. A facility receiving such a volume of waste could cover a few hundred thousand square feet. Assuming that funding was approved, several years may be required to design the facility and additional years to construct and test.

The second option would be to develop several facilities for waste handling at appropriate LANL locations as needed consistent with future decisions about MDA remediation. The facilities would be temporary, using modular equipment as available and appropriate, and could be moved to new locations consistent with remediation schedules. Similar to those described in Section I.3.3.2.7, facilities could include capacity for safety inspections of removed containers, waste processing and storage, radioactive and chemical analyses, and other support services. Facilities would be transportable or consist of modular glovebox or similar systems covered by domed enclosures. Shielded, remotely operated systems may be needed for processing some wastes. The designs of the facilities and their capabilities would depend on the characteristics of the wastes to be addressed, which would be different for different MDAs, and on the acceptance criteria for the treatment or disposal facilities receiving the wastes.

This option could be combined with the expanded use of existing LANL waste management capacity. Existing LANL capabilities for management of waste in TA-54 are described in Section H.3 of Appendix H, along with the environmental impacts of alternatives for relocation, replacement, or augmentation of this capacity. As needed, additional, augmented, or mobile waste management equipment or facilities could be developed at LANL similar to those described in Section H.3.2.2. Use of existing LANL capabilities for remotely handling radioactive material could be also considered.

Although several such facilities may be required, depending on future remediation decisions, the impacts of siting and operating the facilities would be temporary.

I.3.4 Remediation of PRSs other than Material Disposal Areas

In addition to the MDAs addressed in Section I.3.3, numerous PRSs such as firing sites, outfalls, or areas of contaminated soil or sediment must be addressed. The volumes of wastes that may be generation from remediating these PRSs are uncertain, as is the timing for waste generation. Section I.3.4.1 reviews possible treatment technologies. Section I.3.4.2 characterizes waste generated from remediation of representative PRSs. For the Capping and Removal Options, estimates from Section I.3.4.2 were added to projections of wastes from the No Action Option to address the PRSs that may be remediated through FY 2016 (see Section I.3.4.3).

I.3.4.1 Possible Treatment Technologies

Numerous treatment technologies could be used, depending on the contaminant and the contaminated media. As observed in the Federal Remediation Technologies Roundtable's Screening Matrix and Reference Guide, the three primary strategies that may be used separately or in conjunction to remediate most sites are destruction or alteration of contaminants, extraction or separation of contaminants from environmental media, and immobilization of contaminants. Treatment technologies capable of contaminant destruction by altering their chemical structure include thermal, biological, and chemical treatment methods applied either in or ex situ to contaminated media. Treatment technologies commonly used for extraction and separation of contaminants from environmental media include soil treatment by thermal desorption, soil washing, solvent extraction, and groundwater treatment using phase separation, carbon absorption, air stripping, ion exchange, or some combination of technologies. Immobilization technologies include stabilization, solidification, and containment technologies such as disposal in a landfill or construction of slurry walls. Because generally no single technology can remediate an entire site, several treatment technologies may be combined at a single site to form a treatment train. As noted, many treatment technologies require removal of the contaminated media, which, after treatment, may be returned or disposed of as waste. Descriptions of treatment technologies are provided in **Table I–63** (FRTR 2005). Other sources of information about treatment technologies include the Interstate Technology and Regulatory Council and, for groundwater contamination, the Ground-Water Remediation Technologies Analysis Center (GWRTAC 2005).

Treatment technologies used either individually or in combination at any PRS would be applied as needed and as approved by NMED. More complex and involved remedies might include requirements for staging areas and moderate augmentation of infrastructure (such as plumbing for extracted water or other wastes) to support the operational aspects of the remedy. If large volumes of wastewater are generated, there could be an increase in truck traffic to transport the wastewater to (generally onsite) treatment facilities.

Table I–63 Treatment Group Examples

Treatment Groups	*Comments*
Soil, Sediment, and Sludge	
In situ biological treatment	Technologies include bioventing, enhanced biodegradation, and phytoremediation. Bioremediation technologies have been used to remediate soils, sludges, and groundwater contaminated by petroleum hydrocarbons, solvents, pesticides, wood preservatives, and other organic chemicals.
In situ physical/chemical treatment	Uses the physical properties of the contaminants or contaminated medium to chemically convert, separate, or contain the contamination. Treatment technologies include electrokinetic separation, fracturing, soil flushing, soil vapor extraction, and solidification/stabilization.
In situ thermal treatment	Thermally enhanced soil vapor extraction uses temperature to increase the volatility of soil contaminants. In situ vitrification uses heat to melt soil, destroying some organic compounds and encapsulating inorganics.
Ex situ biological treatment (assuming excavation)	Technologies include biopiles, composting, landfarming, and slurry-phase biological treatment.
Ex situ physical/chemical treatment (assuming excavation)	Technologies include chemical extraction, chemical reduction/oxidation, dehalogenation, separation, soil washing, and solidification/stabilization.
Ex situ thermal treatment (assuming excavation)	Technologies include hot-gas decontamination, incineration, open burn/open detonation, pyrolysis, and thermal desorption.
Containment	Containment includes capping of landfills or contaminated areas.
Other treatment processes	Other technologies include excavation, retrieval, and on- and offsite disposal.
Groundwater, Surface Water, and Leachate	
In situ biological treatment	Technologies include enhanced biodegradation (nitrate and oxygen enhancement with either air sparging or hydrogen peroxide), natural attenuation, and phytoremediation of organics.
In situ physical/chemical treatment	Technologies include air sparging, bioslurping, directional wells, dual-phase extraction, thermal treatment, hydrofracturing, in-well air stripping, and passive/reactive treatment walls.
Ex situ biological treatment (assuming pumping)	Contaminated groundwater, surface water, and leachate may be pumped from its location and treated. Treated water may be returned or disposed of as waste. Treatment technologies include bioreactors and constructed wetlands.
Ex situ physical/ chemical treatment (assuming pumping)	Contaminated groundwater, surface water, and leachate may be pumped from its location and treated. Treated water may be returned or disposed of as waste. Biological treatment technologies include adsorption/absorption, advanced oxidation processes, air stripping, granulated activated carbon/liquid-phase carbon adsorption, groundwater pumping, ion exchange, precipitation/coagulation/flocculation, separation, and sprinkler irrigation.
Containment	Containment technologies include physical/biological barriers and deep-well injection.
Air Emissions/Offgas Treatment	
Air emissions/offgas treatment	Several technologies have been applied for removal of volatile organic compounds from offgas streams, including biofiltration, high-energy destruction, membrane separation, nonthermal plasma, oxidation, scrubbers, and vapor-phase carbon adsorption.

Source: FRTR 2005.

I.3.4.2 Remediation of Representative PRSs

Firing Site E-F. This firing site in TA-15 is described in Section I.2.3.1 and contains scattered surface contamination plus small piles of debris. Surveys showed that most uranium was concentrated within the top 10 to 12 inches (25 to 30 centimeters) of soil and that uranium concentrations dropped by a factor of 23 within 1,000 feet (300 meters) of the firing point. Two piles of debris were each 8 feet (2.4 meters) in diameter and 2 feet (0.6 meters) high.[69]

Waste volumes for this appendix were estimated by assuming that material would be removed from an area having a radius of 1,000 feet (300 meters) to an average depth of 1 inch (2.5 centimeters) and adding the waste from the two debris piles. This results in 9,700 cubic yards (7,420 cubic meters) of waste. Similar to the waste distribution for removal of MDA Z (see Section I.3.3.2.4.3), this waste was assumed to be 40 percent solid waste, 15 percent chemical waste, 40 percent low-activity low-level radioactive waste, and 5 percent mixed low-activity low-level radioactive waste.

Firing Site R-44. This firing site in TA-15 is described in Section I.2.3.2, and contains scattered surface contamination plus some small debris piles. After the Cerro Grande fire, much exposed debris was recovered and disposed.

Waste volumes for this appendix were estimated by assuming that material would be removed from an area having a radius of about 500 feet (152 meters) to an average depth of 1 inch (2.5 centimeters), or 2,420 cubic yards (1,850 cubic meters) of waste. Similar to the waste distribution for removal of MDA Z (see Section I.3.3.2.4.3), this waste was assumed to be 40 percent solid waste, 15 percent chemical waste, 40 percent low-activity low-level radioactive waste, and 5 percent mixed low-specific-activity low-level radioactive waste.

260 Outfall. SWMU 16-21(c)-99 is described in Section I.2.7.5. It is an inactive outfall from Building 260 in TA-16 where machine turnings and high explosive washwater were discharged. An interim measure has been performed to remove contaminated soil. Three areas of contamination remain: (1) the outfall source area (excluding the settling pond and surge beds); (2) the outfall settling pond and surge beds; and (3) canyon springs and alluvium. After completing Phase I, Phase II, and Phase III RFIs, and the interim measure, a corrective measures study has been issued establishing corrective measure alternatives (LANL 2003l). The corrective measure alternatives are listed in **Table I–64** (LANL 2003l).

The final remedy for the 260 Outfall was selected by NMED on October 13, 2006. The selected remedy is a combination of alternatives from the corrective measures study:

- Soil removal and offsite treatment and disposal;
- Pressure grouting the surge beds and extending the existing cap; and
- Installing permeable reactive barriers and stormwater filters to treat sediment, surface water, and alluvial groundwater.

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[69] *Firing Site E-F was used more extensively than Firing Site R-44. Some of the debris currently deposited on Firing Site R-44 originated from firing operations at Firing Site E-F.*

Table I–64 Alternative Corrective Measures for the 260 Outfall

Site Area	Alternative Number [a]	Description	Estimated Waste Generation
Outfall source area (excluding settling pond)	I.1	Soil removal and offsite treatment and disposal	131 cubic yards of solid waste
Outfall source area, settling pond, and 17-foot surge bed	II.1	Excavation and offsite disposal of the 17-foot surge bed and replacement/maintenance of the existing cap	52 cubic yards of solid waste
	II.2	In situ grouting of the 17-foot surge bed and maintenance of the existing cap	
	II.3	Maintenance of existing cap and no action for the surge beds	
Canyon springs and alluvial system	III.1	Sediment excavation and offsite disposal, with stormwater filters for springs	13,080 cubic yards of solid waste and 13,080 cubic yards of hazardous waste
	III.2	Natural flushing of sediments coupled with permeable reactive barrier (zero valent iron or granulated activated carbon and calcium sulfate) alluvial groundwater treatment and stormwater filter treatment for springs	
	III.3	Natural/induced flushing of sediments and recovery of spring and groundwater (by interceptor trenches) and treatment in a central treatment system	

[a] NMED selected a final remedy for the 260 Outfall in October 13, 2006. The selected remedy is a combination of the alternatives proposed by LANL staff.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; from feet to meters, multiply by 0.3098.
Source: LANL 2003l.

TA-21 Outfall. This SWMU (21-011(k)) was an inactive NPDES-permitted outfall for liquid waste from former wastewater treatment plants at DP West (see Section I.2.7.6). A voluntary corrective measure was planned to excavate and dispose of contaminated wastes as low-level radioactive waste, excavate and solidify tuff and sediment from hot spots, and place the solidified material in a stabilization cell to be dug near the center of the SWMU (LANL 2002f). The voluntary corrective measure was projected to generate 25 cubic yards (19 cubic meters) of solid waste and 65 cubic yards (50 cubic meters) of low activity low-level radioactive waste. Solidification and onsite stabilization of tuff and sediment were projected to involve 78 cubic yards (60 cubic meters) of material (LANL 2002f). The voluntary corrective measure was subsequently revised and material projected to be solidified onsite was removed. Removal occurred in 2003 (LANL 2003i).

SWMU 73-002 Incinerator Ash Pile. Remediation of the ash pile is complete, including removal of ash and debris waste (see Section I.2.7.11). It was estimated that the pile contained roughly 4,500 cubic yards (3,340 cubic meters) of waste (LANL 2005e). The Investigation Report for Consolidated Unit 73-002-99 and Corrective Action of Solid Waste Management Unit 73-002, at Technical Area 73 was submitted to and approved by NMED (LANL 2006a).

Canyons. Investigations and remediation within LANL canyons are expected to generate about 10 cubic yards (7.6 cubic meters) of solid low-level radioactive waste, 24 cubic yards (18 cubic meters) of mixed low-level radioactive waste, and 9,900 gallons (37,500 liters) of liquid radioactive waste (LANL 2006a).

Security Perimeter Road. Development of a security perimeter road in TA-3 was one of the FY 2005 facility integration projects at LANL that affected existing PRSs; in this case, an electrical equipment storage area (SWMU 61-002), two storage areas in TA-3 (AOC 3-001(i)), and a asphalt landfill (SWMU 03-029) (LANL 2005l). Generation of waste from this project was estimated as about 3,000 cubic yards (2,300 cubic meters) of solid waste and 500 cubic yards (380 cubic meters) of low-level radioactive waste (LANL 2006a). An accelerated corrective action completion report was submitted to NMED on December 15, 2005. Investigation and remediation work included the decontamination and decommissioning of the TA-3 Radio Shop, allowing access to residual petroleum hydrocarbon contamination found while remediating SWMU 61-002 (LANL 2006h). The Security Perimeter Road accelerated corrective action has been completed.

I.3.4.3 Waste Generation Estimates

Compliance with the Consent Order will cause remediation of a large number of PRSs from FY 2007 through FY 2016. There may be several options for remediation, including removing, treating, or stabilizing contamination at a site or controlling exposure to the contamination so risks posed are acceptable. It was assumed that remediation would occur annually, involve activities similar to those described in Section I.3.4.1, and generate similar types of waste as those summarized in Section I.3.4.2. As shown in **Table I–65**, an annual average waste generation rate of 5,200 cubic yards (4,000 cubic meters) was projected. This waste was distributed among different waste types based on consideration of the waste estimates discussed in Section I.3.4.2.

Table I–65 Additional Waste Generation from Remediating Potential Release Sites

Parameter	*Solid Waste*	*Chemical Waste* [a]	*Low-Activity Low-Level Radioactive Waste*	*Mixed Low-Activity Low-Level Radioactive Waste*	*Total Annual Waste*
Annual Volume [b] (cubic yards)	2,900	1,700	630	52	5,200
Shipments	220	140	44	4	410

[a] The chemical waste category includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
[b] In situ volumes. As-shipped volumes would be larger because of swell of excavated material and packaging inefficiencies.
Note: To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal the indicated totals.

I.3.5 Waste Transportation and Disposal Assumptions

After removal of waste from the ground, and following classification and sorting, waste must be placed within containers, treated if necessary, and disposed of. Because so much of the waste that would be generated from MDA exhumation and PRS remediation will be soil and debris, it was assumed that material would swell by about 20 percent following removal. That is, removed waste placed into containers was assumed to be 20 percent larger than the in situ volume.

Solid waste was assumed to be sent to a landfill within New Mexico, with a round-trip distance of 260 miles (418 kilometers). Chemical waste would be sent for treatment before disposal. Several treatment sites could be used depending on the hazardous constituents to be treated. A typical site having a roundtrip distance of 332 miles (534 kilometers) was assumed. It was assumed that all contact-handled and remote-handled transuranic wastes would be sent to WIPP.

Low-level radioactive waste could be disposed of onsite or sent to another site. (Onsite disposal capacity for mixed low-level radioactive waste is not currently available.) It was assumed that low-level and mixed low-level radioactive wastes could be sent to any of a number of commercial or DOE sites for treatment or disposal. Two typical sites—one commercial and one DOE—were assumed, having round-trip distances of 1,378 miles (2,153 kilometers) and 1,550 miles (2,500 kilometers), respectively. It was assumed that low-level and mixed low-level radioactive wastes would be optionally all disposed of onsite (assuming an average one-way travel distance of 5.6 miles [9 kilometers]; all shipped to a different DOE site; or shipped partly to a DOE site and partly to a commercial site, consistent with waste acceptance criteria for the commercial site. (It was assumed that all low-level and mixed low-level radioactive wastes could be shipped to the DOE site, but only low-activity and mixed low-activity low-level radioactive waste could be shipped to the commercial site.)

Container and shipping assumptions are listed in **Table I–66** and summarized below.

An 80 percent packing efficiency (percent of container filled with waste) was assumed for solid waste because of short travel distances, relatively low transport and disposal costs, and to keep within assumed weight limit. A 90 percent packing efficiency was assumed for other nonliquid wastes because of much larger travel distances and transport, treatment, and disposal costs. An 80 percent packing efficiency was assumed for liquid wastes because it is expected that only small volumes would be generated from most remediated sites.

A maximum shipment weight of 20 tons (18 metric tons) for chemical, solid, and low-level radioactive waste, was estimated, assuming a waste density of up to 1.08 tons per cubic yard (1.28 metric tons per cubic meter), typical for dirt and rock, assuming 20 percent swell. Low-activity low-level radioactive waste was assumed to be shipped as low-specific-activity material, pursuant to U.S. Department of Transportation requirements, and placed within soft liners to be transported within Intermodals at two soft liners per Intermodal. Mixed low-activity and alpha-contaminated low-level radioactive waste were assumed to be transported in B-25 boxes. This waste may require treatment before disposal. Drums were assumed for all remote-handled transuranic waste.

For contact-handled transuranic waste, fourteen 55-gallon (0.21-cubic-meter) drums were assumed per TRUPACT-II (transuranic waste package transporter II) outer packaging (WIPP 2005) and three TRUPACT-II packages per shipment. Three TRUPACT-II outer packaging were assumed per contact-handled transuranic waste shipment. A shipped waste density of 1.08 tons per cubic yard results in contact-handled transuranic waste shipments comparable to maximum allowable shipment weights for TRUPACT-II packages (DOE 2004c). Remote-handled transuranic waste was assumed to be shipped in RH-72B casks at three drums per cask (Jensen, Devarakonda, and Biedscheid 2001).

Table I–66 Container and Shipment Assumptions

Waste	*Container*	*Container Volume (cubic feet and cubic meters)*	*Packing Efficiency (percent)*	*Number of Containers per Truck*	*Volume per Shipment* [a] *(cubic yards)*
Nonliquid Waste					
Solid	20-cubic-yard rolloff	540/15.3	80	1	16
Chemical	55-gallon drum	7.35/0.21	90	60	14
Low-level radioactive waste – low activity	Soft liners/ Intermodal	260/7.3	90	2	17
Low-level radioactive waste – alpha	B-25 box	90/2.55	90	5	15
Low-level radioactive waste – remote handled [b]	55-gallon drum	7.35/0.21	90	10	2.5
Mixed low-level radioactive waste – low activity	B-25 box	90/2.55	90	5	15
Mixed low-level radioactive waste – alpha	B-25 box	90/2.55	90	5	15
Mixed low-level radioactive waste – remote handled [b]	55-gallon drum	7.35/0.21	90	10	2.5
Contact-handled transuranic waste [c]	55-gallon drum	7.35/0.21	90	42	10
Remote-handled transuranic waste [d]	55-gallon drum	7.35/0.21	90	3	0.8
Mixed contact-handled transuranic waste [c]	55-gallon drum	7.35/0.21	90	42	10
Mixed remote-handled transuranic waste [d]	55-gallon drum	7.35/0.21	90	3	0.8
Liquid Waste					
Industrial [e]	500-gallon tanks	67/1.9	80	2	3.9
Hazardous [e]	500-gallon tanks	67/1.9	80	2	3.9
Low-level liquid radioactive waste [e]	500-gallon tanks	67/1.9	80	2	3.9
Mixed low-level liquid radioactive waste [e]	500-gallon tanks	67/1.9	80	2	3.9

[a] This assumed volume is applied after an in situ volume increase of 20 percent due to swell of removed material.
[b] The quantity of waste that can be delivered in any single shipment will depend on container surface radiation levels and the design and availability of transportation packaging. Duratek cask capacity ranges from 1 to 21 drums (Duratek 2005). A shielded shipping box can contain up to 27 drums. Assumed 10 drums per shipment.
[c] Assumed use of TRUPACT II [transuranic waste package transporter II] packaging.
[d] Assumed use of RH-72B transportation cask.
[e] Assumed liquids are treated at LANL.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; cubic meters to cubic yards, multiply by 1.308; gallons to liters, multiply by 3.7854.

For remote-handled low-level and mixed low-level radioactive waste, a relatively large number of drums per cask (10) were assumed. It was assumed that most remote-handled wastes would not have surface exposure rates significantly above 200 millirem per hour. Duratek casks range in capacity from 1 to 21 drums, although about 40 percent of available casks can hold up to 14 (Duratek 2005). (The calculated weight [3.2 tons] is within the payload limits of typical casks.) The average number of drums per shipment, however, would be smaller than 14 because of operational, cost, and scheduling considerations. (Only a small amount of remote-handled low-level radioactive waste would be exhumed at any time, and it would be too expensive to rent a cask for long periods of time waiting for it to be completely filled before shipment.)

All liquids were assumed to be treated at LANL. Wastes requiring shipment offsite after this treatment should be comparatively small in volume.

It was assumed that once exhumed, solid, chemical, and low-activity and alpha-contaminated low-level and mixed low-level radioactive wastes would be loaded directly into final shipping containers and then loaded onto trucks for transport to a treatment or disposal facility. It was assumed that transuranic and remote-handled low-level radioactive wastes would require additional processing or repackaging before shipment. For example, transuranic wastes must be placed in package configurations compatible with the WIPP waste acceptance criteria. For processing operations, labor hours per unit volume of waste were assumed based on an analysis for the LANL Decontamination and Volume Reduction System (DOE 1999b). Worker radiation doses for waste processing were assumed based on LANL worker radiation experience for 2004 and 2005. Person-hours for loading containers into trucks were assumed based on a review of other analyses (INEEL 2002d, Wolf 2002), and radiation doses were assessed using the RADTRAN, Version 5, computer code (Weiner et al. 2006) based on assumed container surface radiation rates that were compatible with assumptions for waste transportation (see below). It was assumed that, depending on the type of waste, loading would be accomplished using crews of from 3 to 5 persons having average distances ranging from 3.3 to 16 feet (1 to 5 meters) from the waste package. Analytical support activities were also addressed.

Unit (per shipment) dose and risk estimates were then developed for shipments of waste to treatment and disposal facilities. The estimates were performed using the RADTRAN, Version 5, computer code (Weiner et al. 2006) in accordance with the assumptions in Table I–66. Incident-free radiation exposures to shipment crews (two crewmembers per shipment) were estimated assuming that exposure rates at shipment packaging surfaces were at regulatory limits. Population doses were calculated using comparable assumptions. Crew and population risks were calculated assuming a latent cancer fatality (LCF) rate of 0.0006 per person-rem of exposure.

Possible transportation accidents involving radioactive material were assessed assuming a source for different waste types developed from radioactive inventories within MDA G, the LANL MDA for which information is most complete. LCFs for a possible transportation accident were determined by first calculating the dose from an accident to an MEI, and then multiplying this dose by the probability of an accident and by an LCF rate of 0.0006 per person-rem of exposure. Nonradiological accidents (mechanical injury) were estimated using information about accident frequencies (see Appendix K, Section K.6.2, Accident Rates). For shipments of solid waste, a fatality accident rate for New Mexico was used (1.18 fatalities per 100 million kilometers traveled). For shipments of chemical waste, a fatality accident rate for an urban population zone was used (2.32 fatalities per 100 million kilometers traveled).

Transportation dose and risk assessment results are presented on a per shipment basis in **Table I–67**.

I.3.6 Waste, Materials, Shipment, and Personnel Projections Under Options

I.3.6.1 Waste Generation

No Action Option. **Table I–68** summarizes annual waste projections under the No Action Option starting in FY 2007 and continuing through FY 2016. These projections reflect LANL staff estimates of wastes from environmental investigation and remediation that were made before the March 1, 2005 issuance of the Consent Order. The volumes in this table essentially represent in situ volumes of contaminated material. Because much material may consist of contaminated soil or debris, as-shipped volumes were assumed to be 20 percent larger to account for material swell following removal from the ground.

Table I–67 Transportation Dose and Risk Assessment Results [a]

Typical Destination	Waste	Round-Trip Distance (kilometers)	Crew Dose and Risk: Person-Rem	Crew Dose and Risk: LCF	Population Dose and Risk: Person-Rem	Population Dose and Risk: LCF	Accidents: Radiological (LCF Fatality)	Accidents: Nonradiological (fatalities)
DOE Site	Low-specific activity [b]	2,500	0.0014	8.2×10^{-7}	0.00027	1.6×10^{-7}	1.3×10^{-8}	0.000025
DOE Site	LLW and MLLW [c]	2,500	0.012	7.5×10^{-6}	0.0039	2.4×10^{-6}	1.7×10^{-8}	0.000025
DOE Site	RH-LLW and MLLW [d]	2,500	0.011	6.5×10^{-6}	0.0020	1.2×10^{-6}	3.3×10^{-13}	0.000025
Commercial Site	Low-specific activity [b]	2,153	0.0012	7.1×10^{-7}	0.00023	1.4×10^{-7}	9.6×10^{-9}	0.000021
Commercial Site	LLW and MLLW [c]	2,153	0.011	6.4×10^{-6}	0.0033	2.0×10^{-6}	1.4×10^{-8}	0.000021
WIPP	CH-TRU [e]	1,210	0.023	0.000014	0.0073	4.4×10^{-6}	3.3×10^{-11}	0.000014
WIPP	RH-TRU [e]	1,210	0.035	0.000021	0.0092	5.5×10^{-6}	7.7×10^{-13}	0.000014

LCF = latent cancer fatality, LLW = low-level radioactive waste, MLLW = mixed low-level radioactive waste, RH = remote-handled, WIPP = Waste Isolation Pilot Plant, CH = contact-handled, TRU = transuranic waste.

[a] Results are for one-way distances except for nonradiological accidents, which are for round trips.

[b] Waste shipped in Intermodals.

[c] Waste shipped in B-25 boxes.

[d] Waste shipped in drums.

Note: To convert kilometers to miles, multiply by 0.6213. Numbers have been rounded.

Table I–68 Annual Waste Generation Rates for No Action Option (cubic yards)

Waste	Fiscal Year 2007	Fiscal Year 2008	Fiscal Year 2009	Fiscal Year 2010	Fiscal Year 2011	Fiscal Year 2012
Chemical Waste [a]	2,000	1,400	190	–	50	36
Low-Level Radioactive Waste [b]	990	3,600	4,200	31	–	–
Mixed Low-Level Radioactive Waste [b]	130	200	20	–	300	89
Transuranic Waste [c]	100	100	–	–	–	–
Total	3,200	5,300	4,400	31	350	130
Waste	**Fiscal Year 2013**	**Fiscal Year 2014**	**Fiscal Year 2015**	**Fiscal Year 2016**	**Total**	**–**
Chemical Waste [a]	36	36	36	36	3,800	–
Low-Level Radioactive Waste [b]	–	–	–	–	8,800	–
Mixed Low-Level Radioactive Waste [b]	89	89	89	89	1,100	–
Transuranic Waste [c]	–	–	–	–	210	–
Total	130	130	130	130	14,000	–

[a] Assumed an average waste density of 1 gram per cubic centimeter. Assumed to include waste regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.

[b] Assumed to be low-activity and mixed low-activity low-level radioactive waste.

[c] Includes mixed transuranic waste.

Note: To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal the indicated totals.

Capping Option. Environmental remediation continues as assumed for the No Action Option. In addition, all MDAs are stabilized in place through installation of final evapotranspiration covers. The General's Tanks within MDA A are stabilized using a grout mixture, and other PRSs are remediated. The wastes associated with these assumptions are listed in **Table I–69**. These wastes represent:

- Wastes generated as part of the No Action Option (Table I–68).
- Wastes associated with capping large MDAs according to the schedule in Table I–52.
- Wastes associated with capping the remaining MDAs, assuming that wastes from capping these MDAs are generated in equal annual volumes from FY 2007 through FY 2016.
- Additional wastes associated with remediating PRSs. (Wastes listed in Table I–65 are annually generated.)

Removal Option. Environmental remediation continues as assumed for the No Action Option. In addition, all MDAs are exhumed and other PRSs are remediated. The wastes associated with these assumptions are listed in **Table I–70**. These wastes represent:

- Wastes generated as part of the No Action Option (Table I–68).
- Wastes associated with removing large MDAs according to the schedule presented in Table I–61.
- Wastes associated with removing the remaining MDAs, assuming that wastes from removing these MDAs are generated in equal annual volumes from FY 2007 through FY 2016.
- Additional wastes associated with remediating PRSs. (Wastes listed in Table I–65 are annually generated.)

Removing the MDAs would generate a significant quantity of waste. The largest annual waste generation would occur during FY 2010.

I.3.6.2 Transportation and Disposal of Waste

Annual shipments under the No Action Option are listed in **Table I–71.** Peak shipments of waste would occur in FY 2008.

Table I–69 Capping Option Annual Waste Generation Rates [a, b]

Waste (cubic yards)	Fiscal Year										Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Solid waste	4,300	4,300	4,400	5,300	5,800	4,300	4,800	4,300	4,800	4,500	47,000
Chemical waste [c]	4,100	3,500	2,300	2,100	2,200	2,100	2,100	2,100	2,100	2,100	25,000
Low-level radioactive waste	1,800	4,400	5,000	1,600	2,100	780	1,100	780	1,100	900	20,000
Mixed low-level radioactive waste	200	270	90	71	370	160	160	160	160	160	1,800
Transuranic waste	100	100	–	42	26	–	–	–	–	–	280
Total	10,000	13,000	12,000	9,200	11,000	7,400	8,200	7,400	8,200	7,700	93,000

[a] In situ volumes. As-shipped volumes are assumed to be 20 percent larger to account for material swell following removal from the ground.

[b] In addition, about 1,000 gallons of liquid low-level radioactive waste is projected per year from LANL's environmental restoration project, to be shipped to treatment facilities generally on the LANL site.

[c] Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.

Note: To convert cubic yards to cubic meters, multiply by 0.76456. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–70 Removal Option Annual Waste Generation Rates [a]

Waste	*Fiscal Year*										*Total*
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	
Nonliquid Waste (cubic yards)											
Solid waste	9,200	14,000	25,000	21,000	9,700	9,400	9,400	9,400	9,400	9,200	130,000
Chemical waste [b]	4,600	5,900	10,000	9,100	3,600	2,700	3,200	3,400	2,900	2,700	49,000
Low-level radioactive waste	4,700	12,000	83,000	110,000	96,000	95,000	96,000	96,000	95,000	20,000	710,000
Mixed low-level radioactive waste	250	830	21,000	28,000	14,000	10,000	12,000	12,000	11,000	2,100	110,000
Alpha low-level radioactive waste	–	10,000	81,000	90,000	35,000	31,000	31,000	31,000	31,000	5,700	350,000
Mixed alpha low-level radioactive waste	–	3,300	23,000	23,000	4,300	3,500	3,500	3,500	3,500	630	68,000
Remote-handled low-level radioactive waste	–	–	120	180	180	180	180	180	180	33	1,200
Mixed remote-handled low-level radioactive waste	–	–	13	20	20	20	20	20	20	4	140
Contact-handled transuranic waste	100	450	4,700	5,700	1,700	920	2,800	3,800	1,900	170	22,000
Remote-handled transuranic waste	–	–	23	24	0.57	0.57	0.57	0.57	0.57	0.11	50
Total nonliquid waste	19,000	47,000	250,000	280,000	160,000	150,000	160,000	160,000	160,000	41,000	1,400,000
Liquid Waste (gallons)											
Industrial liquid waste	0	1,000	1,000	28	0	0	0	0	0	0	2,100
Hazardous liquid waste	21	1,100	3,300	3,300	2,500	21	21	21	21	21	10,000
Low-level radioactive liquid waste	1,100	1,300	1,300	1,100	1,100	1,100	1,100	1,100	1,100	1,100	11,000
Mixed low-level radioactive liquid waste	20	20	20	20	20	20	20	20	20	20	200
Total liquid waste [c]	1,100	3,400	5,600	4,400	3,600	1,100	1,100	1,100	1,100	1,100	24,000

[a] In situ volumes. As-shipped volumes are 20 percent larger to account for material swell following removal from the ground.
[b] Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; gallons to liters, multiply by 3.785. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–71 No Action Option Annual Waste Shipments

Waste	***Fiscal Year***										***Total***
	2007	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	
Chemical waste [a]	160	120	16	0	4	3	3	3	3	3	310
Low-level radioactive waste [b]	70	260	290	2	0	0	0	0	0	0	620
Mixed low-level radioactive waste [b]	10	16	2	0	24	7	7	7	7	7	87
Transuranic waste [c]	12	12	0	0	0	0	0	0	0	0	24
Total	250	400	310	2	28	10	10	10	10	10	1,000

[a] Assuming an average waste density of 1 gram per cubic centimeter. Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
[b] Assumed to be low-activity and mixed low-activity low-level radioactive waste.
[c] Includes mixed transuranic waste.
Note: Because numbers have been rounded, the sums may not equal the indicated totals.

Annual shipments under the Capping Option are listed in **Table I–72**, while annual shipments under the Removal option are listed in **Table I–73**. Peak shipments under the Capping Option would occur during FY 2008, and under the Removal Option during FY 2010.

I.3.6.3 Cover Materials, Excavated Soil, and Materials Transport

No Action Option. Materials and requirements for transporting these materials would be comparable to those seen in past years at LANL.

Capping Option. Volumes of capping materials, assuming two thicknesses of final cover, are indicated in **Table I–74**, along with total truck shipments through FY 2016. Sources for this cover material would be borrow areas within LANL or its vicinity. In the table, the “tuff” designation refers to fill material such as crushed tuff. The “additional material” designation refers to topsoil, soil amendment, gravel, and similar materials.

Additional materials may include instrumentation for cover infiltration monitoring, cement grout for stabilizing the General’s Tanks in place, fencing, or other miscellaneous materials.

Removal Option. The process of exhuming the MDAs would cause movement of large quantities of uncontaminated soil. Soil removed from the vicinity of the MDAs would be stockpiled and returned to the excavations. Additional backfill would be needed to account for the removed waste, plus a layer of topsoil and materials intended to promote vegetative growth. Remaining disposal units at the existing Area G footprint following MDA G removal are assumed to be covered with either a thin or thick cap, as are small contaminated areas or landfills in TA-49.

Material volumes and shipments are summarized in **Table I–75**. The table includes volumes and shipments of bulk material for MDA removal, for capping the remaining disposal units in the existing Area G footprint following MDA G removal, and for capping small landfills and areas of contamination in TA-49 (see Tables I–50 and I–51). In most cases, distances of shipments of material that would be removed, stockpiled, and returned to the excavations would be very short. The additional fill and topsoil could come from borrow areas either on or in the vicinity of LANL.

Table I–72 Capping Option Annual Waste Shipments

Waste [a]	*Fiscal Year*										*Total*
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	
Solid waste	330	330	340	410	450	330	360	330	360	340	3,600
Chemical waste [b]	340	290	190	180	180	180	180	180	180	180	2,100
Low-level radioactive waste	120	310	350	110	150	55	80	55	80	63	1,400
Mixed low-level radioactive waste	16	21	7	6	30	13	13	13	13	13	140
Transuranic waste	12	12	0	5	3	0	0	0	0	0	32
Total	820	970	890	710	810	580	640	580	640	600	7,200

[a] In addition, roughly 1,000 gallons of low-level liquid radioactive waste is projected to be generated per year from LANL's environmental restoration project, to be shipped to treatment facilities on the LANL site. This would be accomplished using less than two full shipments.

[b] Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.

Note: Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–73 Removal Option Annual Waste Shipments

Waste	*Fiscal Year*										*Total*
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	
Nonliquid Waste											
Solid waste	700	1,100	1,900	1,600	740	720	720	720	720	700	9,700
Chemical waste [a]	380	490	870	760	300	220	270	290	240	220	4,000
Low-level radioactive waste	330	870	5,900	7,600	6,800	6,700	6,800	6,800	6,700	1,400	50,000
Mixed low-level radioactive waste	20	66	1,700	2,200	1,100	820	920	970	870	160	8,900
Alpha low-level radioactive waste	–	810	6,500	7,200	2,800	2,500	2,500	2,500	2,500	450	28,000
Mixed alpha low-level radioactive waste	–	260	1,900	1,800	340	280	280	280	280	50	5,400
Remote-handled low-level radioactive waste	–	–	58	88	86	86	86	86	86	16	590
Mixed remote-handled low-level radioactive waste	–	–	6	10	10	10	10	10	10	2	66
Contact-handled transuranic waste	12	52	550	670	200	110	330	440	220	20	2,600
Remote-handled transuranic waste	–	–	35	37	1	1	1	1	1	1 [b]	76
Total nonliquid waste	1,400	3,600	19,000	22,000	12,000	11,000	12,000	12,000	12,000	3,100	110,000
Liquid Waste											
Industrial liquid waste	–	1	1	–	–	–	–	–	–	–	3
Hazardous liquid waste	–	1	4	4	3						13
Low-level radioactive liquid waste	1	2	2	1	1	1	1	1	1	1	14
Mixed low-level radioactive liquid waste	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]	1 [b]
Total liquid waste	1	4	7	6	5	1	1	1	1	1	30

[a] Includes wastes regulated under RCRA, TSCA, or the New Mexico Solid Waste Act of 1990, or otherwise unacceptable for sanitary landfill disposal.
[b] Shipment contains less than a full load.
Note: Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–74 Materials and Shipments for Capping All Material Disposal Areas [a]

Material	*Fiscal Year*										*Total*
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	
Volumes (cubic yards)											
Minimum											
Tuff	7,100	7,100	57,000	100,000	190,000	7,300	150,000	11,000	160,000	56,000	750,000
Additional material	590	590	6,600	11,000	130,000	610	120,000	930	120,000	41,000	430,000
Rock armor	–	–	230	810	170	–	–	–	–	–	1,200
Retaining wall	–	–	140	140	–	–	–	–	–	–	280
Total material	7,700	7,700	64,000	120,000	320,000	7,900	280,000	12,000	280,000	97,000	1,200,000
Maximum											
Tuff	19,000	19,000	120,000	250,000	520,000	20,000	420,000	30,000	430,000	150,000	2,000,000
Additional material	1,600	1,600	9,900	21,000	130,000	1,700	120,000	2,500	120,000	42,000	460,000
Rock armor	–	–	230	810	170	–	–	–	–	–	1,200
Retaining wall	–	–	370	380	–	–	–	–	–	–	750
Total material	21,000	21,000	130,000	270,000	660,000	22,000	540,000	33,000	550,000	190,000	2,500,000
Shipments											
Minimum											
Tuff	550	550	4,500	8,100	15,000	570	12,000	870	12,000	4,400	59,000
Additional material	46	46	510	870	9,900	48	9,600	72	9,600	3,200	34,000
Rock armor	–	–	14	48	10	–	–	–	–	–	72
Retaining wall	–	–	10	11	–	–	–	–	–	–	21
Total material	600	600	5,000	9,100	25,000	620	22,000	940	22,000	7,600	92,000
Maximum											
Tuff	1,500	1,500	9,500	20,000	41,000	1,600	33,000	2,400	34,000	12,000	150,000
Additional material	130	130	780	1,600	10,000	130	9.600	200	9,700	3,300	36,000
Rock armor	–	–	14	48	10	–	–	–	–	–	72
Retaining wall	–	–	28	29	–	–	–	–	–	–	57
Total material	1,600	1,600	10,000	21,000	51,000	1,700	42,000	2,600	43,000	15,000	190,000

[a] Includes volumes and shipments for capping small areas in TA-49.

Note: To convert cubic yards to cubic meters, multiply by 0.765. Because numbers have been rounded, the sums may not equal the indicated totals.

Table I–75 Materials and Shipments for Removing All Material Disposal Areas

Material	Fiscal Year										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Volumes (cubic yards) – MDA Removal plus Thin Cap at Area G [a]											
Remove top layer	850	11,000	62,000	67,000	36,000	33,000	35,000	36,000	34,000	6,700	320,000
Remove additional soil	5,200	12,000	560,000	750,000	470,000	440,000	440,000	440,000	440,000	84,000	3,600,000
Stockpile return	6,100	23,000	610,000	800,000	500,000	470,000	470,000	480,000	470,000	91,000	3,900,000
Additional fill	9,300	34,000	240,000	280,000	160,000	150,000	150,000	150,000	150,000	34,000	1,300,000
Crushed tuff for capping.	3,100	3,100	21,000	30,000	30,000	30,000	30,000	30,000	30,000	8,100	220,000
Total tuff and fill	12,000	37,000	260,000	310,000	190,000	180,000	180,000	180,000	180,000	42,000	1,600,000
Additional material for MDA removal	540	2,200	12,000	13,000	6,800	5,900	6,200	6,400	6,000	1,500	61,000
Additional material for capping	260	260	15,000	23,000	23,000	23,000	23,000	23,000	23,000	4,500	160,000
Total additional material	800	2,500	27,000	36,000	30,000	29,000	29,000	30,000	29,000	6,000	220,000
Total material moved	25,000	8,600	1,500,000	2,000,000	1,200,000	1,100,000	1,200,000	1,200,000	1,200,000	230,000	9,700,000
One Way Shipments – MDA Removal plus Thin Cap at Area G [a]											
Remove top layer	60	780	4,400	4,700	2,500	2,300	2,500	2,600	2,400	470	23,000
Remove additional soil	370	880	40,000	53,000	33,000	31,000	31,000	31,000	31,000	6,000	260,000
Stockpile return	430	1,700	43,000	56,000	36,000	33,000	34,000	34,000	33,000	6,400	280,000
Additional fill	660	2,400	17,000	20,000	11,000	10,000	11,000	11,000	11,000	2,400	95,000
Crushed tuff for capping	240	240	1,600	2,400	2,400	2,400	2,400	2,400	2,400	630	17,000
Total tuff and fill	900	2,600	18,000	22,000	14,000	13,000	13,000	13,000	13,000	3,100	110,000
Additional material for MDA removal	39	160	850	940	480	420	440	460	430	110	4,300
Additional material for capping	20	20	1,200	1,800	1,800	1,800	1,800	1,800	1,800	350	12,000
Total additional material	59	180	2,000	2,700	2,300	2,200	2,200	2,300	2,200	460	17,000
Total material moved	1,800	6,100	110,000	140,000	87,000	81,000	83,000	83,000	82,000	16,000	690,000
Volumes (cubic yards) – MDA Removal plus Thick Cap at Area G [a]											
Remove top layer	850	11,000	62,000	67,000	36,000	33,000	35,000	36,000	34,000	6,700	320,000
Remove additional soil	5,200	12,000	560,000	750,000	470,000	440,000	440,000	440,000	440,000	84,000	3,600,000
Stockpile return	6,100	23,000	610,000	800,000	500,000	470,000	470,000	480,000	470,000	91,000	3,900,000
Additional fill	9,300	34,000	240,000	280,000	160,000	150,000	150,000	150,000	150,000	34,000	1,300,000
Crushed tuff for capping.	8,400	8,400	57,000	83,000	83,000	83,000	83,000	83,000	83,000	22,000	600,000
Total tuff and fill	18,000	42,000	290,000	360,000	240,000	230,000	230,000	240,000	230,000	57,000	1,900,000
Additional material for	540	2,200	12,000	13,000	6,800	5,900	6,200	6,400	6,000	1,500	61,000

Material	Fiscal Year										
	2007	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***Total***
MDA removal											
Additional material for capping	700	700	16,000	24,000	24,000	24,000	24,000	24,000	24,000	4,900	160,000
Total additional material	1,200	2,900	2,800	37,000	30,000	29,000	30,000	30,000	30,000	6,400	220,000
Total material moved	31,000	92,000	1,600,000	2,000,000	1,300,000	1,200,000	1,200,000	1,200,000	1,200,000	240,000	10,000,000
One Way Shipments – MDA Removal plus Thick Cap at Area G [a]											
Remove top layer	60	780	4,400	4,700	2,500	2,300	2,500	2,600	2,400	470	23,000
Remove additional soil	370	880	40,000	53,000	33,000	31,000	31,000	31,000	31,000	6,000	260,000
Stockpile return	430	1,700	43,000	56,000	36,000	33,000	34,000	34,000	33,000	6,400	280,000
Additional fill	660	2,400	17,000	20,000	11,000	10,000	11,000	11,000	11,000	2,400	95,000
Crushed tuff for capping	660	660	4,500	6,500	6,500	6,500	6,500	6,500	6,500	1,700	47,000
Total tuff and fill	1,300	3,000	21,000	26,000	18,000	17,000	17,000	17,000	17,000	4,200	140,000
Additional material for MDA removal	39	160	850	940	480	420	440	460	430	110	4,300
Additional material for capping	55	55	1,200	1,800	1,800	1,800	1,800	1,800	1,800	380	13,000
Total additional material	93	210	2,100	2,800	2,300	2,300	2,300	2,300	2,300	490	17,000
Total material moved	2,300	6,600	110,000	140,000	91,000	86,000	87,000	87,000	86,000	18,000	720,000

MDA = material disposal area.

[a] Refers to capping the remaining disposal units in the existing 63-acre Area G footprint following MDA G removal. Includes small volumes and shipments of materials needed to optionally cap sites in Areas 6 and 12 of TA-49.

Note: To convert cubic yards to cubic meters, multiply by 0.765. Because numbers have been rounded, the sums may not equal the indicated totals.

MDA H. Assuming that remediation of MDA H occurs during the time period covered in this SWEIS, bulk material volumes and shipments projected in this section may be augmented as summarized in Sections I.3.3.2.2.2.

I.3.6.4 Equipment, Emissions, and Personnel Assumptions

This section addresses assumptions for equipment use, airborne emissions of machinery combustion products, personnel requirements for PRS remediation, personnel radiological exposures, and industrial accident risks. To do this, assumptions about hourly personnel and machinery use were developed from industrial cost, personnel, and equipment data provided in catalogs from the R.S. Means Company. In addition, the literature was reviewed for assumptions and experience at other remediation efforts such as those discussed in Section I.3.3.1.3.[70]

Several case studies were developed using the Means data that were applicable to the different remediation efforts addressed in this appendix. For each case study, the Means cost data were used, along with other information in the Means catalogs, to estimate personnel hours and machinery use. The estimated personnel and machinery hours included contingency factor multipliers to account for special conditions at sites where radioactive material is involved. Projected personnel hours were used with assumptions about radiation environments associated with various remediation efforts to estimate personnel radiation doses and risks, as well as industrial accident risks. Projected equipment hours were used along with assumptions about hourly fuel requirements to determine gallons of fuel used. This information was then used with procedures and assumptions outlined in Section 3.3 ("Gasoline and Diesel Industrial Engines") of AP 42, EPA's compilation of air pollutant emission factors (EPA 1995), to estimate air emissions of nonradiological pollutants such as carbon monoxide and nitrogen oxides.

Table I–76 outlines each of the case studies and summarizes the results of the calculations using Means data for each study. In this table, equipment, personnel, and fuel use requirements are summarized on both a per-square-foot basis (as in square feet of area addressed) and on a per-cubic-yard basis (as in cubic yards of contaminated material removed). Contingency factor multipliers are also shown for each case study.

Total equipment hours and fuel use were determined for each of the case studies, and the total releases of pollutants associated with this fuel use (in tons released to the air) are summarized in **Table I–77**. **Table I–78** lists total personnel hours for each case study, as well as the calculated industrial risks resulting from these total personnel hours. Industrial risks for each case study were developed using 5-year-average DOE statistics for construction workers from the Computerized Accident and Incident Reporting System database (DOE 2004d) and information from the U.S. Department of Labor Statistics for the overall construction industry (DOL 2003). Information from these tables was used for each of the options in this appendix as discussed below.

[70] *Remediation of MDA H has been addressed in previous NEPA analyses but may occur during the time period covered in this SWEIS. Estimates of equipment and personnel requirements and associated impacts for remediating MDA H were presented in this previous analyses (DOE 2004a).*

Table I–76 Summary of Labor, Equipment Hours, and Fuel Use for Remediation Case Studies

Case Study	*Area (acres)*	*Depth (feet)*	*Volume of Material (cubic yards)*	*Contingency Factor Assumed*	*Labor (hours per square foot)*	*Equipment (hours per square foot)*	*Fuel Use (gallons per square foot)*	*Labor (hours per cubic yard)*	*Equipment (hours per cubic yard)*	*Fuel Use (gallons per cubic yard)*
Case 1Aa – Small area, thin cap	1	3 [a]	6,300	1.5	0.085	0.052	0.32	0.59	0.36	2.2
Case 1Ab – Small area, thick cap	1	8.2 [a]	17,000	1.5	0.17	0.11	0.64	0.43	0.27	1.6
Case 1Ba – Large area, thin cap	20	3 [a]	130,000	1.5	0.075	0.046	0.28	0.52	0.32	1.9
Case 1Bb – Large area, thick cap	20	8.2 [a]	340,000	1.5	0.15	0.090	0.55	0.37	0.23	1.4
Case 2A – Removal of contaminated soil	1	1	1,600	1.5	0.12	0.038	0.20	3.2	1	5.4
Case 3A – Removal of shallow material from a small MDA	1	15	24,000	1.5	1.6	0.52	2.7	2.9	0.93	4.9
Case 3B – Removal of shallow material from a large MDA	20	15	480,000	1.5	1.3	0.42	2.2	2.4	0.76	4
Case 4A – Deeper soil or shaft removal	1	60	48,000	2.0	32	12	72	29	11	64

MDA = material disposal area.

[a] The reference for these case studies is to the thicknesses of the fill material for the caps. Additional materials that would be used for capping (fill for grading, topsoil, and other material) was considered for the estimates. The reference for the remaining case studies is to volume of material removed.

Note: To convert acres to hectares, multiply by 0.40469; feet to meters, multiply by 0.3048; cubic yards to cubic meters, multiply by 0.76459; square feet to square meters, multiply by 0.092903; gallons to liters, multiply by 3.78533. All numbers have been rounded.

Table I–77 Remediation Case Study Total Equipment and Fuel Use and Pollutant Emissions (tons released)

Case Study	*Equipment Hours*	*Fuel Use (gallons)*	*Nitrogen Oxides*	*Carbon Monoxide*	*Sulfur Oxide*	*Particulate Matter* [a]	*Carbon Dioxide*	*Aldehydes*	*Total Organic Carbon (TOC)*
Case 1Aa – Small area, thin cap	2,300	14,000	3.7	9.4	0.24	0.26	150	0.065	0.70
Case 1Ab – Small area, thick cap	4,600	28,000	7.5	19	0.49	0.52	310	0.13	1.4
Case 1Ba – Large area, thin cap	40,000	240,000	66	170	4.3	4.6	2,700	1.1	12
Case 1Bb – Large area, thick cap	79,000	480,000	130	320	8.4	9.0	5,200	2.3	24
Case 2A – Removal of contaminated soil	1,600	8,700	2.3	5.9	0.15	0.16	95	0.041	0.44
Case 3A – Removal of shallow material from a small MDA	23,000	120,000	32	81	2.1	2.2	1,300	0.56	6.0
Case 3B – Removal of shallow material from a large MDA	370,000	1,900,000	520	1,300	34	36	21,000	9.1	98
Case 4A – Deeper soil or shaft removal	530,000	3,100,000	840	2,100	54	58	34,000	15	160

PM_{10} = particulate matter having diameters smaller than 10 micron, MDA = material disposal area.

Note: To convert gallons to liters, multiply by 3.78533; tons to kilograms, multiply by 907.18. Numbers have been rounded.

Table I–78 Remediation Case Study Total Industrial Risks

Case Study	*Total Labor Hours*	*Safety – Construction Industry*			*Safety – DOE Construction*		
		Recordable Injuries	*Lost Workdays*	*Fatalities*	*Recordable Injuries*	*Lost Work Days*	*Fatalities*
Case 1Aa – Small Area, Thin Cap	3,700	0.16	1.7	3.8×10^{-4}	0.042	0.14	–
Case 1Ab – Small Area, Thick Cap	7,500	0.32	3.4	7.8×10^{-4}	0.085	0.28	–
Case 1Ba – Large Area, Thin Cap	65,000	2.8	30	6.8×10^{-3}	0.74	2.5	–
Case 1Bb – Large Area, Thick Cap	130,000	5.4	59	0.013	1.5	4.8	–
Case 2A – Removal of Contaminated Soil	5,100	0.22	2.3	5.3×10^{-4}	0.057	0.19	–
Case 3A – Removal of Shallow Material from a Small MDA	70,000	3.0	32	7.3×10^{-3}	0.79	2.6	–
Case 3B – Removal of Shallow Material from a Large MDA	1,100,000	48	520	0.12	13	43	–
Case 4A – Deeper Soil or Shaft Removal	1,400,000	60	650	0.15	16	53	–

MDA = material disposal area.
Note: Numbers have been rounded.

Total personnel hours and radiation dose from MDA and PRS remediation are the sum of those associated with direct remediation efforts (addressed above) and those associated with remedial design and waste processing and loading onto trucks. Remedial design addresses work performed after the optimum remedial action alternative has been selected and prior to the onset of remedial construction. This work includes activities such as project planning, treatability or other studies, and preparation of design documents. A 10-percent factor for remedial design was assumed based on the range of complexity that would be associated with remediating the MDAs and PRSs. Assumptions for waste processing and loading onto trucks are addressed in Section I.3.5.

I.3.6.4.1 No Action Option

Under the No Action Option, a low level of remediation effort would take place. Personnel hours, air emissions, and industrial risks were estimated by determining ratios of waste volumes listed in Table I–68 to unit information derived for Case Study 2A, Removal of Contaminated Soil. (For example, nitrogen oxide [NO_x] emissions from removal of 1,000 cubic yards of soil as part of LANL's environmental restoration project would be 1,000 cubic yards × 5.4 gallons per cubic yard × 2.3 tons per 8,700 gallons consumed, or 1.4 tons (1,300 kilograms) of nitrogen oxides released.)

Worker radiation exposures were determined by estimating total personnel hours engaged in remediation work (using the above methods) and multiplying these hours by an assumed radiation environment of 2.2×10^{-6} rem per hour (the same as the same hourly exposure rate for remediation of the combined PRS area discussed in Section I.3.6.4.3). Personnel hours and radiation exposures for waste processing and truck loading were assessed as addressed in Section I.3.5.

I.3.6.4.2 Capping Option

Under this option, air emissions and personnel hours, exposure rates, and industrial safety risks were conservatively estimated as addressed for the No Action Option and through consideration of:

- Capping several MDAs
- Generating and handling wastes associated with capping the MDAs
- Generating and handling wastes associated with annually remediating several small PRSs such as Firing Site E-F or the 260 Outfall in various locations within LANL
- Generating crushed tuff in the TA-61 borrow pit for MDA capping

For capping, air emissions and personnel hours and industrial safety risks were proportioned to the nominal sizes of the MDAs and landfills using Case Study 1Aa, 1Ab, 1Ba, or 1Bb. Case Studies 1Aa and 1Ab were used for MDAs and landfills covering about 1 acre (0.4 hectare) or less. This included all MDAs (and the Area 12 landfill in TA-49) except for MDAs B, T, C, and G (and the Area 6 landfill in TA-49), for which Case Study 1Ba or 1Bb was used. The case studies imply the following approximate personnel hourly commitments per cubic yard of capping material:

- Case Study 1Aa: 0.6 hours per cubic yard
- Case Study 1Ab: 0.4 hours per cubic yard
- Case Study 1Ba: 0.5 hours per cubic yard
- Case Study 1Bb: 0.4 hours per cubic yard

These rates are within the range of those that have been estimated in the literature. For example, the environmental assessment for MDA H projected about 2.9 to 3.5 person-hours per cubic yard of emplaced material, assuming placement of 2,860 cubic yards of material over 0.4 acre (0.2 hectare) (DOE 2004b). Sandia projected from 0.4 to 0.49 person-hours per cubic yard of cover material added, assuming a cap covering about 2.6 acres (1.1 hectares) of a mixed waste landfill (SNL 2004). Idaho National Laboratory projected about 0.4 person-hour per cubic yard of material emplaced, assuming covering about 100 acres (40.5 hectares) of a legacy radioactive waste disposal site (INEEL 2002a, 2002b).

The radiation environment that may be expected for capping will vary depending on local levels of contamination, the materials disposed of in the MDAs, and other sources of radiation such as adjacent operational areas. The overall radiation environment for capping was assumed from measurements of external exposure rates at MDA T during 2003 (LANL 2004h). This measurement, taken from a TLD at the boundary of MDA T, was about 100 millirem per year above background. This annual exposure rate is equivalent to an hourly exposure rate of 1.14×10^{-5} rem per hour. Using this exposure rate for all MDAs (except for MDA L and the landfills) should be conservative.

For generating and handling wastes associated with capping the MDAs and landfills, and annually remediating several PRSs, Case Study 2A was assumed. For both situations, the general radiation environment was assumed to be the same as for the combined PRS area (2.2×10^{-6} rem per hour; see Section I.3.6.4.3). Personnel hours and radiation exposures for waste processing and truck loading were assessed as addressed in Section I.3.5.

None of the case studies precisely correspond to borrow pit operation. The closest is Case Study 1Bb, placing a thick cap over a 20-acre (8.1-hectare) MDA. Hence, Case Study 1Bb was assumed to represent borrow pit operation.

I.3.6.4.3 Removal Option

Under this option, air emissions and personnel hours, exposure rates, and industrial safety risks were estimated as addressed for the No Action Option and through consideration of:

- Performing complete removal of several MDAs.
- Generating and handling wastes associated with annually remediating several small PRSs such as Firing Site E-F or the 260 Outfall in various locations within LANL. (Rates and risks were determined in the same manner as for the Capping Option.)
- Generating crushed tuff in the TA-61 borrow pit for backfilling MDAs.

Although removals have occurred at LANL and elsewhere, there is little experience with removals as challenging as those of many of the LANL MDAs. Several assessments have been published addressing removal operations at LANL and elsewhere. Most assessments were for postulated removals (DOE 2004b; INEEL 2002a, 2002d; SNL 2004; LANL 1981), while one addressed the completed removal of a chemical waste landfill (SNL 2003). Estimates of personnel requirements (and other factors) were quite variable.

For this appendix, emissions and personnel were estimated by scaling waste volumes removed for each MDA to unit volume factors for these parameters from Case Studies 3A, 3B, and 4A, as summarized in **Table I–79**. (Case Study 2A was again assumed for waste generated from preliminary MDA removal work and for annually remediating several PRSs.) Also shown are the assumed radiation environments associated with removal of the MDAs. Personnel hours and radiation exposure for waste processing and loading were assessed as addressed in Section I.3.5.

To estimate the general radiation environment for worker radiation dose assessments during MDA removal operations, RESRAD Version 6.3 calculations were performed for several MDAs assuming average waste radionuclide concentrations developed from the same inventories as those used for the air emissions assessment (see Section I.5.6.3.2). The primary value of these assessments is to compare options and to identify possible hazardous conditions. Actual removals would occur while using technical and administrative controls to maintain worker doses within prescribed limits and as low as reasonably achievable.

Table I–79 Case Studies Applied to Material Disposal Area Removal

Material Disposal Area [a]	*Case Study*	*Radiation Environment (rem per hour)*	*Material Disposal Area*	*Case Study*	*Radiation Environment (rem per hour)*
A (Eastern Pits) [b]	3A	0.000013	L (Pits) [i]	3A	Not applicable
A (Central Pit) [b]	3A	1.2×10^{-6}	L (Shafts) [i]	4A	Not applicable
A (Tanks) [b]	3A	1.7×10^{-5}	F [j]	3A	2.2×10^{-6}
B [c]	3B	2.4×10^{-6}	Q [k]	3A	2.2×10^{-6}
T (Beds) [d]	4A	2.8×10^{-5}	N [k]	3A	2.2×10^{-6}
T (Shafts) [d]	4A	0.00025	Z [k]	3A	2.2×10^{-6}
U (Beds) [e]	3A	0.00011	R [k]	3A	2.2×10^{-6}
AB (shafts) [f]	4A	0.00025	D [k]	3A	2.2×10^{-6}
C (Pits) [g]	3B	7.1×10^{-5}	E and K [k]	3A	2.2×10^{-6}
C (Shafts) [g]	4A	0.00025	AA [l]	3A	2.2×10^{-6}
G (Pits) [h]	4A	3.6×10^{-5}	Y [m]	3A	2.2×10^{-6}
G (Shafts) [h]	4A	0.00025	–	–	–

[a] For preliminary site work at any MDA, a radiation environment of 2.2×10^{-6} rem per person-hours was assumed using the radiation environment calculated for the combined potential release site area.
[b] The worker exposure environment was assumed from RESRAD calculations.
[c] The worker exposure environment was estimated from RESRAD calculations.
[d] For MDA T beds, the working exposure environment was estimated from RESRAD calculations. For MDA T shafts, operations were assumed to be controlled to maintain individual exposures (assuming 2,000-hour work year) to levels smaller than 500 millirem in a year.
[e] Exposure environment was assumed from RESRAD calculations.
[f] Assumed the same exposure environment as that for the MDA T shafts.
[g] Exposure environments were assumed from RESRAD calculations, with a maximum exposure rate of 0.00025 rem per hour to maintain individual exposures less than 500 millirem in a year.
[h] MDA G pits contain pockets of small, high-activity waste containing cobalt-60 and cesium-137. Assumed that special measures would be taken for these pockets to maintain worker exposures to levels as low as reasonably achievable. Based the average radiation environment for MDA G pits on RESRAD calculations by excluding two small pockets of cobalt-60 and cesium-137. For MDA G shafts, assumed that worker exposure rates would be maintained to levels so that no individual receives more than 500 millirem in a year, assuming 2,000 work hours per year.
[i] MDA L should contain very little radioactive material, although precautions would be required for the presence of toxic and hazardous constituents.
[j] Used the worker exposure environment estimated for the combined PRS area.
[k] Assumed the same worker exposure environment as that for the combined PRS area.
[l] Assumed the same worker exposure environment as that for the combined PRS area.
[m] Worker exposure environment was estimated from RESRAD calculations.

If the radiation environment was not too high as determined from these calculations, the RESRAD calculations were assumed. However, DOE regulations prescribe an upper radiation dose limit of 5 rem (total effective dose equivalent) in a year. Special approval is required before allowing radiation doses to exceed 2 rem in a year, and administrative controls must be imposed to further reduce radiation exposures. The *DOE Standard Radiological Control Manual* indicates that an administrative control level of 500 millirem in a year (or less) should be challenging and achievable (DOE 1999c). Assuming 2,000 work hours per year and a 0.5-rem-per-year average dose level, worker radiation exposures would be limited to an average dose rate of 2.5×10^{-4} rem per hour. This average dose rate was the maximum assumed for removal of any MDA.

In addition, a radiation environment for worker radiation dose assessment (2.2×10^{-6} rem per hour) was estimated for the assumed annual remediation of several small PRSs and MDAs. This radiation environment was determined using RESRAD Version 6.3 calculations assuming average radionuclide concentrations developed from the inventory assumed for the combined PRS area discussed in Section I.5.6.3.2.

Case Study 1Bb was again assumed to represent nonradiological releases and worker industrial risks from operations of the TA-61 borrow pit.

I.3.6.5 Affected Area Assumptions

Remediating the MDAs and PRSs will affect LANL property. In addition to the land area comprising the surface footprints of the MDAs and PRSs, additional area will be temporarily affected by operations supporting remediation. For example, capping an MDA may require temporary use of land for storage of bulk materials. Following completion of the task, the land would be restored. The amount of land that would thus be temporarily affected would depend on regulatory decisions, logistical considerations, and other factors.

MDAs. Temporary support areas associated with capping MDAs may include:

- A project management area, including a management trailer and space for staging equipment;
- An area for parking personal vehicles;
- An area for temporary management or storage of any wastes that may be generated; and
- An area for stockpiling bulk materials such as crushed tuff.

The size of a temporary project management area for any MDA may depend on the magnitude of the job, but should in most cases cover less than 1 acre (0.4 hectare). (The management area envisioned for remediating MDA H under any alternative covered only 0.2 acre (0.1 hectare) [DOE 2004b].) It is also expected that, for most MDAs, there should be no need to site additional personal vehicle parking infrastructure because sufficient nearby parking infrastructure should already exist.

For most MDAs, capping should not involve generation of significant quantities of waste. Hence, temporary waste management areas should (for most MDAs) be far smaller than 1 acre (0.4 hectare). Because most waste so generated will probably be either solid waste or low-activity low-level radioactive waste, storage time should be minimal. Roll-offs and Intermodals staged at a location for receipt of bulk waste would be present for the time required to fill them; when filled, they would be removed and replaced as needed by additional roll-offs and Intermodals. A 20-cubic-yard roll-off has typical dimensions of 8 by 20-22 by 4 feet tall (2.4 by 6.1-6.7 by 1.2 meters tall) (Burris 2005). Given packaging inefficiencies and swell of excavated waste, each roll-off is projected to contain about 13 cubic yards (10 cubic meters) of waste (see Table I–66). Assuming 10-foot (3-meter) side-to-side spacing and 5-foot (1.5-meter) end-to-end spacing, about 450 square feet (41.8 square meters) would be needed to temporarily store about 13 cubic yards (10 cubic meters) of low-activity waste. A site containing 10 roll-offs, or 130 cubic yards (100 cubic meters) of waste, would cover only about 0.1 acre (0.04 hectare).

The largest acreage may be dedicated to temporary storage of bulk materials. For many MDAs, much bulk material could be delivered directly to the worksite. But because of logistical or other considerations, it may be necessary to stockpile capping materials near the work area. Therefore, it was conservatively assumed that capping any MDA could require the temporary storage of 6 months' worth of capping materials.[71] It was estimated by assuming a series of long, parallel rows of spoil piles, each pile roughly triangular in cross section. Because the material was assumed to be delivered and moved using trucks, loaders, and bulldozers, the piles were assumed to each be 10 feet (3 meters) high. The separation between piles was assumed to be 10 feet (3 meters). These assumptions result in an area commitment of 0.2 square feet per cubic foot (0.66 square meters per cubic meter) of stored spoil, considering a 20 percent swell of delivered material following initial excavation.

Temporary support areas associated with removing MDAs may include:

- A project management area, including a management trailer and space for staging equipment.
- An area for parking personal vehicles.
- An area for temporary management or storage of wastes.
- Capacity for storing bulk materials such as excavation spoils, final cover materials, or demolition debris.
- Possible capacity for preliminary classification of exhumed materials by hazard and for staging for further management.
- Possible capacity to process or package some wastes before shipment for further treatment or disposal.
- Possible capacity to characterize the waste in terms of organic, inorganic, and radioactive material content.

Similar to the assumption for capping MDAs, management areas associated with removal of most MDAs are assumed to cover less than 1 acre (0.4 hectare) for each MDA. (Additional areas may be needed for removal of waste from larger MDAs, or for decontaminating equipment.) It is also expected that, for most MDAs, there should be no need to site additional personal vehicle parking infrastructure because sufficient nearby parking infrastructure should already exist.

Areas needed for temporary management or storage of exhumed wastes would be larger than those for MDA capping. Depending on the MDA, waste management support areas may need to address a variety of wastes, including remote-handled waste. Shielded bunkers or similar facilities may be required, as may facilities for decontamination of equipment. However, because the bulk of the material removed from the waste would be very low-activity bulk material, it was again assumed that roughly 0.01 acre (0.004 hectare) would be required to store

[71] *Six months' capacity is assumed because, although work is expected to proceed in stages, there may be need for long-term storage of some materials.*

about 13 cubic yards (10 cubic meters) of waste. Capacity for temporary storage and management of 3 months' generation of waste was assumed for each MDA.[72]

A significant commitment of land may be associated with temporary storage of bulk materials such as overburden or backfill. Land requirements are assumed to be 0.2 square feet per cubic foot (0.66 square meters per cubic meter) of spoil (stockpiled overburden, removed clean fill, backfill, and topsoil), assuming a 6-month storage capacity and 20 percent material swell.[73]

Additional land commitments may be needed for some MDAs for hazard classification of exhumed materials, waste processing or packaging of some wastes (for example, transuranic or remote handled wastes), or waste characterization (see Section I.3.3.2.8). Needed capacity would depend on regulatory decisions (for example, partial versus complete removal), volumes and characteristics of the exhumed wastes, and other factors. Assuming complete removal of all MDAs, capacity may be needed at several locations within LANL. Extrapolating from the sizes of facilities proposed for the investigation and remediation program for MDA B (Section I.3.3.2.7), complete MDA removal could temporarily involve up to 84 acres (34 hectares).[74]

Additional PRSs. Support commitments for remediating other PRSs will generally be small and, again, temporary, but will vary depending on the PRS and the remediation decision. Temporary support areas may be needed for project management, temporary waste storage, equipment staging, or personal vehicle parking.

I.4 Affected Environment

This section provides summary descriptions of the natural and human environments possibly affected by the options considered in this appendix. Detailed descriptions of these environments within and near LANL are in Chapter 4 of this SWEIS.

I.4.1 Land Resources

Land resources include land use and visual resources. Land use is defined as the way land is developed and used in terms of the kinds of anthropogenic activities that occur (e.g., agriculture, residential areas, industrial areas) (EPA 2006). Visual resources are natural and manmade features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture (DOI 1986).

I.4.1.1 Land Use

Land use at LANL is addressed in Chapter 4, Section 4.1.1, of this SWEIS. Existing land use is depicted in Figure 4–4. MDAs addressed in this appendix are listed in **Table I–80** along with

[72] *Three months' capacity was assumed because, in most cases, wastes would be stored for only a limited time before shipment and in consideration of RCRA storage requirements, which may be applicable for some wastes.*

[73] *These assumptions result in a calculated area for temporary storage of bulk materials from MDA H of about 1.3 acres (0.5 hectares), assuming 40 months of excavation, which is similar to the 1.2 acres (0.5 hectares) projected in the environmental assessment for MDA H (DOE 2004a).*

[74] *Assumed an additional five of each type of support facility (investigation facilities, waste processing facilities, and temporary laboratories). Assumed one each for removal of MDAs C and AB, one each for the remaining MDAs in TA-21, and two each for all MDAs in TA-54. As needed, the capacity could be used to support removal of the remaining small MDAs. From the proposed investigation and remediation of MDA B (Section I.3.3.2.7), this acreage is estimated as 6 (2 acres) + 6 (10 acres) + 6 (2 acres) = 84 acres (34 hectares).*

their approximate sizes. The sizes of selected PRSs are also presented. A discussion of land use at each TA listed in Table I–80 is presented below, as well as at TA-61, which contains the principal LANL borrow pit.

Table I–80 Approximate Sizes of Material Disposal Areas and Selected Potential Release Sites

Technical Area	*Material Disposal Area*	*Approximate Size of Material Disposal Area Site (acres)*	*Potential Release Site*	*Approximate Size of Potential Release Site (acres)*
6	F	1.4	–	–
8	Q	0.2	–	–
15	N	0.28	Site E-F	11
15	Z	0.4	Site R-44	6
16	R	11.5	260 Outfall (16-021(c) -99)	0.7
21	A	1.25	–	–
21	B	6.0	–	–
21	T	2.2	–	–
21	U	0.2	–	–
33	D	0.03	–	–
33	E	1.4	–	–
33	K	1.0	–	–
35	X [a]	0.05	–	–
36	AA	1.4	–	–
39	Y	0.2	–	–
49	AB	0.45	–	–
50	C	11.8	–	–
54	G	63 [b]	–	–
54	L	2.6 [b]	–	–
73	–	–	Ashpile	1.2

[a] Although MDA X has been recommended for no further action and will likely not require significant further remediation, it is near several other potential release sites in TA-35.
[b] Listed acreage is for the areas containing the MDAs.
Note: To convert acres to hectares, multiply by 0.4047.

Technical Area 6. TA-6 covers 500 acres (202 hectares), of which only 1 percent is occupied by a gas cylinder staging facility, vacant buildings pending decommissioning, and a meteorological tower. It is south of TA-3, on a mesa between Twomile and Pajarito Canyons. Existing land use includes High-Explosive Research and Development and Reserve. MDA F is within the south-central portion of TA-6 in an area presently designated as Reserve. In the future, MDA F and the southern portion of the area could be redesignated as Experimental Science (LANL 2003f). According to the *Comprehensive Site Plan* for 2001, TA-6 is within the Anchor Ranch Planning Area. Future development is planned for the western half of the Planning Area; thus, development in the immediate vicinity of MDA F is unlikely (LANL 2001c).

Technical Area 8. Also known as the GT or Anchor West Site, TA-8 is at the western end of LANL. It covers 267 acres (108 hectares) and contains the Radiographic Testing Facility and MDA Q. The TA forms a portion of the Experimental Engineering Planning Area at LANL. Work includes high explosive research and development and testing (LANL 2001c). Current land use designations include High-Explosive Research and Development and Reserve; future land use is not expected to change (LANL 2003f). MDA Q is within an area designated as Potential Infill (LANL 2001c).

Technical Area 15. Centrally located within LANL, TA-15 is largely on Threemile Mesa. It is bounded on the north by Pajarito Canyon and on the south by Water Canyon. The entire TA is designated as High Explosive Testing. The future land use designation is likely to remain the same (LANL 2003f). As determined by the *Comprehensive Site Plan* for 2001, MDAs N and Z and Firing Sites E-F and R-44 are within areas classified as Potential Infill (LANL 2001c).

Technical Area 16. TA-16 covers 1,950 acres (789 hectares) at the southwest corner of LANL; it is adjacent to Bandelier National Monument. Land use includes High-Explosive Research and Development, Public and Corporate Interface, Physical and Technical Support, and Reserve. Future land use is expected to remain largely unchanged except that the Public and Corporate Interface area in the western portion of the TA will increase in size and the Physical and Technical Support area will no longer exist (LANL 2003f). MDA R and the 260 Outfall (SWMU 16-021(c)-99) are within the northern portion of the area designated as High-Explosive Research and Development. According to the *Comprehensive Site Plan* for 2001, MDA R covers 11.5 acres (4.7 hectares) and falls within areas designated as Potential Infill and No Development Zone (Hazard). The 260 Outfall is within an area designated as No Development Zone (Hazard) (LANL 2001c).

Technical Area 21. TA-21 covers 312 acres (126 hectares) at the eastern end of DP Mesa, near the central business district of the Los Alamos Townsite. The airport is immediately north of TA-21 across DP Canyon. Much of the TA has been developed, mainly the west-central portion of the TA. Remaining portions consist of sloped areas, some of which would likely not accommodate development. Access to the TA is via DP Road.

TA-21 was identified for possible conveyance to Los Alamos County under Section 632 of Public Law 105-119 (see Chapter 4, Section 4.1.1, of this SWEIS). This TA has been divided into four subtracts for purposes of the land conveyance: TA-21-1 (West), which consists of two units, and TA-21-2 (East). (The subtracts have also been designated A-8, A-15-1, A-15-2, and A-16, respectively. Subtracts A-8, A-15-1, and A-15-2 cover 33.7 acres (13.6 hectares) and either have been or are scheduled to be conveyed to the county. Conveyance of the 252-acre (102-hectare) A-16 subtract has been withdrawn; MDAs A, B, T, and U are within this subtract.

Land use includes Waste Management, Service and Support, Nuclear Materials Research and Development, and Reserve. Future land use is slated as Reserve (LANL 2003f). The MDAs are within two areas designated as No Development Zone (Hazard).

Technical Area 33. Located in the southeastern corner of LANL and also known as the Hot Point Site, TA-33 covers 1,919 acres (777 hectares). It is bounded on the north by TA-70, on the southeast by the Rio Grande, and on the southwest by Bandelier National Monument and the Santa Fe National Forest. TA-33 is designated as Experimental Science and Reserve and is used for experiments that require isolation or do not require daily oversight. In the future, the area used for Experimental Science will likely increase and that for Reserve decrease (LANL 2003f). As determined by the *Comprehensive Site Plan* for 2001, TA-33 falls within the Rio Grande

Development Area. MDAs D, E, and K are all within areas classified as Potential Infill (LANL 2001c).

Technical Area 35. Also known as Ten Site, TA-35 is used for nuclear safeguards research and development; reactor safety research; optical science and pulsed-power system research; and metallurgy, ceramic technology, and chemical plating activities. TA-35 covers 150 acres (61 hectares) in the northern half of LANL on a finger mesa between Mortandad Canyon and Ten Site Canyon. Land use includes Nuclear Materials Research and Development, Experimental Science, Physical and Technical Support, and Reserve. Future land use is expected to be similar except that the Physical and Technical Support land use category will likely be absent (LANL 2003f). TA-35 is part of the Pajarito Corridor West Development Area, one of the most restricted areas at LANL. Infill development at TA-35 is possible to replace the small, temporary structures scattered throughout the area (LANL 2001c).

Technical Area 36. Also known as the Kappa Site, TA-36 has four active firing sites. The TA is in a remote area in the southeastern portion of LANL. The TA is part of the Dynamic Testing Planning Area at LANL, which is the largest LANL planning area, covering 2,777 acres (1,124 hectares) (LANL 2001c). Land use at the TA is nearly exclusively High-Explosive Testing, with small areas of Physical and Technical Support and Reserve. Future land use is expected to be similar except the Physical and Technical Support area may not be present (LANL 2003f). TA-36 is within the Water Canyon Development Planning Area. MDA AA is in an area designated as Potential Infill (LANL 2001c).

Technical Area 39. TA-39 is at the bottom of Ancho Canyon in the south-central part of LANL. Covering 2,444 acres (989 hectares), TA-39 was created when explosives work at TA-15 became too crowded. Like TA-36, TA-39 is part of the Dynamic Testing Planning Area at LANL. Nearly the entire TA is classified as High-Explosive Testing, with small areas of Physical and Technical Support and Reserve. Future land use is expected to be similar (LANL 2003f). TA-39 is within the Water Canyon Development Area. MDA Y in the central portion of the TA in an area designated as Potential Infill (LANL 2001c).

Technical Area 49. TA-49 covers 1,280 acres (518 hectares) and is largely undeveloped. The TA is within the south-central portion of LANL and is bordered on the south by Bandelier National Monument. Land use designations include High-Explosive Testing, Physical and Technical Support, and Reserve; these designations are not expected to change in the future (LANL 2003f). MDA AB is within the Physical and Technical Support land use zone. According to the *Comprehensive Site Plan* for 2001, TA-49 is within the Water Canyon Development Area. The general area containing MDA AB is categorized as Potential Infill, indicating that some future development could take place; however, such development would not occur within the MDA (LANL 2001c).

Technical Area 50. TA-50 covers 62 acres (25 hectares). It is 1.3 miles (2.1 kilometers) southeast of TA-3 along Pajarito Road. Land use designations include Waste Management and Reserve. Only the portion of the TA north of MDA C contains buildings. Future land use categories are projected to be similar except that the Waste Management land use area could be enlarged to include the entire northern part of the TA (LANL 2003f). TA-50 is within the Pajarito Corridor West Development Area as set forth in the *Comprehensive Site Plan* for 2001.

Although the area to the south of Pajarito Road is designated as suitable for Secondary Development, the portion of the TA containing MDA C is designated as No Development Zone (Hazard) (LANL 2001c).

Technical Area 54. TA-54 covers 858 acres (347 hectares). MDAs G and L encompass 68 acres (28 hectares), or 7.2 percent of the TA. The 3-mile (4.8-kilometer) northern border of the site forms the boundary between LANL and San Ildefonso Pueblo lands. The residential area of White Rock borders the site at its eastern boundary. Land use within TA-54 is categorized as Experimental Science, Waste Management, and Reserve. Future land use is likely to be similar except that the area devoted to waste management is predicted to expand such that it forms a continuous band along the TA's southern boundary (LANL 2003f). According to the *Comprehensive Site Plan* for 2001, TA-54 is within the Pajarito Corridor East Development Area. The area containing MDAs G and L is categorized as Potential Infill, indicating that some future development could take place; however, such development would not occur within the MDAs (LANL 2001c).

Technical Area 61. Also known as the East Jemez Site, TA-61 is northeast of TA-3 and covers 297 acres (120 hectares). TA-61 is used for physical support and contains infrastructure facilities, including the Los Alamos County Landfill covering 48 acres (19 hectares). The generalized land use categories for the TA include Physical and Technical Support and Reserve. The 43-acre (17-hectare) area containing the borrow pit is next to East Jemez Road in the eastern portion of the TA in an area designated as Physical and Technical Support. The borrow pit is east of the Royal Crest Manufactured Home Community. Future land use will probably be similar (LANL 2003f). According to the *Comprehensive Site Plan* for 2001, the TA is within the Sigma Mesa Development Area that could undergo considerable future development (LANL 2001c).

Technical Area 73. This TA covers 272 acres (110 hectares) along the northern boundary of LANL next to NM 502 (East Road). The TA comprises the Los Alamos County Airport, which is owned by DOE and managed by the Los Alamos County. Land use consists of Airfield and Reserve; it is not expected to change in the future (LANL 2003f). The ashpit is north of the airport terminal building. Land use along East Road near TA-73 includes offices and other light commercial and retail land uses, as well as several churches, a swimming facility, and a park. TA-73 is part of the Omega West Planning Area. The Los Alamos County Airport is part of the DOE land exchange package (see Chapter 4, Table 4–2) (LANL 2001c).

I.4.1.2 Visual Environment

LANL visual resources are addressed in Chapter 4, Section 4.1.2, of the SWEIS. This section discusses the visual setting of the TAs addressed in Section I.4.1.1.

Technical Area 6. TA-6 is on a mesa between Twomile and Pajarito Canyons. The area is largely undeveloped; however, it contains a gas cylinder staging facility, vacant buildings pending decommissioning, and a meteorological tower. The heavily wooded area is visible from Pajarito Road and from higher elevations to the west along the upper reaches of the Pajarito Plateau rim (NNSA 2003). MDA F is a grassy area of which a portion is fenced. These areas are not readily visible by the public because Twomile Mesa Road, passing to the south of the MDA, is not a public road.

Technical Area 8. TA-8 is between the upper reaches of Pajarito Canyon to the north and TA-16 to the south. Although portions of the TA are forested, the part of the TA containing MDA Q has been cleared and contains a few structures within a grassy area. The site would generally not be visible to the public because trees separate it from West Jemez Road. From higher elevations to the west, TA-8 appears as part of a larger developed area.

Technical Area 15. Situated on Threemile Mesa, TA-15 is bounded on the north by Pajarito Canyon and on the south by Water Canyon. Additionally, the northern part of the TA is dissected by Threemile Canyon and the central portion by Potrillo Canyon. The TA contains scattered facilities within a largely forested area. The dispersed arrangement of facilities reflects the use of the TA for high-explosive research, development, and testing. Due to the isolated nature of TA-15, buildings and structures are generally not visible to the public. If viewed from higher elevations to the west, the TA appears largely as wooded with only a scattering of facilities located throughout. MDAs N and Z and Firing Sites E-F and R-44 present a disturbed appearance that would be indistinguishable from other facilities within TA-15 when viewed from higher elevations to the west.

Technical Area 16. TA-16 is in the southwestern corner of LANL and is bounded on the north by Cañon de Valle and on the south by Water Canyon. Most buildings and structures are in the western part of the TA, with some facilities visible from West Jemez Road. From the mountains to the west, the TA appears as highly developed in the west, with development being replaced by forests in the east. Although portions of MDA R within and immediately adjacent to the High-Explosives Development Area are cleared of forest cover, some of the 11.5-acre (4.7-hectare) site is wooded. The 260 Outfall is generally tree covered.

Technical Area 21. Facilities at TA-21 are on a mesa between Los Alamos Canyon to the south and DP Canyon to the north. Developed portions of the TA present an industrial appearance. Undeveloped portions of the mesa remain vegetated with native grasses, shrubs, and small trees. The canyons are wooded. While portions of the site, particularly the water tower, can be seen from locations along NM 502, the MDAs are not visible. From higher elevations, developed portions of TA-21 have an industrial appearance and would be visible, although the MDAs would appear as cleared or grassy areas (DOE 1999e).

Technical Area 33. TA-33, in the southeast corner of LANL, is bordered by the Rio Grande on the east, TA-39 and TA-70 on the north, and Bandelier National Monument and Santa Fe National Forest on the west. Most of the TA is forested, although three small areas of development are present. As viewed from NM 4, the area would have a natural appearance. MDAs D, E, and K are within these developed areas, each containing buildings, roads, and parking lots; however, these areas are not visible to the public.

Technical Area 35. This TA is part of a highly developed portion of LANL extending along the upper 2.7 miles (4.3 kilometers) of Pajarito Road. This area therefore presents the appearance of a mosaic of industrial buildings and structures interspersed with forests along the mesa. Views of TA-35 are generally blocked by trees and other development along Pajarito Road. Mortandad Canyon is wooded and has a natural appearance when viewed from a distance and from nearby.

Technical Area 36. The largest LANL TA, TA-36 is traversed or bordered by several forested canyons, including Pajarito, Threemile, Potrillo, and Fence Canyons. Although TA-36 is largely undeveloped and forested, that portion of the TA containing MDA AA includes several buildings. MDA AA is an open area, although it is not accessible to the public.

Technical Area 39. Similar to other large TAs within this portion of LANL, TA-39 is largely forested with pockets of development. MDA Y is to the east of Ancho Road within a developed area. As with most other MDAs, the MDA is a cleared area that cannot be viewed by members of the public.

Technical Area 49. Only a small portion of TA-49 is developed, although several roads cut through portions of the site. Most of the TA is made up of scattered trees and shrubs with a grassy understory. Overall, the site has a natural appearance. The MDAs are within the Frijoles Mesa Site, which contains scattered buildings and roads. The MDAs appear little different than surrounding areas in that they are grass covered and contain scattered shrubs and trees.

Technical Area 50. TA-50 is along Pajarito Road. While much of the mesa along which the road passes is forested, TA-50 is one of a series of TAs along the upper 2 miles (3.2 kilometers) of the road within which development has taken place. Thus, this area presents the appearance of a mosaic of industrial buildings interspersed along a forested mesa. Views of the area from a distance are described in Chapter 4, Section 4.1.2, of this SWEIS. TA-50 includes both portions of the mesa and Mortandad Canyon. Development has occurred on that portion of the site north of Pajarito Road, with the remaining portions of the mesa and the canyon south of the road remaining forested. Although near views of TA-50 are industrial in nature, they are available only to site personnel because Pajarito Road is closed to the public. MDA C is along Pajarito Road and appears as a fenced grassy field. Future plans call for a landscape improvement buffer to be planted along Pajarito Road (LANL 2001c).

Technical Area 54. TA-54 is at the eastern end of Pajarito Road and borders both the San Ildefonso Pueblo and White Rock. While buildings and structures of the TA are visible from higher elevations to the west, near views of many TA elements are limited, as Pajarito Road is closed to the public. However, the dominant feature of the site is the white domes of MDA G in the eastern end of the TA. These domes contrast with the natural landscape and can be seen for many miles from locations in the Nambe-Española area and from locations in western and southern Santa Fe (LANL 2004f). They are visible from the lands of the San Ildefonso Pueblo. The remaining portions of MDAs G and L are less visible from a distance, as they do not contain similar structures.

Technical Area 61. TA-61 is in the northern portion of LANL along East Jemez Road. The TA is bordered by Los Alamos Canyon to the north and Sandia Canyon to the south. Although the Los Alamos County Landfill is the largest facility in TA-61, the borrow pit is also a significant feature. The borrow pit is 2 miles (3.2 kilometers) east of the landfill. Although much of TA-61 presents a forested appearance from higher elevations to the west, the borrow pit (and landfill) would be visible as an area devoid of vegetation. Yet the borrow pit is not visible from East

Jemez Road because of its location relative to the road, trees bordering the road, and a small hill on the north side of the pit.

Technical Area 73. This TA is along the northern boundary of LANL next to NM 502 (East Road). The Los Alamos County Airport is north of the road and DP Canyon is south of it. Views of the TA include those from the north across Pueblo Canyon and from East Road. Views from East Road include the airport to the north and undeveloped wooded areas to the south. The airport is visible from the subdivision to the west. A visual assessment of this tract, made in conjunction with the conveyance of land to Los Alamos County, determined that views of the airport have moderate value, while those of DP Canyon have high value (DOE 1999e).

I.4.2 Geology and Soils

Geology, soils, and mineral resources at LANL are addressed in Chapter 4, Section 4.2, of the SWEIS.

Geology. LANL site geology consists primarily of a complex series of interlayered volcanic deposits. As discussed in Section 4.2, the degree of welding, induration, and fracturing of the rocks at LANL plays an important role in slope stability and subsurface fluid flow. These characteristics are important because the MDAs have generally been cut to varying depths into the upper units of the Tshirege Member of the Bandelier Tuff to varying depths. This may provide a groundwater flow conduit between disposed materials and subsurface permeable rocks. Depending on their location and existing constructed surfaces, certain MDAs may be susceptible to erosion and surface failure (LANL 1999b).

Subunits of the Tshirege Member dip gently southeastward on the Pajarito Plateau. The paleotopography of the pre-Tshirege surface may strongly influence the direction of possible groundwater flow and contaminant migration in subsurface units beneath the MDAs. The paleotopography of the pre-Otowi surface may influence the flow direction of potential perched groundwater (DOE 1999a).

Soils. A description of LANL soils was included in the *1999 SWEIS* and is updated in Chapter 4, Section 4.2.3, of this SWEIS. This update includes a description of the soils, the effects of the May 2000 Cerro Grande Fire, and the soil monitoring program. In most cases, environmental restoration activities would not affect native soils because MDAs and PRSs are in areas that have already been disturbed by LANL activities.

Mineral Resources. The only mineral resource being mined at LANL is crushed tuff from the East Jemez Road borrow pit in TA-61. The source material is the Tshirege member of the Bandelier Tuff. Other materials needed to support the corrective action or closure program for LANL MDAs include soil to support vegetation and rock for erosion control. Local offsite sources and excess materials from LANL building construction are available.

I.4.3 Water Resources

Water resources are addressed in Chapter 4, Section 4.3, and Appendix E, Groundwater in the Vicinity of LANL, of the SWEIS. Appendix F, Environmental Sample Data, presents sample information pertaining to water resources.

Water resources in the LANL region include surface waters, sediments, floodplains, and groundwater located onsite, on adjacent properties, and extending to northern New Mexico and southern Colorado. The LANL area includes 15 regional watersheds (see Chapter 4, Figure 4–12), with 12 watersheds crossing LANL boundaries. Water resources were affected by the 2000 Cerro Grande Fire in that it increased the potential for surface runoff and soil erosion in burned areas (see Chapter 4, Section 4.3.1.7). Water resources were the focus of many of the investigations that have been performed at LANL. Several historical investigations pertaining to the LANL MDAs are summarized in the MDA Core Document (LANL 1999b). LANL water resources are a major focus of the Consent Order. Investigations being performed in accordance with the Consent Order are meant to fully characterize the nature, extent, fate, and transport of contaminants that may have entered groundwater and surface water resources at LANL.

Surface Water. Most canyons that drain the LANL site are dry for most of the year. Surface water in the area occurs primarily as short-lived or intermittent reaches of streams. Perennial surface water of varying lengths exists in Sandia, Pajarito, and Water Canyons, and Cañon de Valle. Many streams flow in response to only local precipitation or snowmelt. While there is minimal direct use of the surface water within LANL except by wildlife, streamflow may extend beyond the LANL boundaries where there may be more direct use of the water. LANL programs manage several sources that may impact local water resources, such as liquid effluents discharged through NPDES permitted outfalls, stormwater runoff, sediment transport, and dredge and fill activities or other work within perennial, intermittent, or ephemeral watercourses. LANL personnel routinely monitor surface water, stormwater, and sediments as part of LANL's ongoing environmental monitoring and surveillance program, and the results are published annually.

Sediments occur in and along LANL's canyons and watersheds, primarily as narrow bands of canyon bottom deposits that can be transported by surface water flows, effluent discharges, stormwater runoff, or flooding within canyons. Past LANL activities have caused contamination of sediments both onsite and downstream, occurring primarily because of effluent discharge from LANL outfalls and the transport of contaminated sediments from runoff and effluent flow. Sediments in some watersheds and canyons were transported and redistributed downstream from LANL after the Cerro Grande Fire. An overview of sediment quality and contamination levels is provided in Chapter 4, Section 4.3.1.5, of this SWEIS. Investigation and, if necessary, remediation of contaminated sediment at LANL is being conducted in conformance with the Consent Order and other regulatory criteria.

Floodplains are normally dry land areas that can become inundated with surface waters during a period of runoff due to precipitation or snowmelt. The Cerro Grande Fire impacted the extent and elevation of the floodplains in LANL canyons. Several flood and sediment structures were constructed as part of the emergency response to the fire. Following the fire, floodplain boundaries were remapped for all the major watersheds within LANL, as illustrated in Chapter 4, Figure 4–15, of this SWEIS.

Groundwater. Groundwater beneath the Pajarito Plateau is separated into alluvial groundwater in the canyons, intermediate perched groundwater beneath some of the canyons and the western portion of the plateau at depths of 100 to 750 feet (30.5 to 229 meters), and a regional aquifer at depths of 600 to 1,200 feet below the surface of the plateau. About 350 to 620 feet (107 to 189 meters) of unsaturated tuff, basalt, and low-moisture-content sediments separate the alluvial and perched groundwater zones and the regional aquifer. **Table I–81** summarizes the approximate depths of the regional groundwater table underneath the MDAs considered in this project-specific analysis, as well as the canyon watersheds associated with each MDA (LANL 1999b).

Table I–81 Watersheds and Depth to Regional Water by Material Disposal Area

Technical Area	*Material Disposal Area*	*Watershed/Canyon*	*Depth to Regional Water (feet)*
6	F	Twomile	1,275
8	Q	Pajarito	1,200
15	N	Cañon de Valle	1,170
15	Z	Cañon de Valle	1,200
16	R	Cañon de Valle	1,240
21	A	DP	1,230
21	B	Los Alamos	1,300
21	T	DP	1,240
21	U	DP	1,220
33	D	Rio Grande	910
33	E	Chaquehui	760
33	K	Chaquehui	820
35	X	Ten Site	1,160
36	AA	Potrillo	770
39	Y	North Ancho	590
49	AB	Ancho	1,120
50	C	Ten Site	1,175
54	G	Pajarito, Cañada del Buey	900
54	L	Cañada del Buey	940

Note: To convert feet to meters, multiply by 0.3048.
Source: LANL 1999b.

Effluent discharge, natural spring discharge, and stormwater runoff create surface waters that infiltrate into the alluvium of some canyons to create shallow, unconfined groundwater. Intermediate perched groundwater is often found beneath canyons having alluvial groundwater and usually does not extend laterally beneath the mesas. Intermediate perched zones may be confined or unconfined, and may not be contiguous along the length of a canyon.

Discharge of effluents has resulted in detection of radionuclide contamination in alluvial groundwater samples from DP, Los Alamos, and Mortandad Canyons. Tritium has been found in intermediate-depth wells in Pueblo, Los Alamos, Mortandad, Pajarito, and Water Canyons, and technetium-99 in one well in Mortandad Canyon. Nonradioactive contaminants found in alluvial and intermediate-depth groundwater samples in Pueblo, Los Alamos, Mortandad, Pajarito, Water, Cañon de Valle, and Sandia Canyons include chromium, nickel, molybdenum, perchlorate, nitrate, barium, 1,4-dioxane, and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (see Chapter 4, Section 4.3.2, of the SWEIS).

Regional groundwater flows toward the east and southeast to the Rio Grande. Little natural recharge occurs along the mesa tops where most LANL facilities and MDAs are located. For the past 5 years, LANL has been drilling and testing wells, monitoring wells, and modeling the subsurface groundwater hydrology as part of its *Hydrogeologic Work Plan* (see Chapter 4, Section 4.3.2, of the SWEIS). Some contamination of the regional aquifer has occurred, as summarized in Section 4.3.2. LANL personnel conduct subsurface modeling addressing contaminant transport pathways near water supply wells.

I.4.4 Air Quality and Noise

Chapter 4, Section 4.4, of the SWEIS presents a detailed discussion of the climate, current air quality, and noise environments at LANL.

I.4.4.1 Climatology and Meteorology

The Los Alamos region has a semiarid, temperate mountain climate (DOE 1999a). Climatological information presented in the *1999 SWEIS*, and as updated for this SWEIS, has been derived from measurements at the official Los Alamos meteorological weather station and tower which is in TA-6. Additional towers are located in TA-41, TA-49, TA-53, and TA-54, and on Pajarito Mountain. The locations of all six towers are shown in Chapter 4, Figure 4–19, of this SWEIS.

Meteorological conditions are influenced by the Pajarito Plateau elevation. For example, temperatures in the Los Alamos area vary with altitude, averaging 5 ^{o}F (3 ^{o}C) higher in and near the Rio Grande Valley and 5 to 10 ^{o}F (3 to 5.5 ^{o}C) in the Jemez Mountains. The Los Alamos region is characterized by seasonable, variable rainfall, with precipitation ranging historically from 10 to 20 inches (25 to 51 centimeters) per year. The normal annual precipitation for Los Alamos from 1961 to 1990 was 19 inches (48 centimeters). Annual precipitation rates within the county decline toward the Rio Grande Valley. For example, the Jemez Mountains receive over 25 inches (64 centimeters) of precipitation annually, while normal precipitation for White Rock has been 14 inches (34 centimeters). About 36 percent of the annual precipitation for Los Alamos County and LANL has resulted from thundershowers that occur in July and August. Los Alamos County wind speeds vary seasonally, but average 7 miles per hour (3 meters per second). (Wind rose information from the LANL meteorological stations is presented in Chapter 4, Section 4.4.1.1, of this SWEIS.) Thunder- and hailstorms are common in Los Alamos County, and lightning can be frequent and intense. Flash flooding is possible in arroyos, canyons, and low-lying areas (DOE 1999a).

Since publication of the *1999 SWEIS*, the LANL region has experienced a notable drought. As discussed in Chapter 4, Section 4.4.1, of this SWEIS, between 1995 and 2004, only 1 year (1997) had above-average precipitation. The drought facilitated the Cerro Grande Fire in May 2000.

A summary of the local climate data for MDAs as measured at the nearest LANL meteorological station from each MDA are presented in **Table I–82**. Mesas are typically sunnier and windier than the canyons or slopes (LANL 1999b).

Table I–82 Comparative Summaries for Los Alamos National Laboratory Meteorological Stations with Nearby Material Disposal Areas

Meteorological Station	*Nearby MDAs*	*Average Temperature (°C)*		*Average Temperature (°F)*		*Precipitation (inches per year)*	*Winds (meters per second)*	*Winds (miles per hour)* [a]
		Min	*Max*	*Min*	*Max*			
TA-6	F, Q, N, Z, R, X, C	1.8	15	35	59	19.69	2.49	5.6
TA-49	Y, AB	3.4	16	38	61	18.68	2.41	5.4
TA-53	A, B, T, U	4.4	17	40	62	15.97	2.9	6.5
TA-54	D, E, K, AA, G, L	0.99	18	34	64	14.57	2.74	6.1

°C = degrees Celsius, °F = degrees Fahrenheit, MDA = material disposal area, Min = minimum, Max = maximum, TA = technical area.
Source: LANL 1999b.

I.4.4.2 Air Quality and Visibility

Air quality considerations include nonradiological air quality in terms of criteria pollutants such as nitrogen dioxide, sulfur dioxide, and particulates; radiological air quality; and visibility. Los Alamos County, including LANL, is in attainment with all state ambient air quality standards and with the National Ambient Air Quality Standards (see Chapter 4, Section 4.4.2.3, of this SWEIS). As addressed in Chapter 4, Section 4.4.3, a long-standing and extensive program has existed at LANL to ensure that possible radiological exposures of members of the public from air emissions are maintained to levels as low as reasonably achievable below all applicable standards. Periodic environmental surveillance and compliance reports document compliance with state, EPA, and DOE standards.

Visibility is measured according to a standard visual range. Visibility has been monitored by the National Park Service at Bandelier National Monument since 1988. Average visibility from 1993 through 2002 ranged from 79 to 113 miles (127 to 182 kilometers) (LANL 2004f).

I.4.4.3 Noise, Air Blasts, and Vibration

The LANL noise, air blast, and vibration environment is discussed in Chapter 4, Section 4.4.5, of this SWEIS. Background sounds, vehicular traffic, routine operations, and high-explosives testing contribute to noise levels. Air blasts (air pressure waves or overpressures) are intermittent, accompanying an explosive detonation, and may be heard by workers and the public. Most ground vibrations are from aboveground explosives research.

Sound intensity is expressed in decibels (dB) above the standard threshold of hearing. Noise levels at frequencies corresponding to maximum human sensitivity are used to set human limits for auditory protection. These frequencies are called A-weighted (after middle A and its harmonics), and the sound intensity scale used for this purpose is given in dBA units.

Occupational exposures to noise are compared against a Threshold Limit Value established by the Occupational Safety and Health Administration. The Threshold Limit Value is the sound level to which a worker may be exposed for a specified work period without probable adverse effects on hearing. The Threshold Limit Value for continuous noise is 85 dBA over 8 hours.

The Threshold Limit Value for impulse (impact) noise over 8 hours is not fixed because the daily allowed number of impulses depends on the level of each impulse. No individual impulse should exceed 140 dBA. An action level of 82 dBA for both continuous and impulse noise over an 8-hour workday has been established at LANL. Use of protective equipment is recommended above the action level (DOE 2004b).

I.4.5 Ecological Resources

This section addresses the ecological setting (that is, terrestrial resources, wetlands, and protected and sensitive species) of each of the technical areas listed in **Table I–83**. Also addressed are the potential transport and uptake of wastes by plants and animals. Although there are reaches of perennial streams on LANL, no fish species have been found within the LANL boundaries.

Table I–83 Summary of Material Disposal Area and Potential Release Sites Vegetation Zones

Technical Area	*Site*	*Vegetation Zone*
Material Disposal Area		
6	F	Ponderosa pine
8	Q	Grassland
15	N	Ponderosa pine
15	Z	Grassland
16	R	Ponderosa pine
21	A	Ponderosa pine
21	B	Ponderosa pine
21	T	Ponderosa pine
21	U	Ponderosa pine
33	D	Juniper savannah
33	E	Pinyon-Juniper woodland
33	K	Pinyon-Juniper woodland
35	X	Ponderosa pine
36	AA	Pinyon-Juniper woodland
39	Y	Pinyon-Juniper
49	AB	Ponderosa pine
50	C	Ponderosa pine
54	G	Pinyon-Juniper woodland
54	L	Pinyon-Juniper woodland
Potential Release Site		
15	Firing Site E-F	Grassland
15	Firing Site R-44	Ponderosa pine
16	260 Outfall (16-021(c)-99)	Ponderosa pine
61	Borrow pit	Ponderosa pine
73	Ashpile	Ponderosa pine

Discussions of threatened and endangered species concentrate on those species for which Areas of Environmental Interest have been established. These include the Mexican spotted owl, bald eagle, and southwestern willow flycatcher. Areas of Environmental Interest have been established in accordance with a habitat management plan. An Area of Environmental Interest essentially consists of a core zone containing important breeding or wintering habitat and a buffer zone around the core area. The buffer protects the area from disturbances that would degrade the value of the core zone (LANL 1998b). Ecological resources of LANL as a whole are described in Chapter 4, Section 4.5, and vegetation zones are shown in Chapter 4, Figure 4–25, of this SWEIS.

Ecological Resources of Technical Areas

Technical Area 6. TA-6 is located primarily within the Ponderosa Pine Forest vegetation zone, although areas along the north-facing slope of Sandia Canyon are included in the Mixed Conifer Forest zone. Vegetation typical of the Ponderosa Pine Forest zone includes ponderosa pine (*Pinnus ponderosa* P&C Lawson), gambel oak (*Quercus gambelii* Nutt.), New Mexico locust (*Robinia neomexicana* Gray), and pine dropseek (*Blepharoneuron tricholepis* [Torr.] Nash). Located within the Ponderosa Pine Forest zone, MDA F is a grassy area of which portions are fenced; thus, its use by wildlife would be limited largely to birds, small mammals, and reptiles. Large mammals are excluded from much of the MDA because of fencing. The Cerro Grande Fire impacted TA-6 at severity levels varying from high to low-unburned. The portion of the TA containing MDA F burned at a low-unburned severity level (DOE 2000b). There are no wetlands within TA-6, although a narrow band of riparian vegetation exists along portions of the stream channel of Twomile Canyon.

The southeastern portion of TA-6 is within the core and buffer zones of the Pajarito Canyon Mexican spotted owl Areas of Environmental Interest. TA-6 does not fall within the Area of Environmental Interest for the bald eagle or southwestern willow flycatcher (LANL 2000c). MDA F is not in either the core or buffer zone of the Mexican spotted owl.

Technical Area 8. TA-8 falls primarily within the Ponderosa Pine Forest vegetation zone; however, the portion of the TA within which MDA Q is located is categorized as Grassland. Although the Cerro Grande Fire did not affect much of TA-8, its northeastern portion burned at a low-unburned severity level and a small area in the extreme northeast corner at a high severity level. That portion of the TA containing MDA Q burned at a low-unburned severity level (DOE 2000b). There are no wetlands or aquatic resources within the immediate vicinity of MDA Q, and no portion of TA-8 falls within any of the LANL Areas of Environmental Interest.

Technical Area 15. As is the case for TA-8, TA-15 is primarily located within the Ponderosa Pine Forest vegetation zone; however, areas within the central and southern part of the TA are classified as Grasslands. The Cerro Grande Fire affected about half of TA-15, burned at a low-unburned severity level. At this level, seed sources are expected to remain viable (DOE 2000b). MDA N and Firing Site E-F are located within the Grassland vegetation zone; however, all sites are grassy areas located near buildings and roads. One linear wetland is located in TA-15 within Threemile Canyon; however, it is not close to any MDA or firing site. This wetland is 0.3 acre (0.1 hectare) in size and contains Baltic rush (*Juncus balticus* Willd.) and a number of grasses (ACE 2005).

Portions of TA-15 are within the Pajarito Canyon, Threemile Canyon, and Water Canyon-Cañon de Valle Mexican spotted owl Areas of Environmental Interest. Core areas generally include the canyons, while buffer zones include some of the mesas. The areas containing the two firing sites do not include either the core or the buffer zones for any of the spotted owl Areas of Environmental Interest. However, MDAs N and Z are within the buffer zone of the Water Canyon-Cañon de Valle Area of Environmental Interest, with a small portion of MDA Z within the core zone. Areas of Environmental Interest for the bald eagle and southwestern willow flycatcher do not include any portion of TA-15 (LANL 2000c).

Technical Area 16. Vegetative cover within TA-16 is largely ponderosa pine; however, an area of grassland occurs within the west-central part of the TA, and a mixed conifer forest occurs along north-facing slopes of Cañon de Valle and Water Canyon. Most development within TA-16 has occurred within the Ponderosa Pine Forest vegetation zone. Although the western part of the TA was not burned during the Cerro Grande Fire, most of the remaining area burned at a low-unburned severity level. However, the central part of the TA burned at a medium severity level (DOE 2000b). At this level, seed stocks can be adversely affected and erosion can increase because of the removal of vegetation and ground cover (DOE 2000b). Within the Ponderosa Pine Forest vegetation zone, MDA R and the 260 Outfall burned at a low-unburned severity level. Excepting those portions of MDA R and the outfall that are within and immediately adjacent to the High-Explosives Processing Area, both PRSs are in forested areas that provide habitat for species common to mixed conifer forests, including large mammals.

Two wetlands have been identified within TA-16; however, they are located a considerable distance to the east of MDA R and the 260 Outfall. These wetlands total 0.04 acre (0.02 hectare) in size and contain Baltic rush and various grasses (ACE 2005).

Only the eastern portion of TA-16 is within the Water Canyon-Cañon de Valle Mexican spotted owl Area of Environmental Interest. Additionally, a very small area on the northern border of the TA is within the buffer zone of the Pajarito Canyon Areas of Environmental Interest. MDA R and the 260 Outfall are not included in either Area of Environmental Interest. No part of the TA is included within Areas of Environmental Interest for the southwestern willow flycatcher or bald eagle (LANL 2000c).

Technical Area 21. About 20 percent of the TA is developed. Although most of TA-21 is within the Ponderosa Pine Forest vegetation zone, the more easterly portion of Los Alamos Canyon is within the Pinyon-Juniper Woodland zone. Wildlife within undisturbed portions of the TA would be typical of those two zones (DOE 1999a). The Cerro Grande Fire did not directly affect TA-21 (DOE 2000b). The MDAs are fenced grassy fields (except those portions of MDAs A and B that are covered with asphalt); thus, wildlife would be limited to birds, small mammals, and reptiles. Large mammals are excluded from the MDAs because of fencing. No wetlands have been identified within TA-21 (ACE 2005).

TA-21 is entirely within the Los Alamos Canyon Area of Environmental Interest, with the southern and eastern portions included within the core zone. The MDAs are located within developed areas of TA-21 that are within both the core and buffer zones of the Los Alamos Canyon Areas of Environment Interest (LANL 2000c). TA-21 does not include any portion of the Areas of Environmental Interest for the bald eagle or southwestern willow flycatcher.

Technical Area 33. Although TA-33 is mostly within the Pinyon-Juniper Woodland vegetation zone, the eastern part of the TA is within the Juniper Savannah zone at lower elevations near the Rio Grande River. The TA is largely undeveloped. None of TA-33 was affected by the Cerro Grande Fire (DOE 2000b). Although only one small (0.01-acre [0.004-hectare]) wetland dominated by cattails (*Typha* spp.) is within the TA, the TA borders the region's most important aquatic resource, the Rio Grande (ACE 2005). MDAs D and K are within the Pinyon-Juniper Woodland vegetation zone, while MDA E is within the Juniper Savannah vegetation zone. All three MDAs are located away from the wetland and river.

Being located near the Rio Grande River, the eastern portion of TA-33 is within portions of the White Rock Canyon bald eagle Area of Environmental Interest. Yet of the three MDAs within the TA, only MDA D is within this Area of Environmental Interest; however, the MDA is within the core zone. Because bald eagles winter along White Rock Canyon adjacent to the Rio Grande, the Area of Environmental Interest is considered occupied from November through March.

Technical Area 35. TA-35 is entirely within the Ponderosa Pine Forest vegetation zone, but is a highly developed area. Yet the portions of the TA falling within Mortandad Canyon are in a natural state and thus contain wildlife typical of ponderosa pine forests. TA-35 burned at a low-unburned severity level during the Cerro Grande Fire (DOE 2000b). The only wetland present within TA-35 is located in the northwest corner of the TA and is an extension of a wetland primarily located in TA-55. This wetland is 1.2 acres (0.5 hectare) in size; coyote willow (*Salix exigua* Nutt.), cattail, Baltic rush, and various sedges (*Carex* spp.) are some of the species present (ACE 2005).

TA-35 is within the Pajarito Canyon and Sandia-Mortandad Canyon Mexican spotted owl Areas of Environmental Interest. While the southern portion of the TA is within the buffer zone of the former Area of Environmental Interest, the entire TA is within either the buffer or core zone of the latter Area of Environmental Interest.

Technical Area 36. TA-36 is the largest TA at LANL and encompasses both Pinyon-Juniper Woodland and Ponderosa Pine Forest vegetation zones. The TA is largely undeveloped and provides habitat suitable for species typical of both zones. Only the very northern portion of TA-36 was burned during the Cerro Grande Fire, at a low-unburned severity level (DOE 2000b). Although MDA AA is generally within the Pinyon-Juniper Woodland vegetation zone, it is within a developed portion of the TA. It therefore provides minimal wildlife habitat. Although not situated in the immediate area of MDA AA, a series of nine wetlands are within TA-36 along Pajarito Canyon. These wetlands total 15.2 acres (6.2 hectares). Plants found within these wetlands include coyote willow, Baltic rush, sedges, common spike rush (*Eleocharis palustris* (L.) Roemer & Schultes), American speedwell (*Veronica americana* Schwein. ex Benth), and cattail. There are no aquatic resources near MDA AA.

TA-36 includes portions of the buffer and core zones of the Pajarito Canyon, Threemile Canyon, and Water Canyon-Cañon de Valle Mexican spotted owl Areas of Environmental Interest. However, MDA AA is not within any of these three Areas of Environmental Interest (LANL 2000c).

Technical Area 39. Although most of TA-39 is in a Pinyon-Juniper Woodland vegetation zone, the northwestern part of the TA includes an area of grassland and ponderosa pine forest on the north-facing slopes of Water and Ancho Canyons. Because the area is largely undeveloped, wildlife typical of each vegetation zone is expected. TA-39 was not impacted by the Cerro Grande Fire (DOE 2000b). MDA Y is within the Pinyon-Juniper Woodland portion of the TA; however, it is a cleared area along Ancho Road that provides little wildlife habitat. There are no wetlands or aquatic resources in TA-39.

The northern portion of TA-39 includes both buffer and core zones of the Water Canyon-Cañon de Valle Mexican spotted owl Area of Environmental Interest. MDA Y is located in the central portion of the TA and does not fall within this Area of Environmental Interest (LANL 2000c).

Technical Area 49. TA-49 contains three separate vegetation zones—Ponderosa Pine Forest, Pinyon-Juniper Woodland, and Grassland. In general, Ponderosa Pine Forest is found on north-facing canyon slopes, while Pinyon-Juniper Woodland is present in the eastern quarter of the TA and Grassland occupies the remainder of the area.

The TA is largely in a natural state with a few scattered buildings at the Frijoles Mesa Site. Wildlife using the TA would include species typical of each vegetation zone. TA-49 was largely unaffected by the Cerro Grande Fire because only the northern edge of the TA burned at a low-unburned severity level (DOE 2000b). MDA AB is in the Frijoles Mesa Site in the central portion of the TA and is presently within the Grassland vegetation zone. The separate MDA AB areas are grass covered with scattered shrubs and trees. There are no wetlands within TA-49.

The northern part of TA-49 is within both the buffer and core zones of the Water Canyon-Cañon de Valle Mexican spotted owl Area of Environmental Interest. It does not include portions of the Areas of Environmental Interest for the bald eagle or southwestern willow flycatcher. The northern elements of MDA AB are within the buffer zone of the Mexican spotted owl Area of Environmental Interest (LANL 2000c).

Technical Area 50. TA-50 is within the Ponderosa Pine Forest vegetation zone. Although most of the area north of Pajarito Road has been developed, the area south of the road is in a more natural state. During the Cerro Grande Fire, the entire TA burned at a low-unburned severity level (DOE 2000b). Wildlife within undeveloped portions of the TA would be typical of ponderosa pine forests (DOE 1999a). MDA C is a relatively large grassy area that is fenced. Wildlife would be limited to small mammals, birds, and reptiles. There are no wetlands within TA-50.

TA-50 is within both the core and buffer zones of the Pajarito Canyon Mexican spotted owl Area of Environmental Interest and the buffer zone of the Sandia-Mortandad Canyon Area of Environmental Interest. MDA C falls within the buffer zone of both Mexican spotted owl Areas of Environmental Interest. TA-50 does not include portions of the Areas of Environmental Interest for the bald eagle or southwestern willow flycatcher (LANL 2000c).

Technical Area 54. TA-54 is primarily within the Pinyon-Juniper Woodland vegetation zone; however, a ponderosa pine forest occurs on the north-facing slope of Cañada del Buey. Wildlife using the TA would include species typical of both vegetation zones. Although most of the area was untouched by the Cerro Grande Fire, the northwestern portion of the TA burned at a low-unburned to medium severity level. At a medium severity level, seed stocks can be adversely affected and erosion can increase because of the removal of vegetation and ground cover (DOE 2000b). MDAs G and L are disturbed areas having minimal ground cover, and each is enclosed by a fence. Thus, wildlife would be limited to small mammals, birds, and reptiles. Large mammals are excluded from the MDAs because of fencing. Although a series of wetlands occur along Pajarito Canyon (see the description of TA-36), none are found within any of the MDAs (Marsh 2001).

A portion of TA-54 is within the core and buffer zones of the southwestern willow flycatcher Areas of Environmental Interest; however, the Area of Environmental Interest is restricted to the canyon and does not include any part of the MDAs. Areas of Environmental Interest for the Mexican spotted owl and bald eagle do not encompass any part of TA-54 (LANL 2000c).

Technical Area 61. TA-61, including the borrow pit, falls within the Ponderosa Pine Forest vegetation zone. Although wildlife within undeveloped portions of the TA would be typical of ponderosa pine forests, the borrow pit lacks cover and therefore suitable habitat for wildlife. Most of TA-61 was unaffected by the Cerro Grande Fire. However, the very eastern portion of the TA, including the borrow pit area, burned at a low-unburned severity level (DOE 2000b). There are no wetlands or aquatic resources within the borrow pit site. However, the largest contiguous wetland on LANL, the Sandia wetland, is south of the Los Alamos County Landfill. This wetland is dominated by cattails. In 2000, it encompassed 3.5 acres (1.4 hectares), a 48 percent reduction in size from 1996; presently, it covers 3 acres (1.2 hectares) (Bennett, Keller, and Robinson 2001; ACE 2005).

TA-61 is within the buffer and core zones of both the Los Alamos Canyon and Sandia-Mortandad Canyon Mexican spotted owl Area of Environmental Interest. The borrow pit is within the buffer zone of the former and the core zone of the latter (LANL 2000c). TA-61 does not fall within the Area of Environmental Interest for the bald eagle or southwestern willow flycatcher (LANL 2000c).

Technical Area 73. TA-73 is covered by ponderosa pine forest and pinyon-juniper woodland in the east. Wildlife using the TA would include species typical of both vegetation zones such as mule deer and elk (DOE 1999a). The TA was not burned by the Cerro Grande Fire (DOE 2000b). There are no perennial surface watercourses within the TA. There are no wetlands in TA-73 (ACE 2005).

TA-73 is within the Los Alamos Canyon Mexican spotted owl Area of Environmental Interest. A small section of the southeastern part of the TA is within the core zone, while the remaining portions of TA-73 are within the buffer zone. TA-73 does not encompass any part of the Areas of Environmental Interest for the southwestern willow flycatcher or bald eagle (LANL 2000c).

Potential Transport and Uptake of Wastes

The ecological setting of the MDAs affects the potential for transport and uptake of radioactive and chemical constituents. Animals may burrow into disposal units, excavating contaminated materials and providing conduits for moisture to the waste. Plants can grow roots into disposal units, incorporating contaminants that may be dispersed to surface soil when the plants defoliate. Plants can also reduce erosion of disposal unit covers and remove moisture from the soil that could otherwise percolate into disposal units. Typical plant species common to the Pajarito Plateau have average measured root depths ranging from less than 0.3 feet (0.1 meters) to greater than 5 feet (1.6 meters). Typical indigenous burrowing animals have average measured burrow depths ranging from about 0.3 feet (0.1 meters) to nearly 10 feet (3.0 meters) (LANL 1999b).

I.4.6 Human Health

Chapter 4, Section 4.6, of this SWEIS discusses measures taken at LANL to maintain the quality of human health for both workers and the public. Chapter 4, Figures 4–26 and 4–27 illustrate radiation doses to populations and maximally exposed individuals from 1993 through 2005.

I.4.7 Cultural Resources

Cultural resources are human imprints on the landscape and are defined and protected by Federal laws, regulations, and guidelines. Cultural resources within LANL and its region are classified as archaeological resources, historic buildings and structures, and traditional cultural properties. Cultural resources at LANL are addressed in Chapter 4, Section 4.7, of this SWEIS. This section summarizes the cultural resources of each of the technical areas addressed in Section I.4.1.1. Cultural resources are not expected within the MDAs themselves because all MDAs are highly disturbed areas.

I.4.7.1 Archaeological Resources and Historic Buildings and Structures

Technical Area 6. Twelve archaeological resource sites have been identified within TA-6. These sites include rock features, an artifact scatter, a one- to three-room structure, structures, wagon road segments, water control features, and a fence. Four of the 12 archaeological sites are eligible for listing in the National Register of Historic Places, 5 are of undetermined status, and 3 are not eligible. There is one historic structure eligible for listing in the National Register of Historic Places, the “concrete bowl” in TA-6. There are seven cultural resource sites in the vicinity of MDA F.

Technical Area 8. TA-8 contains 11 archaeological sites, including lithic scatters, a wagon road segment artifact scatters, a lithic and ceramic scatter, and a historic structure. Of these sites, four are eligible for listing in the National Register of Historic Places, 1 is of undetermined eligibility, 1 is not eligible, and 5 have not been evaluated for their eligibility. Six historic buildings in TA-8 are eligible for listing in the National Register of Historic Places. Three are located near MDA Q. Only one cultural resource site is in the vicinity of MDA Q.

Technical Area 15. TA-15 contains numerous cultural resource sites; thus, this section identifies only those sites within about a 1,000-foot (305-meter) radius of each MDA and firing site. There are 9 archaeological sites in the vicinity of MDA N, 7 sites in the vicinity of MDA Z, 11 sites in the vicinity of Firing Site E-F, and 3 sites in the vicinity of Firing Site R-44. These sites include Pueblo roomblocks, a plaza Pueblo, a water control structure, one- to three-room structures, cavates, a lithic scatter, and a rock shelter. Of these features, thirteen are eligible for listing in the National Register of Historic Places, 4 are not eligible, and 14 have yet to be formally assessed for their eligibility. Two historic buildings in TA-15 are eligible for listing in the National Register of Historic Places. One of these buildings is within the R-44 SWMU. However, there are 26 additional significant buildings that have yet to be assessed for National Register of Historic Places eligibility.

Technical Area 16. Although TA-16 contains a fairly large and diverse number of cultural resource sites, only two are in the vicinity of MDA R and the 260 Outfall. One site is a lithic scatter of undetermined prehistoric affiliation. One site is an archaeological site that has not been formally evaluated for National Register of Historic Places eligibility, but is considered not eligible for listing. However, there is a historic process building that is eligible and is situated about 1,300 feet (400 meters) south of MDA R and the 260 Outfall. There are also other archaeological sites and National Register of Historic Places-eligible buildings within the TA, but none are in the vicinity of MDA R or the 260 Outfall.

Technical Area 21. Five archaeological sites have been identified within TA-21. These sites include a cavate, a rock shelter, trails or stairs, and an enclosure. These sites are eligible for listing on the National Register of Historic Places. One of the historic trails passes close to MDA B. Sixteen buildings and structures eligible for listing in the National Register of Historic Places are located within TA-21, a number of which are near the MDAs.

Technical Area 33. Similar to TA-15, TA-33 contains numerous cultural resource sites. Thus, the following discussion addresses only those resources in the vicinity of each MDA. There is one archaeological site near MDA D, six near MDA E, and three near MDA K. Archaeological sites in the vicinities of the MDAs include Pueblo roomblocks, one- to three-room structures, a lithic scatter, a cavate, rock shelters, and rock features. Four of these sites are eligible for listing in the National Register of Historic Places, one is not eligible, and two are of undetermined eligibility. Seven National Register of Historic Places-eligible buildings and structures are in TA-33. Additionally, there are other potentially significant historic buildings that have not yet received eligibility assessments.

Technical Area 35. TA-35 does not contain any known archaeological sites, but does include one building eligible for listing in the National Register of Historic Places. There are other potentially significant historic buildings that have not been assessed for National Register of Historic Places eligibility.

Technical Area 36. Because TA-36 contains numerous archaeological sites, only those resources within the vicinity of MDA AA are addressed. The three cultural resource sites identified near MDA AA include a one- to three-room structure, a rock shelter, and lithic and ceramic scatters. None of the sites have been formally assessed for eligibility for listing in the National Register of Historic Places; however, without further evaluation, one is deemed to be eligible and the other two are deemed to be of undetermined eligibility. One structure, north of MDA AA, is eligible for listing on the National Register of Historic Places. There are other potentially significant historic buildings that have not been assessed for National Register of Historic Places eligibility.

Technical Area 39. TA-39 is the second largest TA at LANL and contains numerous archaeological sites; thus, only those in the vicinity of MDA Y are addressed. Seven archaeological sites are in or near MDA Y. These resources include lithic and ceramic scatters, rock features, cavates, and a rock shelter. None of the sites have been formally determined to be eligible for listing in the National Register of Historic Places; however, they are all deemed eligible or potentially eligible for listing. To date, no building or structure in TA-39 has been formally determined eligible for listing in the National Register of Historic Places. However, there are other potentially significant historic buildings that have not yet been reviewed for eligibility.

Technical Area 49. As with other large TAs on LANL, TA-49 contains numerous archaeological sites; thus, only those resources in the vicinity of MDA AB are summarized in this section. Forty-four archaeological sites are near MDA AB and include rock art, rock features, rock shelters, lithic scatters, one- to three-room structures, Pueblo roomblocks, and plaza Pueblos. Twelve of the 44 cultural resource sites have been formally declared eligible or potentially eligible for listing on the National Register of Historic Places, 1 is not eligible, and 31 are of undetermined status. Two buildings eligible for listing in the National Register of Historic Places are in TA-49; both are in the general vicinity of MDA AB. There is one additional potentially significant historic building that has not yet been assessed for eligibility.

Technical Area 50. TA-50 contained a single archaeological site and historic structure south of MDA C that was eligible for listing on the National Register of Historic Places. This site has been excavated. Currently, there are no buildings or structures in TA-50 eligible for listing. However, there are several potentially significant historic buildings that have yet to be reviewed for National Register of Historic Places eligibility.

Technical Area 54. Because TA-54 has many cultural resource sites, only those resources within the vicinity of MDAs G and L are addressed. There are 22 cultural resource sites near MDA G and 10 near MDA L. Of the cultural resource sites near MDA G, 7 have been excavated within the MDA area and 1 partially excavated within Zone 4. Fifteen of the sites are eligible for listing on the National Register of Historic Places. The 10 sites near MDA L are also eligible for listing on the National Register of Historic Places. Sites include lithic scatters, rock art, rock shelters, cavates, Pueblo roomblocks, plaza Pueblos, one- to three-room structures, and pit structures. Twenty-eight sites are eligible for listing in the National Register of Historic Places. A number of prehistoric sites were within MDA G; however, these were examined by archaeologists before its development. No buildings or structures in TA-54 have been evaluated for National Register of Historic Places eligibility. There are, however, four potentially significant historic buildings within TA-54.

Technical Area 61. TA-61 contains six archaeological sites. These sites include a trail and stairs, a number of cavates, and a historic structure. Four of the archaeological sites are eligible for listing in the National Register of Historic Places. Two sites are of undetermined eligibility. There are no cultural resources in the immediate vicinity of the borrow pit. No buildings or structures within TA-61 are eligible for listing in the National Register of Historic Places.

Technical Area 73. Nine archaeological sites have been identified within TA-73, including lithic and ceramic scatters, a cavate, a one- to three-room structure, a Pueblo roomblock, garden plots, and trails or stairs. Four of the archaeological sites are eligible for listing in the National Register of Historic Places. Two are not eligible, and three are of undetermined status. None of the cultural resource sites within TA-73 are near the ashpile. Two historic buildings within

TA-73 are eligible for listing on the National Register of Historic Places. One of these, a storage building, is in the vicinity of the ashpile. There are several other potentially significant historic buildings within TA-33 that have yet to be assessed for National Register of Historic Places eligibility.

I.4.7.2 Traditional Cultural Properties

A traditional cultural property is a significant place or object associated with historical and cultural practices or beliefs of a living community rooted in the community's history and is important in maintaining the community's continuing cultural identity. Within LANL's boundaries, there are ancestral villages, shrines, petroglyphs, sacred springs, trails, and traditional use areas that could be identified by Pueblo and Athabascan communities as traditional cultural properties. See Chapter 4, Section 4.7.3, for a discussion of traditional cultural properties. Some of the cultural resources addressed above may also be considered important in maintaining the continuing cultural identity of the local pueblo communities and so are considered traditional cultural properties.

I.4.8 Socioeconomics and Infrastructure

Socioeconomics and infrastructure are addressed in Chapter 4, Section 4.8, of this SWEIS and summarized below.

I.4.8.1 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The number of jobs created could affect regional employment, income, and expenditures. Job creation is characterized by (1) construction-related jobs that tend to be short in duration and transient, and thus less likely to impact public services; and (2) operation-related jobs that would last longer and could thus create additional service requirements. Chapter 4, Section 4.8.1, of this SWEIS summarizes, in the LANL region, economic characteristics, demographic characteristics, regional income, housing, local transportation, and the growth in recent years of the LANL-affiliated workforce. LANL currently has about 13,500 employees. These employees have had a positive economic impact on northern New Mexico.

I.4.8.2 Infrastructure

Site infrastructure includes the physical resources required to support the construction and operation of LANL facilities (see Chapter 4, Section 4.8.2). Utility infrastructure encompasses the electrical power, natural gas, steam, and water supply systems at LANL. Electrical service to LANL is supplied through a cooperative arrangement with Los Alamos County, the Los Alamos Power Pool. DOE operates a natural-gas-fired steam and electrical power generating plant within TA-3, capable of producing up to 20 megawatts of power. The natural gas system includes a high-pressure main and distribution system to Los Alamos County and pressure-reducing stations at LANL buildings. Over 90 percent of the gas used at LANL is used for heating. The Los Alamos water production system consists of 14 deep wells, 153 miles (246 kilometers) of main distribution lines, pump stations, and storage tanks. The system supplies potable water to all of the county, LANL, and Bandelier National Monument.

I.4.9 Waste Management

LANL has a well-developed infrastructure and extensive facilities for managing radioactive, toxic, and hazardous materials. Many facilities are in TA-50 and TA-54 and include treatment of liquid radioactive and hazardous wastes; solid radioactive waste through measures such as dewatering or compaction; hazardous wastes (particularly characteristic wastes) through methods such as neutralization or reaction to eliminate reactivity concerns; and high explosive-contaminated material, often by burning. LANL has facilities to characterize the radioactive and hazardous content of the waste. Some wastes are stored onsite, including some low-level radioactive, TSCA, and hazardous wastes, as well as transuranic wastes. Stored transuranic wastes are being retrieved for repackaging and shipment to WIPP. Additional information is in Chapter 4, Section 4.9, of this SWEIS.

Solid waste disposal capacity will exist at LANL on a temporary basis. LANL and Los Alamos County have both used a solid waste landfill located within TA-61. Established in 1974, the landfill must close to comply with solid waste management regulations administered by NMED (LANL 2005d). The landfill is expected to operate through fall 2008 (Finfrock 2008). A solid waste transfer station located at the existing county landfill is to open at that time. Access to the landfill is via East Jemez Road (LANL 2005d). LANL nonhazardous waste will be processed through this new transfer station, and municipal and LANL waste will be transported to a location outside of Los Alamos County. Waste will be collected, processed, and transferred into larger trucks before being shipped offsite. Management and operation of the transfer station will be by Los Alamos County (LANL 2005a).

The only operating low-level radioactive waste disposal facility at LANL is at Area G in TA-54. Disposal of mixed low-level radioactive waste is not authorized, although disposal of waste containing PCBs occurs. Low-level radioactive waste disposal operations will be expanded initially into Zone 4 of TA-54, an expansion of about 30 acres (12 hectares), and then as necessary into Zone 6 of TA-54 (72 acres total). This expansion was addressed in Volume II (*Project-Specific Siting and Construction Analyses*) of the *1999 SWEIS* (DOE 1999a) (see Appendix H, Section H.3). The disposal units at Zone 4 would contain shafts for wastes requiring special controls (such as remote-handled-waste or wastes containing biological hazards or PCBs), as well as several pits or trenches for routine wastes. Assuming a delivery rate of 2,600 to 3,900 cubic yards (2,000 to 3,000 cubic meters) of waste per year, Zone 4 should be able to provide disposal capacity for 40 to 60 years (LANL 2005h).

I.4.10 Transportation

Motor vehicles are the primary means of transportation at LANL (see Chapter 4, Section 4.10). Principal access routes to each of the MDAs and PRSs listed in Table I–80 are listed in **Table I–84**. The principal access road to the TA-61 borrow pit is East Jemez Road.

Table I–84 Principal Access Routes to Material Disposal Areas and Selected Solid Waste Management Units

TA	*MDA or SWMU*	*Principal Access*	*Comments*
6	MDA F	Twomile Mesa Road	Terminates in TA-40 to the west; intersects with Anchor Ranch Road and West Jemez Road (NM 501) to the east.
8	MDA Q	Anchor Ranch Road	Intersects with West Jemez Road to the southwest.
15	MDA N	R-Site Road	Intersects with Anchor Ranch Road to the west. Anchor Ranch Road intersects with West Jemez Road to the southwest.
15	MDA Z SWMUs E-F, R-44		Intersects with R-Site Road to the north.
16	MDA R	K-Site Road	Intersects with Anchor Branch Road.
16	SWMU 260 Outfall	K-Site Road	Intersects with Anchor Ranch Road.
21	MDAs A, B, T, U	DP Road	Intersects just to the west of TA-21 with NM 502 in the Los Alamos Townsite.
33	MDAs D, E, K	NM 4	
35	MDA X and other nearby SWMUs	Pecos Drive	Intersects with Pajarito Road in TA-50.
36	MDA AA	Potrillo Drive	Intersects with Pajarito Road in TA-18.
39	MDA Y	NM 4	
49	MDA AB	Frijoles Mesa Drive	Intersects with NM 4 to the west.
50	MDA C	Pajarito Road	Passes through TA-50 and intersects with NM 501 (East and West Jemez Roads) to the east and NM 4 to the west.
54	MDAs G and L	Mesita del Buey Road	Intersects with Pajarito Road in the northern area of TA-54. Pajarito Road intersects with NM 501 (East and West Jemez Roads) to the east and NM 4 to the west.
73	Ashpile	East Road	

TA = technical area, MDA = material disposal area, SWMU = solid waste management unit, NM = New Mexico.

Figure I–25 shows many of the principal transportation routes within LANL. Materials such as concrete or fill dirt could be delivered using NM 4 to the west or NM 502 to the east. Waste and materials moved within LANL would be transported mainly over NM 501 (East and West Jemez Roads), NM 502, NM 4, and Pajarito Road. Much of the waste sent offsite from LANL for treatment or disposal may be transported over NM 502 to the east (**Figure I–26**). NM 502 intersects with NM 30 in San Ildefonso. NM 30 passes north to Española. NM 502 continues east, interesting with US 285/84. US 285/84 is routed north to Española and south to Santa Fe, where it intersects with I-25. A new Santa Fe bypass connects with US 285/84 north of Santa Fe and passes to the northwest of Santa Fe, connecting with I-25 west of Santa Fe. I-25 connects with I-40 in Albuquerque to the south.

The primary route designated by the State of New Mexico for radioactive and other hazardous material shipments to and from LANL is the 40-mile (64-kilometer) corridor between LANL and I-25 at Santa Fe. This route passes through the Pueblos of San Ildefonso, Pojoaque, Nambe, and Tesuque and along the northern segment of Bandelier National Monument (DOE 1999a).

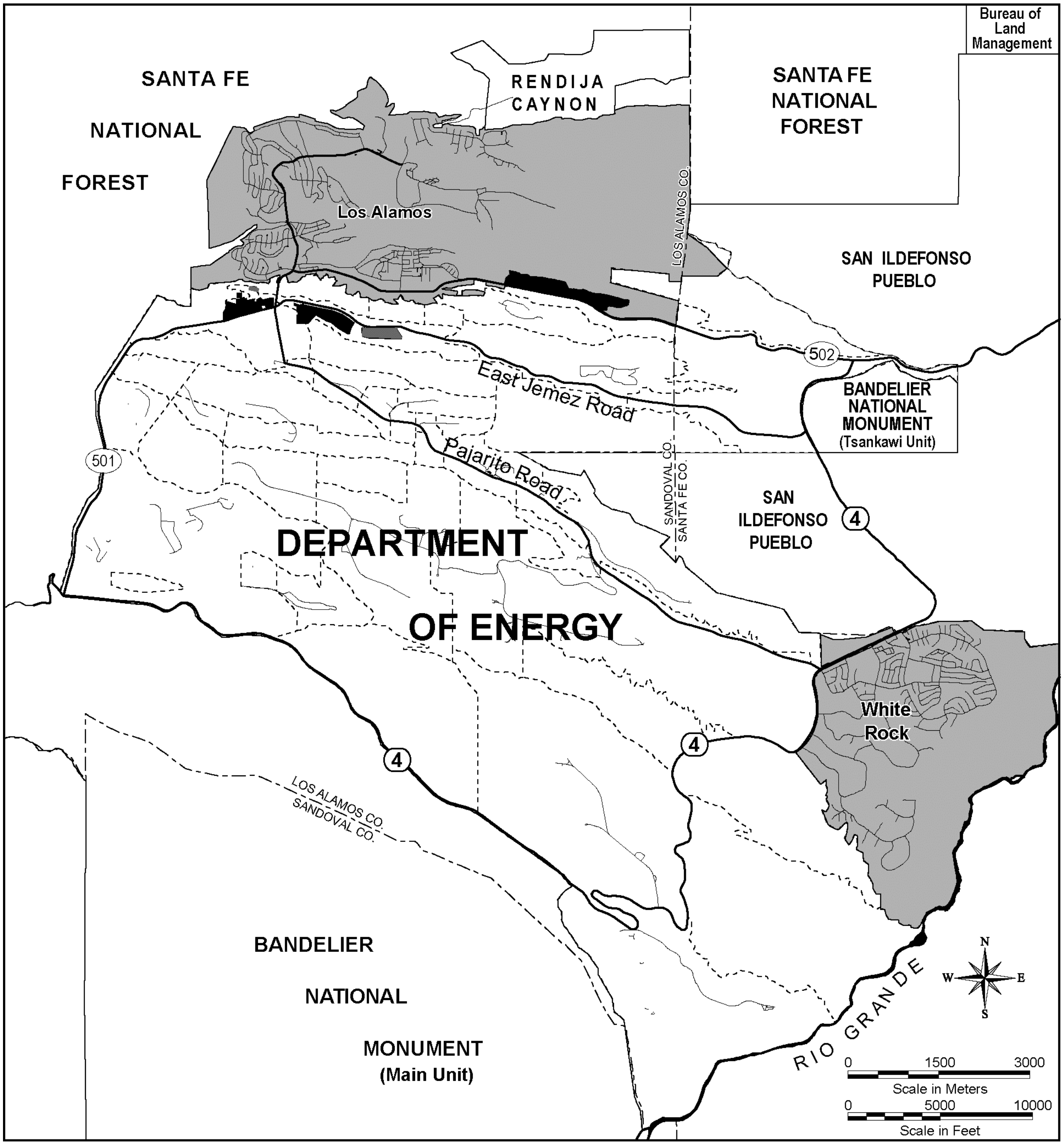

Figure I–25 Major Transportation Routes within Los Alamos National Laboratory

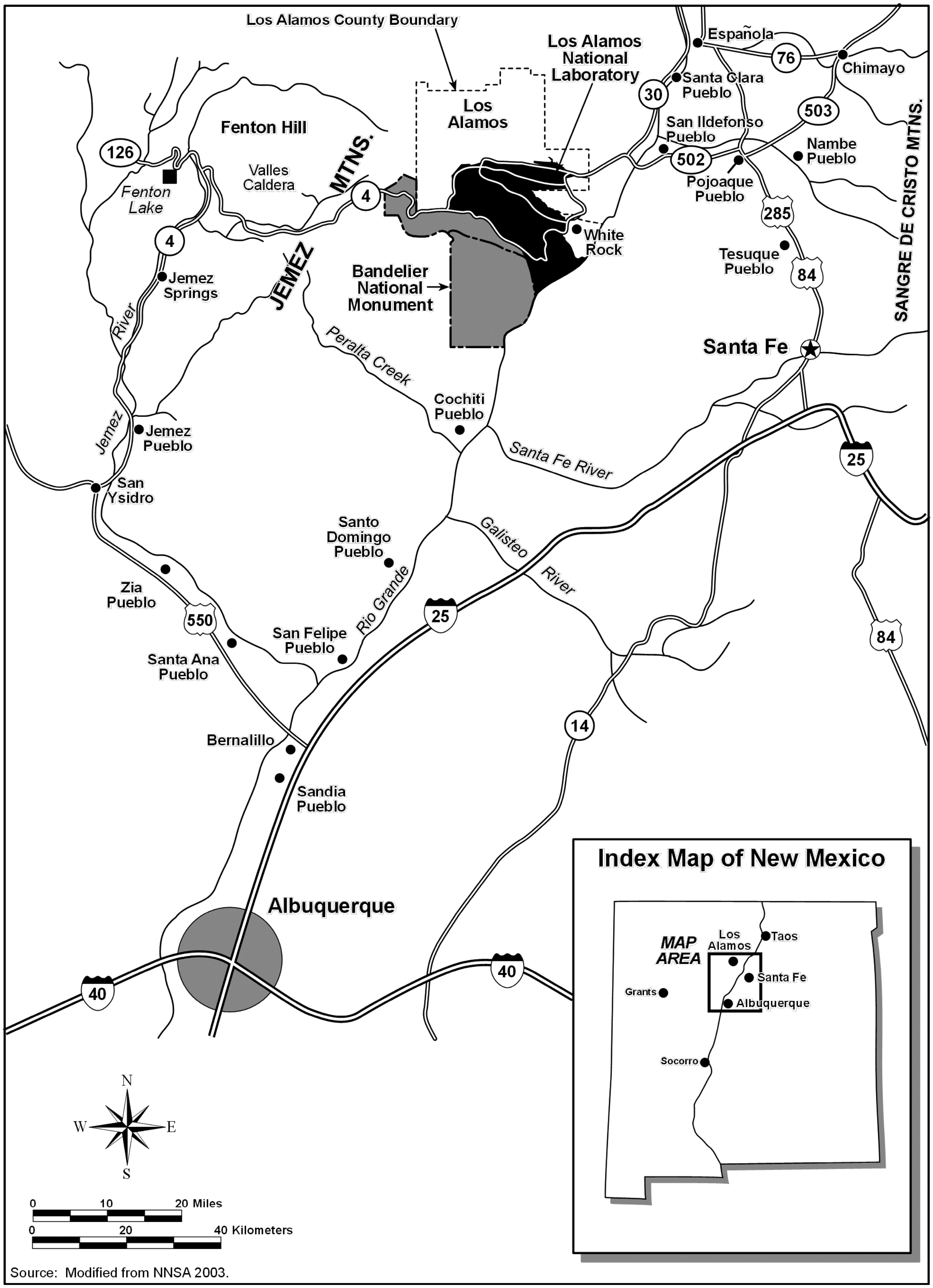

Figure I–26 Major Transportation Routes Outside of Los Alamos National Laboratory

I.4.11 Environmental Justice

As summarized in Chapter 4, Section 4.11, of this SWEIS, a majority of residents (54 percent) in the eight potentially affected counties surrounding LANL designated themselves as minorities in the 2000 Census. Hispanics and American Indians composed approximately 91 percent of the minority population. The percent of low-income population residing in these counties was reported to be approximately 13 percent in the 2000 census, compared to nearly 18 percent of the total population of New Mexico.

Estimates of transportation impacts are based on an assumed route from LANL heading east on NM 502 and south toward I-25 passes through San Ildefonso, Pojoaque, Nambe, and Tesuque Pueblo lands.

The Pueblo of San Ildefonso is a minority-dominated community and had a median household income of $30,457 in the 2000 census. About 12.4 percent of the families lived below the poverty level. The median household income in Pojoaque was $34,256, with 11.3 percent of families living below the poverty level (DOE 2004b).

I.5 Environmental Consequences

The major options considered in this appendix are No Action, Capping, and Removal. As the LANL environmental restoration project continues, so do operational and decommissioning activities at LANL. These activities may have environmental benefits and detriments, and will generate wastes requiring treatment and disposal. DD&D of structures in TA-18 and TA-21 is addressed in Appendix H, Sections H.1 and H.2. Wastes projected from recovery of transuranic waste from storage are addressed in Section H.3. Total wastes from all sources are addressed in Chapter 5, Section 5.9, of this SWEIS.

I.5.1 Land Resources

Resources include land use and the visual environment (physical characteristics, air quality, light pollution).

I.5.1.1 No Action Option

Under the No Action Option, LANL would continue its environmental restoration project at levels as described for the Expanded Operations Alternative in the *1999 SWEIS* (DOE 1999a).

I.5.1.1.1 Land Use

Continuing LANL's environmental restoration project would reduce the amount of land and property at LANL that is contaminated with radioactive or hazardous constituents. There would be a wider range of options for future use of this land and property. However, many, if not most, of the PRSs being addressed under LANL's environmental restoration project are near other operating facilities. Operation of these facilities, and the missions conducted within the TAs containing these facilities, are largely independent of remediation actions for individual PRSs. Therefore, continuing the environmental restoration project would probably not change many basic restrictions such as control of access to LANL and particular TAs. Restrictions would probably continue consistent with security or safety needs. Nonetheless, within the context of the overall LANL mission and that for particular TAs, continuing the environmental restoration project could result in expanded options for some lands and property.

I.5.1.1.2 Visual Environment

Continuing LANL's environmental restoration project should generally improve visual resources as older structures and signage warning of possible hazards are removed for lack of need, and areas are revegetated. But there could be some temporary, short-term reductions in the visual environment. For example, vegetative covers over small portions of land being remediated may be removed. But this visual effect would be temporary until vegetation is restored. Small quantities of dust could be generated, which could slightly reduce visual quality. But dust generation would be localized and temporary and could be mitigated.

But the large domes at Area G in TA-54 would remain until operations associated with the domes (such as transuranic waste storage) are completed. The domes contrast with the natural landscape and can be seen from the Nambe-Española area, from areas in western and southern Santa Fe, and from lands of the San Ildefonso Pueblo. Recovery of aboveground stored waste is planned for completion by the end of FY 2012. DD&D of structures in Area G will be performed in three phases during FY 2010, FY 2012, and FY 2014, to be completed early in FY 2015 (see Appendix H, Section H.3, of this SWEIS).

I.5.1.2 Capping Option

I.5.1.2.1 Land Use

Site Investigations. Consent Order investigation programs such as well installation and monitoring will not change the designated land use in the TAs where the investigations take place. Wells or other monitoring equipment should not require significant dedication of land once installed. However, there may be temporary commitments of land to construct the investigation systems. For example, installation of a well may require temporary clearing of several hundred square feet of vegetation. But this resource commitment would be short lived. Following well installation, the affected land would be allowed to return to its original condition.

Remediation of MDAs. Because the Capping Option would stabilize rather than remove existing contamination, future use of the MDAs would remain restricted. At present, most MDAs are open areas that are fenced and excluded from any use other than safely maintaining inventories of waste. In the future, the MDAs would continue to be surveyed and maintained to protect public health and safety and the environment.

Although 37 acres (15 hectares) of TA-21 either have been or will be conveyed to Los Alamos County, conveyance of most of TA-21 has been deferred. Many of the structures in TA-21 will be removed (see Appendix H, Section H.2). Yet because capping would stabilize rather than remove existing contamination, development within the TA would be restricted. The MDAs are within areas designated as No Development Zone (Hazard). This designation is expected to continue under the Capping Option.

Capping the MDAs within TA-54 would result in no significant change to current restrictions on accessing the land comprising the MDAs. Overall, those portions of TA-54 currently used as waste management areas would still be used for that purpose. If some of the transuranic waste currently stored in the Area G shafts is left in place (see Section I.3.3.2.1.2.2), then long-term institutional controls (which include land use restrictions, signage, and other controls) may be needed, as called for in 40 CFR Part 191.

The Capping Option would maintain the commitment of roughly 110 acres (45 hectares) of land as waste disposal areas. In addition, the Capping Option would involve the temporary commitment of land to support capping activities; following capping, the land would be remediated as needed and made available for other uses. As addressed in Section I.3.6.5, temporary support areas may include project management areas, areas for parking personal vehicles, areas for temporarily storing any wastes that may be generated, and areas for stockpiling bulk materials. Project management areas are expected to be small, involving total commitment of only a few acres for all MDAs. For most MDAs, personal vehicles could probably be parked at existing facilities; little additional parking capacity should be needed. Because capping MDAs is expected to generate only small quantities of waste, only a few acres would be temporarily affected as waste storage areas.

The largest temporary commitment of land would be for temporary storage of bulk capping materials. Assuming that capping requires the temporary storage of a 6-month supply of materials at each MDA, then 37 to 81 acres (15 to 33 hectares) of land could be temporarily affected.[75]

Remediation decisions at the MDAs may involve a combination of measures (some portions capped; some portions removed). Activities at TA-21 will include DD&D as well as MDA remediation, which may in combination temporarily affect up to 130 acres (53 hectares).

Remediation of Other PRSs. Removal of contamination at PRSs such as Firing Sites E-F and R-44 at TA-15 would probably not result in significant changes in land use. Remediating the firing sites would not independently change the operational mission assigned to TA-15, and the land use classification would remain High-Explosive Testing. Remediating the 260 Outfall would result in no change in land use; TA-16 is expected to remain as LANL's high explosive processing area, with attendant security restrictions. Similarly, action to remediate groundwater and surface water contamination within canyons (or elsewhere) would not by itself change current land use within the TAs containing these canyons.

Remediation of PRSs may directly affect several acres of land on an annual basis, assuming that remediation involves removal of contamination from the affected area. Additional acreage may be temporarily committed to support remediation. For example, removal operations at surface contamination sites such as firing sites may require the temporary establishment of management areas (including management trailers) or waste storage and processing areas. Remediation of subsurface volatile organic compound plumes will require temporary commitment of small quantities of land for extraction or offgas treatment systems. Installation of subsurface barriers such as slurry walls or permeable reactive barriers will require temporary areas for project

[75] *Includes capping contaminated areas in TA-49.*

management, equipment parking, and bulk materials storage. Possible installation of groundwater pump-and-treat systems may require a temporary commitment of land for equipment installation. Operation of the systems would require temporary dedication of land for pumping equipment, treatment systems, plumbing, and temporary water storage.

Borrow Pit. Use of the borrow pit on East Jemez Road in TA-61 as a source for capping materials would result in no changes to the current land use category for the TA (Physical and Technical Support and Reserve).

I.5.1.2.2 Visual Environment

Site Investigations. Consent Order investigation programs will have some visual impacts. There would be temporary clearing or vegetation disruption to construct the investigation systems. Installing a well may require temporary clearing of several hundred square feet of land. But visual impacts would be short lived. Cleared or disrupted areas would be allowed to return to their original condition. Site monitoring and sample collection systems would be unobtrusive.

Remediation of MDAs. Capping the MDAs would have short-term visual impacts. It would require stripping or disrupting the existing vegetative cover over the MDAs, placing cover materials in compacted lifts, and providing for revegetation. But not all land would be affected at the same time, and many of the MDAs are not readily visible by the public.

The Capping Option would involve placement of final covers on up to 110 acres (45 hectares) of LANL property containing MDAs and landfills. However, because capping would take place over a period of 10 years of different times within different TAs, a much smaller area would be affected during any single year. In addition to presenting a disturbed appearance, there could be temporary visual impacts of suspended dust. These impacts could be mitigated using water sprays or other techniques.

In addition, there would be areas temporarily affected by support operations needed to construct the caps. In addition to small project management areas for MDAs requiring remediation, there would be areas used by site workers for parking personal vehicles, as well as areas used for temporary management of waste or demolition debris, or temporary storage of bulk materials such as crushed tuff. These areas would have an industrial appearance. However, it is probable that most of the areas so affected would be in previously disturbed areas, and because most MDAs are near existing LANL facilities, parking areas may already largely exist, meaning no change in existing appearance.

The average affected will depend on regulatory decisions, operational needs, and related LANL activities. Remediation decisions for the MDAs may involve a combination of measures. Activities at TA-21 will include DD&D as well as MDA remediation, which may temporarily impact up to 130 acres (53 hectares).

After capping is completed for most MDAs, there would be only minor changes in visual resources. Once the MDAs are capped, those visible from higher elevations to the west would have the same grassy appearance as they had before capping began. Support areas would be remediated as needed. But similar to the No Action Option, there would be a noticeable improvement at Area G within TA-54, where a grassy field would eventually replace the visually intrusive white domes. This replacement would improve views from the Jemez Mountains, the Pueblo of San Ildefonso, and as far away as the towns of Española and Santa Fe.

If some of the transuranic waste currently stored in the Area G shafts is left in place (see Section I.3.3.2.1.2.2), then long-term institutional controls may be needed as called for in 40 CFR Part 191. Passive institutional controls would include markers or other devices intended to warn against unauthorized intrusion into the disposal area, and these markers or devices, which would be designed to be long lasting, may be visible at a distance.

Remediation of Other PRSs. Visual impacts associated with remediating other PRSs would depend on their location and the nature and extent of the contamination. For example, the firing sites in TA-15 are in a restricted, wooded area. Because removal of contamination would involve surface recovery rather than excavation, minimal damage to existing vegetation would probably occur. Remediating the 260 Outfall would require partial clearing and excavating some areas. Any visual impacts of dust or particulate matter that may be suspended from remediation operations could be mitigated. Remediation of subsurface volatile organic compound plumes would require installation of vapor removal and treatment systems that would be small and visually unobtrusive. Installation of subsurface barriers such as slurry walls or permeable reactive barriers would require temporary disruption of land, but affected land could be revegetated as needed. Possible use of groundwater pump-and-treat systems may result in a temporary industrial appearance at the remediation sites, given the possible need for pumping equipment, treatment systems, plumbing, and temporary water storage. These systems should be relatively compact, however.

In any event, several acres of land may be annually visually affected through continued remediation of dozens of LANL PRSs. Individual affected areas would be generally small, and many would be in locations not routinely accessed by the public. Once remediation is complete, the affected areas would quickly return to a similar appearance, when viewed from afar, to that before remediation was initiated.

Borrow Pit. Visual impacts may be associated with operation of the borrow pit in TA-61 to provide fill for MDA capping. Quantities of fill and other materials needed to cap the MDAs would be large. To obtain the required fill, the small hill that currently screens the pit from observation from East Jemez Road may require removal. Thus the pit, which is a cleared area several acres in size, may become visible from East Jemez Road. There could also be visual impacts of suspended dust from borrow pit operation. These impacts could be mitigated using water sprays or other techniques. (See Section I.5.4.2.1 for an estimate of the quantities of dust raised from borrow pit operation.)

I.5.1.3 Removal Option

I.5.1.3.1 Land Use

Site Investigations. Impacts on land use under the Removal Option would be the same for site investigations as under the Capping Option.

Removal of MDAs. Under the Removal Option, there would be fewer restrictions on land use than under the Capping Option. Capping the MDAs is expected to cover about 110 acres (45 hectares) of land, which would be retained as exclusion areas for radioactive waste. Removing the MDAs could free the land occupied by the MDAs for other purposes. Any buffer area surrounding the MDAs could also be used for other purposes.

But implementation of the Removal Option may not cause major changes in the designated uses of the TAs containing MDAs. Operating or inactive contaminated facilities would remain near MDAs C, G, and L. Assuming complete removal at MDAs A, T, and U, there may be residual stabilized contamination after other, nearby, structures are removed (see Appendix H, Section H.2). After removal of MDA AB, other nearby PRSs in TA-49 may remain. A similar situation exists at the other, smaller, MDAs. While future use of the remediated sites is not yet known, it is likely that the land would be reused to support existing and future LANL missions.

The Removal Option would involve the temporary commitment of land to support removal operations; following removal, the land would be remediated as needed and be made available for other uses. Temporary support areas may include project management areas; areas for parking personal vehicles; areas for temporary storage of waste; capacity for storing bulk materials such as excavation spoil; and capacity for waste hazard identification, waste processing, or characterization. Project management area requirements will be probably small for most MDAs. Larger area commitments may be needed for removal of large MDAs such as MDA C or G. For most MDAs, personal vehicles could probably be parked at existing facilities. However, removal of MDA G could require a large work force, which may require development of additional capacity for vehicle parking.

It is expected that removing the MDAs could require up to 63 acres (25 hectares) for temporary storage or management of mostly low-activity bulk waste. Assuming that removing the MDAs requires the temporary storage of a 6-month supply of spoil, then the Removal Option would temporarily affect up to 99 acres (40 hectares) of land for bulk material storage. An additional 10 to 22 acres (4 to 9 hectares) would be temporarily affected for capping remaining disposal units in Area G and small areas in TA-49. Also, 84 acres (34 hectares) may be needed to site several hazard identification, waste processing, or characterization facilities around LANL. However, because removal would take place over a period of 10 years at different times within different TAs, smaller areas than those estimated above would be affected annually.

Remediation decisions for the MDAs may involve a combination of measures. Remediation will be coordinated with other LANL activities such as DD&D. Combined DD&D and MDA remediation at TA-21 may temporarily affect up to 130 acres (53 hectares).

Remediation of Other PRSs. The Removal Option is expected to have the same effect on land use for other LANL PRSs as the Capping Option.

Borrow Pit. The Removal Option is expected to have the same effect on land use for the TA-61 borrow pit as the Capping Option.

I.5.1.3.2 Visual Environment

Site Investigations. Visual impacts of the Removal Option would be the same for site investigations as under the Capping Option.

Remediation of MDAs. Under the Removal Option, many of the larger MDAs may be exhumed under enclosures similar to those used for transuranic waste recovery at TA-54. (The investigation and remediation program at MDA B will be conducted under enclosures.) These enclosures would be visible from greater distances than would the MDAs under the Capping Option, but their presence would be temporary. After waste removal is completed, the enclosures would be removed and the backfilled excavations revegetated. MDAs not exhumed under enclosures would present a disturbed appearance while removal takes place. However, after removal is complete, the excavations would be backfilled and revegetated.

As under the Capping Option, implementation of the Removal Option would temporarily visually affect land used to support removals. Support activities could include management and staging areas; waste inspection, treatment, packaging, and storage areas; equipment decontamination areas; parking areas for worker vehicles; and areas for bulk storage of materials such as exhumed soil. The amount of acreage so affected would depend on regulatory decisions, operational needs, and other LANL infrastructure and activities. Remediation decisions for the MDAs may involve a combination of measures, as contemplated for MDA B within TA-21. DD&D and MDA remediation within TA-21 may temporarily impact up to 130 acres (53 hectares).

The Removal Option would probably cause smaller visual impacts of suspended dust than the Capping Option. Waste removal at the larger MDAs may occur within enclosures, and air exhausted from these structures would be filtered.

Remediation of Other PRSs. The Removal Option is expected to have the same visual impacts for other LANL PRSs as the Capping Option.

Borrow Pit. Visual impacts may be associated with operation of the borrow pit in TA-61 to provide backfill for the excavated MDAs. Quantities of fill would be large and comparable to those required under the Capping Option (see Section I.5.1.2.2). To obtain the required fill, the small hill that currently screens the pit from observation from East Jemez Road may require removal. Thus the pit, a cleared area several acres in size, may become visible from East Jemez Road. The potential for visual impacts of suspended dust would be comparable to those under the Capping Option.

I.5.2 Geology and Soils

Resource areas of interest are: (1) the possibility of geological effects on MDAs and other PRSs; (2) soil contamination; and (3) the need for soil, rock, and similar materials for MDA remediation. Site investigations conducted under the Consent Order, as well as LANL surveillance and maintenance programs for nuclear environmental sites, should have little or no effect on these resource areas.

I.5.2.1 No Action Option

Under the No Action Option, concerns identified at the MDAs and all other PRSs at LANL from erosion or other mass-wasting processes would be addressed. But action to address the long-term protection of the MDAs from erosion and other possible mass-wasting damage would not occur consistent with the schedules in the Consent Order.

The environmental restoration project would continue to address contamination in soil or other media at the LANL PRSs. But the activities of LANL environmental restoration project activation would not necessarily be consistent with the schedules or priorities of the Consent Order.

The TA-61 borrow pit would continue to operate at existing levels.

I.5.2.2 Capping Option

Geological Effects. Covers for the MDAs would be contoured and provided with runon and run-off control measures consistent with their design. In addition, soils adjacent to or beneath the waste may be affected by construction of vertical or subwaste horizontal containment walls. The final designs of the covers would follow completion of the corrective measure studies being performed for the Consent Order. The corrective measure studies would include conceptual models of each MDA that would consider long-term geologic processes such as cliff retreat.

Soil Contamination. Other than that existing as a gas or vapor, contamination within the subsurface of the MDAs and in the immediate vicinities would be fixed in place. Capping would not by itself address any contamination existing as vapor within soil, such as volatile organic compounds or tritium as a gas or vapor. However, soil vapor volatile organic compounds can be removed and treated using unobtrusive equipment that would be compatible with the installed evapotranspiration covers (see Section I.3.3.2.2.4). Remediation of the firing sites, the outfalls, and other PRSs would address existing soil contamination at these PRSs.

Borrow Pit. Under the Capping Option, the MDAs would be capped in place using evapotranspiration covers. To construct these covers, from 750,000 to 2,000,000 cubic yards (570,000 to 1,500,000 cubic meters) of crushed tuff may be needed through 2016, assuming that all such material is obtained from the TA-61 borrow pit. (From 370,000 to 930,000 cubic yards (280,000 to 710,000 cubic meters) of crushed tuff would be needed through 2011.) The site containing the borrow pit covers 43 acres (17 hectares). Assuming an excavation depth of 50 feet (15 meters), excavating 750,000 cubic yards (570,000 cubic meters) of tuff would create a hole 9.3 acres (3.8 hectares) in size, while excavating 2,000,000 cubic yards (1,500,000 cubic meters) of tuff would create a 50-foot (15-meter) hole roughly 25 acres (10 hectares) in size.

Alternatively, the required fill for the MDA covers may be partially obtained from offsite sources, at additional cost and transportation impacts. In addition to fill, construction of the MDA covers through 2016 would require 440,000 to 460,000 cubic yards (340,000 to 350,000 cubic meters) of additional rock, gravel, topsoil, and other bulk materials from local sources. The total quantity of crushed tuff, rock, and other bulk materials needed through 2016 would range from 1.2 to 2.5 million cubic yards (0.92 to 1.9 million cubic meters).

I.5.2.3 Removal Option

Geological Effects. Complete removal of the MDAs would eliminate concern about the susceptibility of the MDAs to erosion or other geological processes. For partial removal of MDAs, there would be residual, but reduced, concerns because high-concentration pockets of contamination would be removed.

Soil Contamination. This option would greatly reduce existing soil contamination in the vicinity of the MDAs. Contamination existing as a soil or gas would also be largely eliminated. Remediation of the firing sites, outfalls, sediments in canyons, and other PRSs would address existing soil contamination at these PRSs.

Borrow Pit. Under the Removal Option, the waste in all MDAs considered in this appendix would be removed. Roughly 1,300,000 cubic yards (990,000 cubic meters) of backfill would be needed to replace the excavated waste and contamination, as well as 61,000 cubic yards (47,000 cubic meters) of rock, gravel, topsoil, and other bulk materials obtained from local sources. In addition, from 190,000 to 510,000 cubic yards (150,000 to 390,000 cubic meters) of crushed tuff would be needed for capping the remaining disposal units at the existing Area G footprint in TA-54, plus 160,000 cubic yards (120,000 cubic meters) of additional bulk materials from local sources. Roughly 31,000 to 84,000 cubic yards (24,000 to 64,000 cubic meters) of crushed tuff, and 2,600 to 7,000 cubic yards (2,000 to 5,400 cubic meters) of additional materials may be needed to cap other landfills, and contaminated areas such as those in Areas 6 and 12 of TA-49. A total of 1.6 to 1.9 million cubic yards (1.2 to 1.5 million cubic meters) and about 220,000 cubic yards (170,000 cubic meters) of rock, gravel, and other bulk materials would be needed, or about 1.8 to 2.2 million cubic yards (1.4 to 1.7 million cubic meters) of combined tuff, rock, and other bulk materials.

Assuming that the crushed tuff would be obtained from the TA-61 borrow pit, then removal of up to 1,900,000 cubic yards (1,500,000 cubic meters) of material from the pit would create a 50-foot (15-meter) hole, 24 acres (9.7 hectares) in size. The demands on the borrow pit would be comparable to those under the Capping Option and could, again, be reduced by obtaining some backfill from other local sources.

I.5.3 Water Resources

Possible impacts on surface water and groundwater resources would be addressed as part of any required corrective measure evaluation to be performed for MDAs and other PRSs in accordance with the Consent Order. A corrective measure evaluation for an MDA would consider alternatives, including capping and removal, two bounding options for MDA remediation that are considered in this appendix.

I.5.3.1 No Action Option

I.5.3.1.1 Surface Water

Under the No Action Option, surface water quality would be gradually improved as continuing corrective measures are performed on LANL PRSs. There would be fewer risks to surface water because sources of contamination in soil and sediments would be stabilized in place or removed.

I.5.3.1.2 Groundwater

Gradual improvements to groundwater quality would occur.

Investigative and monitoring programs have long existed at LANL to assess the presence of contaminants, and to obtain information needed to predict impacts on water resources. Investigations have addressed radionuclide transport beneath pits at MDA G, tritium transport around disposal shafts at MDA G, volatile organic compound transport at MDA L and MDA G, and plutonium transport at MDA T. Investigations intended to characterize vadose zone hydrologic conditions have included injection well tests, natural tracer analyses, chloride measures, stable isotope measurements, and in situ moisture monitoring (LANL 1999b).

In compliance with an earlier version of DOE's Radioactive Waste Management Order, DOE 435.1 (DOE 2001), a performance assessment and a composite analysis were issued in 1997 for the Area G low-level radioactive waste disposal facility in TA-54 (LANL 1997). The performance assessment addresses all waste projected to be disposed of at Area G following September 25, 1988, while the composite analysis addresses all sources of radioactive material within the disposal area that may cause impacts on a hypothetical future member of the public. The performance assessment and composite analysis are of interest because of the large inventory of radionuclides within Area G. The results of the analyses are summarized in **Table I–85** and represent projected exposures to members of the public over the next 1,000 years (LANL 1997).

Table I–85 Material Disposal Area G Performance Assessment and Composite Analysis Summary Results

Inventory	*Analysis*	*Location*	*Calculated Peak Dose (millirem per year)*	*Performance Objective (millirem per year)*
Performance assessment	Air pathway	Cañada del Buey	6.6×10^{-2}	10
Composite analysis	All pathways	Cañada del Buey	5.5 [a]	30 to 100
Performance assessment	Groundwater protection	White Rock Pajarito Canyon	4.5×10^{-5} [b]	4
Performance assessment	All pathways	White Rock Pajarito Canyon	1.0×10^{-4}	25
Composite analysis	All pathways	White Rock Pajarito Canyon	7.2×10^{-3} [c]	30 to 100

[a] This dose was determined at an assumed receptor location in Cañada del Buey assuming airborne suspension and transport of surface contamination from biotic intrusion into buried waste.

[b] From Section 4.1.2 of LANL 1997, the peak annual dose within 1,000 years was 4.5×10^{-5} millirem, occurring at 700 years at the Pajarito Canyon location of maximum projected groundwater concentration. Beyond 1,000 years, the peak annual dose was 1.4×10^{-5} millirem, occurring at 4,000 years at a location 330 feet (100 meters) downgradient of MDA G.

[c] From Section 4.2.1 of LANL 1997, the dose of 7.2×10^{-3} millirem was determined at an assumed receptor location in Pajarito Canyon, and includes a 1.9×10^{-7} millirem dose from hypothetical ingestion of groundwater. A dose of 1.2×10^{-5} millirem was determined at a location 330 feet (100 meters) downgradient of MDA G, and includes a 4.6×10^{-6} millirem dose from hypothetical ingestion of groundwater.

Source: LANL 1997.

With respect to the groundwater pathway, the model used for the analyses considered transport of contaminants from leachate vertically downward through the vadose zone to the regional aquifer or laterally to the perched alluvial groundwater in Pajarito Canyon, where the contaminants may be transported downward to the regional aquifer. For the performance assessment, doses for the groundwater pathway were determined at hypothetical receptor locations at the LANL boundary near White Rock, at a point 330 feet (100 meters) east-southeast of MDA G, and in Pajarito Canyon. For the composite analysis, doses for the groundwater pathway were determined at the locations of maximum projected concentration downgradient of MDA G and in Pajarito Canyon (LANL 1997). The doses were calculated assuming the continuation of the existing temporary disposal covers at Area G.

The performance assessment and composite analysis for Area G are being revised. Work being done at LANL to develop conceptual models of the hydrogeology and numerical models of groundwater flow under the Pajarito Plateau will be incorporated into the revised performance assessment and composite analysis and will be applicable to future modeling efforts such as those used to develop remediation alternatives for the MDAs in corrective measure evaluations. Many of the more recent efforts to develop these conceptual models were published in an August 16, 2005, online publication of *Vadose Zone Journal*. Journal articles are summarized in Appendix E of this SWEIS.

Researchers developing improved conceptual models have postulated low rates of downward migration based on low rates of infiltration (for example, 0.04-0.08 inches [1-2 millimeters] per year) at LANL mesa tops, particularly in the eastern part of LANL (Birdsell et al. 1999, 2000, 2005; Kwicklis et al. 2005). A newly generated infiltration map for the Los Alamos area has been constructed using estimates of infiltration at points in upland areas, as well as estimates of streamflow losses and gains along canyon bottoms (Kwicklis et al. 2005). Although infiltration rates of less than 0.08 inches (2 millimeters) per year were estimated for mesa tops, larger infiltration rates were estimated at higher elevations in the Sierra de los Valles (for example, greater than 25 millimeters per year in mixed conifer areas to greater than 7.9 inches (200 millimeters) per year for areas having aspen). Canyon bottom infiltration rates depend on the size and elevation of the canyon's watershed and on the history of effluent discharge. Canyon infiltration rates can range from those that are not significantly different from surroundings mesa tops to several hundred millimeters per year (Kwicklis et al. 2005).

Either by increased matrix flow or fracture flow, flow focusing can cause flow and contaminant migration to increase above that otherwise predicted. For example, LANL staff point out that although mesa tops exhibit low infiltration, rates can become high in mesa top areas that contain faults or have become "disturbed" in some manner (for example, areas covered with asphalt or located in drainage diversions). Such anomalous (non-"background") infiltration rates should be considered in risk assessments of disturbed areas (Kwicklis et al. 2005). In the more extreme cases, the net infiltration rate has been estimated to be as high as 12 inches (300 millimeters) per year (Birdsell et al. 2005).

(Birdsell et al. 2005) describes conditions, and the results from disturbances, at two dry mesas, Mesita del Buey and Frijoles Mesa. At Mesita del Buey, downward fluxes vary with depth and across the mesa and are estimated to range from 0.001 to 0.2 inches (0.03 to 6 millimeters) per year. The estimates were made using volumetric moisture content and chloride data (Newman 1996) from four boreholes and from numerical modeling (Birdsell et al. 2000). Further, the four boreholes have depth intervals where fluxes are smaller than 1 millimeter per year. Chloride-based residence times range from 1,300 to 17,000 years (Newman 1996). These estimates of flux and residence time indicate very little water movement.

But there is evidence that dry mesa conditions can change when the water balance is perturbed; for example, when water is added to the soil from wastewater lagoons or stormwater diversion ditches. Focused runoff from an asphalt pad near a borehole on Mesita del Buey caused ponding in a localized area. Moisture content measurements in the borehole showed increasing water content as deep as 24 meters (roughly 80 feet) in less than 10 years after the ponding was initiated (Birdsell et al. 2005).

Dry conditions at Frijoles Mesa are similar to those at Mesita del Buey (that is, estimated infiltration rates are 0.3 to 2 millimeters per year, based on chloride data from a 210-meter borehole). At MDA AB on Frijoles Mesa, hydrodynamic testing was performed in 1960 and 1961 at the bottoms of numerous deep shafts that had been backfilled with sand and crushed tuff. One area at MDA AB was paved with asphalt in 1961 in an attempt to minimize surface contamination. But the asphalt inhibited evapotranspiration and dammed surface water along its edge. In 1975, the asphalt pad over a backfilled shaft collapsed, leaving a 6 × 7 × 4 foot (1.8 × 0.9 × 1.2 meter) hole in the asphalt and underlying fill, and probably causing the standing water seen in Core Hole 2. After the standing water was bailed dry, the asphalt developed cracks; estimates of leakage through the cracked pad ranged from 2.4 to 15 inches (60 to 388 millimeters) per year. Standing water was again observed in Core Hole 2. Data from two other boreholes in 1994 indicated elevated water contents to a depth of 18 meters (roughly 60 feet). In contrast, background water-content profiles measured in five boreholes around the site showed tuff water content below about 10 feet (3 meters) to be less then ten percent. Numerical simulations for MDA AB based on an infiltration rate of 2.4 inches (60 millimeters) per year during the period 1961 through 1994 showed a reasonable fit to a water content profile obtained in 1994 (LANL 1992b, Birdsell et al. 1999, 2005). In 1998 and 1999, Core Hole 2 was grouted and abandoned, the asphalt was removed, and the site regraded and capped with an evapotranspiration cover (see Section I.2.5.3). Since then, the upper 20 feet (6 meters) of soil beneath the cover appear to be slowly drying (Levitt et al. 2005, Birdsell et al. 2005).

The field and laboratory study by Nyhan et al. (LANL 1984) at Area T illustrated that water can move rather efficiently through the tuff at mesa tops, and that mobile contaminants can move quickly in response to the water flux. Roughly 1.2 million gallons (4,600 cubic meters) of water were disposed of in Absorption Pit 1 at Area T over a 2-month period (LANL 1984).

Subsurface contaminant data collected beneath the absorption beds show evidence of contaminant transport associated with fractures, while subsurface data collected in boreholes adjacent to the beds showed none. The general assumption is that fracture transport occurred while the beds actively received liquid waste, and that the contaminants associated with the fractures are remnants of previous fracture flow episodes. The data support the idea that some fractures in the nonwelded to moderately welded tuff will flow when the matrix is saturated (Birdsell et at. 2005).

Flow focusing of some form may have caused the apparent observed movement of radionuclides from disposal units at Area G in TA-54. As cited in the MDA G investigative work plan, five radionuclides (americium-241, plutonium-238, plutonium-239, uranium, and cobalt-60) were found at depths exceeding 80 feet (24 meters) in four RFI boreholes at MDA G. Tritium was found in one borehole to a depth of 130 feet (40 meters) (LANL 2004c).

To conclude, MDAs are disturbed areas, and this, or flow focusing, may have caused or contributed to the observed elevated water content in subsurface soils and movement of contaminants at some MDAs. Uncertainty about the long-term infiltration rates at MDAs leads to uncertainty about the long-term performance of the MDAs. The result is uncertainty about possible future human risk from groundwater contamination, assuming nothing is done to reduce long-term infiltration into the MDAs. Deep contamination may be evidence of accelerated contaminant migration, due to possible fast paths (vertical fractures) or areas of increased infiltration and matrix flow, or both. The No Action Option would leave the MDAs vulnerable to these uncertainties.

I.5.3.2 Capping Option

I.5.3.2.1 Surface Water

Site Investigations. Investigations conducted under the Consent Order will provide additional information about the identity and extent of contaminants in groundwater and surface waters and information needed to predict impacts on water resources. The investigations may cause small risks to surface water quality because of generation of purge water as part of well sampling. However, this purge water would be retained and managed as required in the Consent Order, indicating that impacts on surface water of the investigation programs would be minimal.

Remediation of MDAs. Installing final covers at the MDAs would cause short-term risks to surface waters. Industrial equipment would disturb land, disrupting existing covers and presenting opportunities for runoff and erosion to transport soil and small levels of contamination to canyons. In addition, capping the MDAs would require the import of large quantities of tuff and surface amendment, some of which could be eroded into canyons. These risks would be reduced and mitigated using best management practices consistent with documented stormwater pollution prevention plans.

Despite possible short-term detriments, the Capping Option is expected to improve surface water quality compared to the No Action Option. A final cover is being designed consistent with the update of the performance assessment and composite analysis for the Area G low-level radioactive waste disposal facility. The final cover will extend over MDA G. Features of the final cover to resist biological intrusion would reduce the potential for contact by burrowing animals. Because of this, and because the final covers would overlie existing levels of surface contamination at MDA G, surface water pathways should be correspondingly protected from runoff and erosion of surface contamination. The design and installation of the final covers for the other MDAs would similarly minimize surface water runon and runoff and erosion and would similarly protect surface water resources.

Remediation of Other PRSs. Continued progress would be made in remediating PRSs at various locations within LANL. There would be less contamination in soils and sediments that could present a risk to surface water quality.

Borrow Pit. Expanded use of the borrow pit in TA-61 has the potential for affecting surface water quality in Sandia Canyon. To preclude significant impacts, the expanded use would be consistent with a stormwater pollution prevention plan that would be prepared for the expanded use. Runoff control structures or features would be installed as needed, and operational or administrative controls would be implemented consistent with the plan.

I.5.3.2.2 Groundwater

Site Investigations. Site investigations under the Consent Order are expected to have little or no impact on groundwater quality.

Remediation of MDAs. Placement of final covers over the MDAs, which would be among the alternatives considered in corrective measure evaluations for MDAs performed under the Consent Order,[76] would reduce risks to groundwater quality. Work on developing final covers has progressed over many years. Some of the considerations and tradeoffs to be weighed are addressed in Appendix C of the *MDA Core Document* (LANL 1999b). Technical and regulatory guidance on design, installation, and monitoring of alternative final landfill covers, including evapotranspiration covers, has been issued by the Interstate Technology and Regulatory Council (ITRC 2003b).

The long-term effectiveness of a final cover in reducing infiltration into the disposed waste at Area G or any of the other MDAs will depend on its design and construction, considering the natural processes that will affect its performance. Conventional covers, often called RCRA covers, include a resistive barrier layer as the primary barrier to percolation into underlying wastes. Alternative covers, often called evapotranspiration covers, depend on water storage and evapotranspiration. They have received increasing regulatory acceptance, particularly for arid locales. A few examples of research into use of alternative covers include the EPA Alternative Cover Assessment Project that has been ongoing since 1998 (DRI 2002a, 2002b; Roesler, Benson, and Albright 2002); test plots at LANL (Breshears, Nyhan, and Davenport 2005; Nyhan 2005); and a recently constructed cover over a uranium mill tailings site at Monticello, Utah (Waugh et al. 2001). Case studies addressing the use of evapotranspiration covers at landfills covering a range of climatic conditions are presented at a website hosted by EPA's Technology Innovation Program.

One of the studies cited in the EPA *Alternative Cover Assessment Project Report* is the Alternative Landfill Cover Demonstration at Sandia National Laboratories in Albuquerque, New Mexico. This Sandia project is performing side-by-side tests of six test plots, each 330 feet (100 meters) long and 43 feet (13 meters) wide, and each comprising a different cover design, including an evapotranspiration cover design (Dwyer 2001).

The LANL field demonstration was initiated in 1981 with the goals of developing barriers against biological intrusion and systems for groundwater and surface water management. In 1984, test sections of two cover designs were constructed. The cover sections have been monitored with respect to water balance, vegetation cover, rooting patterns, geotextile liner deterioration, preferential flow paths, and soil properties. It was determined, among other things, that the structure, bulk density, and effective permeability of cover layers can be altered over

[76] A corrective measure evaluation performed for MDA G in TA-54 would be coordinated with the update to the performance assessment and composite analysis that is currently under preparation. This update would consider the application of a final evapotranspiration cover over the disposal units, and would also update information about the site and the contents of the disposal units.

time by pedogenic processes, root intrusion, animal burrowing, and other disturbances (Breshears, Nyhan, and Davenport 2005). Another set of test plots at LANL investigated the total water balance within four unvegetated evapotranspiration covers having varying slopes. Evaporation usually increased with increasing slope, while interflow and seepage usually decreased with increasing slope (Nyhan 2005).

Evapotranspiration landfill covers can limit infiltration if properly designed, constructed, and maintained. Technical and regulatory guidance for design, installation, and monitoring of evapotranspiration landfill covers has been issued by the Interstate Technology and Regulatory Council (ITRC 2003b). If there are fast paths under waste facilities through which water and contaminants move episodically, covers may significantly inhibit that kind of transport by limiting the rapid water infiltration that drives it. However, the design of a successful cover will depend on systematic planning against processes that can degrade its performance over time. Accurate predictions of percolation rates through landfill covers will depend on knowledge of soil water storage and evapotranspiration. These elements will be influenced by the hydraulic properties of the soil used in the covers and by the properties of covering vegetation. Changes in vegetation can affect cover performance, and mineralogical and textural changes to the soil due to pedogenic processes can change the water retention properties of the soil layer. The potential for extreme weather events should be considered. Cover designs should also incorporate features to limit adverse changes caused by animal and root intrusion. Another consideration is the potential for long-term subsidence caused by slow decomposition and consolidation of the waste within the disposal units.

Remote-Handled Transuranic Waste Option. The option of leaving some remote handled transuranic waste in place would need to be protective of water resources, and such protection would be addressed as part of analyses performed for this option. In addition to future assessments performed as part of corrective measure evaluations under the Consent Order, inventories of transuranic and associated radioactive material would be included in composite analyses for Area G performed in compliance with DOE Order 435.1 (DOE 2001). These composite analyses address all radiological pathways involving potential release of radioactive material to an uncontrolled area, including pathways involving possible transport of contaminants by surface water and groundwater. And as noted in Section I.3.3.2.1.2.2, if required, an assessment pursuant to 40 CFR Part 191 may be performed. Such an assessment would address possible movement of contaminants from the disposal area by both surface water and groundwater.

Remediation of Other PRSs. Remedial actions conducted under the Consent Order will either improve groundwater quality or reduce risks to it from LANL PRSs. The scope of any remediation program for any watershed cannot be fully defined at this time, although potential remediation alternatives could range from no action to more significant activities such as in situ bioremediation, permeable reactive barriers, or groundwater pump-and-treat systems.

Borrow Pit. Operation of the TA-61 borrow pit should have no impact on groundwater quality.

I.5.3.3 Removal Option

I.5.3.3.1 Surface Water

Surface water quality would be improved compared to the No Action Option.

Site Investigations. Investigations conducted under the Consent Order may cause small risks to surface water quality because of generation of purge water from well sampling. But this purge water would be retained and managed as required in the Consent Order. Hence, impacts on surface water of the investigation program would be minimal.

Remediation of MDAs. Under the Removal Option, contamination in most LANL MDAs would be removed. Assuming that the contamination is removed to screening levels, surface water could remain at slight risk. Complete removal would eliminate the great bulk of the contamination at the MDAs. The contamination at the MDAs would be subsequently treated and disposed of either on or offsite. (By either method, disposal would be consistent with groundwater and surface water protection criteria and goals at the disposal facilities.) Partial removal of waste from MDAs would result in smaller risks to surface water resources than either the No Action or the Capping Option. After waste is partially removed from the MDAs, residual contamination would be stabilized and capped.

Removal of the waste and contamination at the MDAs would entail small, short-term risks to surface waters. Excavated waste may spill or release liquids. Industrial equipment would disturb land, disrupting existing covers and causing opportunities for runoff and erosion to transport soil and small levels of contamination into canyons. Removal of the MDAs would require the import of very large quantities of tuff and surface amendment, some of which could be eroded into canyons. These risks would be reduced and mitigated using techniques, including safe waste management procedures, contamination control, monitoring, and best management practices.

Remediation of Other PRSs. As part of the Removal Option, continued progress would be made in remediating PRSs within LANL. There would be less contamination in soils and sediments that could present a risk to groundwater or surface water quality.

Borrow Pit. Because the amount of material to be removed under the Removal Option is comparable to that under the Capping Option, impacts on surface water quality would be comparable.

I.5.3.3.2 Groundwater

Site Investigations. Similar to that under the Capping Option, there should be few, if any, impacts on or risks to groundwater from conducting site investigations under the Consent Order.

Remediation of MDAs. Because the bulk of the contamination in most MDAs would be removed, groundwater risks would be greatly reduced, although some slight risk may remain from any remaining contamination meeting screening levels. In addition, the filled, compacted excavation may still experience larger infiltration rates (for a time) than undisturbed areas, which might further drive migration of deeper contaminants that are beyond the reach of the excavation.

Partial removal of waste from MDAs, such as that contemplated for MDA B, would result in smaller risks to groundwater resources than either the No Action or Capping Options. Residual contamination in the MDAs would be stabilized and capped.

Remediation of Other PRSs. Improvements in groundwater quality from implementation of the Consent Order would be the same as those addressed for the Capping Option.

Borrow Pit. Similar to the Capping Option, operation of the TA-61 borrow pit should have little to no effect on groundwater quality.

I.5.4 Air Quality and Noise

I.5.4.1 No Action Option

I.5.4.1.1 Air Quality

Continuing LANL's environmental restoration project may have small impacts on air quality. Pollutants would be emitted from operation of waste management facilities supporting environmental restoration, as well as from vehicles and construction equipment. Combustion products would be emitted from thermal treatment of any high explosives recovered as part of the environmental restoration project. These releases, however, would probably be small compared with those that would occur as part of ongoing LANL operations and DD&D activities involving safe destruction of high explosives.

Pollutant releases from heavy equipment operation for contaminated material recovery during environmental restoration were estimated for the No Action Option using the procedures outlined in Section I.3.6.4, for which emissions were related to the volumes of wastes projected to be generated. Calculated total release of nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SOx), particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}), carbon dioxide (CO_2), aldehydes, and total organic compounds are presented in **Table I–86** in units of tons.

Table I–86 No Action Option Projected Pollutant Releases to Air from Heavy Machinery Operation

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
NO_x	4.6	7.7	6.3	0.045	0.51	0.18	0.18	0.18	0.18	0.18
CO	12	19	16	0.11	1.3	0.45	0.45	0.45	0.45	0.45
SO_x	0.30	0.50	0.41	0.0029	0.033	0.012	0.012	0.012	0.012	0.012
PM_{10}	0.32	0.54	0.44	0.0032	0.036	0.013	0.013	0.013	0.013	0.013
CO_2	190	310	260	1.8	21	7.3	7.3	7.3	7.3	7.3
Aldehydes	0.080	0.13	0.11	0.00079	0.0089	0.0032	0.0032	0.0032	0.0032	0.0032
TOCs	0.86	1.5	1.2	0.0086	0.10	0.034	0.034	0.034	0.034	0.034

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.
Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Small levels of dust (and particulate matter) would be released to the air, as well as small quantities of radionuclides. These releases are not expected to result in emissions that would exceed applicable standards. The major sources of criteria pollutants at LANL have not been historically from the environmental restoration project (see Chapter 4, Section 4.4.2.2, of this SWEIS). Continuing environmental restoration should not, therefore, result in major changes to existing compliant conditions. Nonetheless, there would be continued release of small quantities of volatile organic compounds to the air from some MDAs.

Trends have shown reductions in annual doses to the public from release of radionuclides to the air. Continuing these programs should therefore neither reverse these trends nor cause noncompliance with NESHAP.

I.5.4.1.2 Noise

Continuing the LANL environmental restoration project should result in some levels of sound perceived as noise. This would result from operation of construction equipment and vehicles. Vehicle noise would result from operation of personal vehicles and from transport of wastes and other materials. Under the No Action Option, the total number of one-way waste shipments from the environmental restoration project is estimated at about 1,000 through FY 2016. The largest number of one-way shipments (400 or about 1.6 per working day) is projected to occur in FY 2008. Therefore, the noise from continuing the current program should be similar to that resulting from the past several years in which environmental restoration has taken place at LANL.

I.5.4.2 Capping Option

I.5.4.2.1 Air Quality

Site Investigations. Site investigations under the Consent Order should have few, if any, impacts on LANL air quality.

Remediation of MDAs and Other PRSs. The Capping Option may have temporary impacts on air quality. Compared to the No Action Option, the Capping Option would require the use of additional heavy equipment that would result in additional air emissions. Pollutants including nitrogen oxides, carbon monoxide, sulfur oxide, PM_{10}, carbon dioxide, aldehydes, and total organic compounds are summarized in **Tables I–87** and **I–88** in units of tons released to the air. Table I–87 lists pollutants released for the entire Capping Option. Table I–88 lists pollutants for capping the existing Area G footprint and for capping MDAs A, B, T, and U in TA-21. Quantities released were calculated using the procedures outlined in Section I.3.6.4.

In addition, dust (and particulate matter) would be dispersed into the air from grading, earthmoving, and compaction. This could occur at the MDAs being remediated and at locations where sources of capping materials would be excavated. Dust and particulate emissions would be mitigated, however, by standard dust control measures such as water sprays.

Small levels of radionuclides may be discharged into the air from capping the MDAs because of small quantities of radionuclides and other contaminants in soil. Construction activities that abrade and loosen the soil would help to promote release. But these levels would be small and temporary. Capping would be accompanied, as needed, by installation of soil vapor extraction systems to address phases of volatile organic compounds at some MDAs (see Section I.3.3.2.2.4). As needed, vapor withdrawn from soil using the extraction systems would be treated using carbon absorption, catalytic oxidation, or other technologies.

Table I–87 Capping Option Projected Pollutant Releases to Air from Heavy Machinery Operation

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
Minimum-Thickness Cap										
NO_x	20	23	52	77	190	15	160	18	160	64
CO	49	57	130	200	470	39	400	45	410	160
SO_x	1.3	1.5	3.4	5.0	12	1.0	10	1.2	11	4.1
PM_{10}	1.4	1.6	3.6	5.4	13	1.1	11	1.2	11	4.4
CO_2	790	920	2,100	3,100	7,600	620	6,500	730	6,600	2,600
Aldehydes	0.34	0.40	0.91	1.4	3.3	0.27	2.8	0.31	2.9	1.1
TOCs	3.7	4.3	9.8	15	35	2.9	30	3.4	31	12
Maximum-Thickness Cap										
NO_x	24	27	69	120	270	20	220	25	230	87
CO	61	68	170	310	690	50	560	63	570	220
SO_x	1.6	1.8	4.5	8.0	18	1.3	14	1.6	15	5.7
PM_{10}	1.7	1.9	4.8	8.5	19	1.4	16	1.8	16	6.1
CO_2	980	1,100	2,800	5,000	11,000	810	9,000	1,000	9,300	3,500
Aldehydes	0.42	0.48	1.2	2.1	4.8	0.35	3.9	0.44	4.0	1.5
TOCs	4.5	5.1	13	23	51	3.8	42	4.8	43	16

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.
Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Grouting the General's Tanks in MDA A may result in release of small quantities of pollutants into the air, principally from operation of equipment and vehicles. Activities preliminary to grouting may result in a one-time release of small quantities of hydrogen or other gases as noted in Section I.3.3.2.2.5. Similarly, if some transuranic wastes are left in TA-54 under the option discussed in Section I.3.3.2.1.2.2, there may be some small release of pollutants into the air as part of stabilization activities (for example, grout encapsulation or in situ vitrification). Stabilization activities may result in small releases of pollutants from operation of heavy equipment. If vitrification is considered, the process would generate water vapor and organic combustion products that would be drawn into an offgas treatment system.

Otherwise, under the Capping Option, continued remediation of PRSs may release small quantities of radionuclides into the air and cause public exposures to radiation. Public doses from such releases are estimated in Section I.5.6.2.2.

Table I–88 Projected Pollutant Releases to Air from Heavy Machinery Operation from Capping Area G and Combined Material Disposal Areas A, B, T, and U

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
Area G [a]										
Minimum-Thickness Cap										
NO_x	–	–	–	–	150	–	150	–	150	48
CO	–	–	–	–	370	–	370	–	370	120
SO_x	–	–	–	–	9.4	–	9.4	–	9.4	3.1
PM_{10}	–	–	–	–	10	–	10	–	10	3.4
CO_2	–	–	–	–	5,900	–	5,900	–	5,900	2,000
Aldehydes	–	–	–	–	2.5	–	2.5	–	2.5	0.85
TOCs	–	–	–	–	27	–	27	–	27	9.2
Maximum-Thickness Cap										
NO_x	–	–	–	–	200	–	200	–	200	68
CO	–	–	–	–	510	–	510	–	510	170
SO_x	–	–	–	–	13	–	13	–	13	4.4
PM_{10}	–	–	–	–	14	–	14	–	14	4.7
CO_2	–	–	–	–	8,200	–	8,200	–	8,200	2,700
Aldehydes	–	–	–	–	3.5	–	3.5	–	3.5	1.2
TOCs	–	–	–	–	38	–	38	–	38	13
Material Disposal Areas A, B, T, and U										
Minimum-Thickness Cap										
NO_x	–	–	4.1	33	22	0.16	–	–	–	–
CO	–	–	10	82	55	0.41	–	–	–	–
SO_x	–	–	0.27	2.1	1.4	0.010	–	–	–	–
PM_{10}	–	–	0.29	2.3	1.5	0.011	–	–	–	–
CO_2	–	–	170	1,300	890	6.5	–	–	–	–
Aldehydes	–	–	0.072	0.57	0.38	2.8×10^{-3}	–	–	–	–
TOC	–	–	0.77	6.1	4.1	0.030	–	–	–	–
Maximum-Thickness Cap										
NO_x	–	–	7.9	59	37	0.32	–	–	–	–
CO	–	–	24	180	110	0.95	–	–	–	–
SO_x	–	–	11	79	50	0.41	–	–	–	–
PM_{10}	–	–	0.81	6.0	3.8	0.032	–	–	–	–
CO_2	–	–	320	2,400	1,500	13	–	–	–	–
Aldehydes	–	–	170	1,200	770	6.3	–	–	–	–
TOCs	–	–	1.6	12	7.4	0.062	–	–	–	–

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.

[a] Refers to capping the existing Area G footprint in TA-54, which includes MDA G.

Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Borrow Pit. Projected annual releases of pollutants from operation of heavy equipment at the TA-61 borrow pit, using procedures outlined in Section I.3.6.4, are listed in **Table I–89**.

Table I–89 Capping Option Projected Pollutant Releases to Air from Technical Area 61 Borrow Pit Heavy-Machinery Operation

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
Minimum Thickness Cap										
NO_x	2.7	2.7	22	39	71	2.7	57	4.2	59	21
CO	6.7	6.7	54	99	180	6.9	140	11	150	53
SOx	0.17	0.17	1.4	2.5	4.6	0.18	3.7	0.27	3.8	1.4
PM_{10}	0.19	0.19	1.5	2.7	5.0	0.19	4.0	0.29	4.1	1.5
CO_2	110	110	880	1,600	2,900	110	2,300	170	2,400	850
Aldehydes	0.046	0.046	0.38	0.69	1.2	0.048	1.0	0.073	1.0	0.37
TOCs	0.50	0.50	4.1	7.4	13	0.52	11	0.79	11	3.9
Maximum Thickness Cap										
NO_x	7.3	7.3	45	94	200	7.5	160	11	160	57
CO	18	18	110	240	490	19	400	29	410	140
Sox	0.47	0.47	3.0	6.1	13	0.49	10	0.74	10	3.7
PM_{10}	0.51	0.51	3.2	6.6	14	0.52	11	0.80	11	4.0
CO_2	290	290	1,800	3,800	8,000	300	6,400	460	6,500	2,300
Aldehydes	0.13	0.13	0.80	1.6	3.4	0.13	2.7	0.20	2.8	1.0
TOCs	1.4	1.4	8.6	18	37	1.4	30	2.2	30	11

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.
Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Potential dust levels at the borrow pit were estimated using Equation 1 from *Compilation of Air Pollutant Emission Factors*, *Volume 1: Stationary Point and Area Sources*, Section 13.2.4, "Aggregate Handling and Storage Piles (EPA 1995). An average wind speed of 2.9 meters per second and an average moisture content of 3.4 percent was assumed.[77] Also, assuming that the material would be "dropped" twice (once when piled and once when placed in a truck); assuming no controls or mitigation measures; and assuming an 8.2-foot (2.5-meter) cap at all MDAs, the largest release (1,000 pounds [450 kilograms]) of PM_{10} would occur during FY 2011. Emissions of dust and particulates would be mitigated, however, using standard dust control measures such as water sprays.

Localized emissions of criteria pollutants, particulates, and dust would be further reduced if some material was obtained from other sources.

I.5.4.2.2 Noise

Site Investigations. Site investigations under the Consent Order would cause very small noise impacts from activities such as well installation.

[77] *A moisture content of 3.4 percent was assumed from Table 13.2.4-1 of AP42 (EPA 1995). It is typical for exposed ground of western surface coal mines.*

Remediation of MDAs and Other PRSs. The Capping Option would have increased noise impacts as compared to the No Action Option. Heavy equipment would be used during site preparation and for earthmoving. The noise would depend on the equipment design and its quantity—that is, the scale of operation would depend on the size of the worksite. Issues would include the effect of noise on workers, other LANL personnel, or the public in the vicinities of the worksites. Workers would be equipped with hearing protection if the work produced noise levels above the LANL action level of 82 dBA. These measures, as well as adherence to other safe operating procedures such as training and designated worker exclusion areas, should preclude serious injuries from noise exposures. Regarding persons near the worksite, noise levels would depend on the characteristics of the equipment, separation distance, and presence of physical features that can attenuate noise, such as topography or vegetation. Heavy equipment such as front-end loaders and backhoes would produce intermittent noise levels at 73 to 94 dBA at 50 feet (15 meters) from the worksite under normal working conditions (DOE 2004b). Considering physical features, noise levels from this equipment could return to background levels within about 1,000 feet from the noise source.

Accompanying this noise would be that from trucks shipping waste to on- and offsite destinations and deliveries of cover materials. Assuming all solid waste under the Capping Option is shipped offsite, the total number of one-way shipments from FY 2007 through FY 2016 would increase from about 1,000 under the No Action Option to 7,200. Waste shipments under the Capping Option would average about 3 per day, assuming 250 working days per year. The largest number of one-way waste shipments (970 shipments) would occur during FY 2008. One-way shipments of crushed tuff, rock, gravel, and other capping materials would total from 92,000 to 191,000 over 10 years, or an average of 9,200 to 19,100 per year (37 to 76 trucks per day), depending on the thickness of cover. This increase in one-way truck traffic should be small compared with normal vehicle traffic in the LANL area. For example, a September 2004 study recorded vehicular traffic counts at several locations in the LANL region (KSL 2004). Average weekday traffic counts for selected locations were (KSL 2004):

- 9,502 vehicles per day on East Jemez Road near its intersection with NM 4
- 4,984 vehicles per day on Pajarito Road near its intersection with NM 4
- 12,185 vehicles per day on NM 502 (East Road) west of its intersection with NM 4
- 16,866 vehicles per day on Diamond Drive just south of its intersection with East Jemez Road
- 6,019 vehicles per day on West Jemez Road just south of its intersection with Camp May Road

Traffic on East Jemez Road may be heard in the trailer park on East Jemez Road. Traffic passing by the trailer park could include shipments of solid waste to the transfer station at the county landfill, and shipments of crushed tuff from the TA-61 borrow pit. (However, shipments of solid waste generated by LANL's environmental restoration project have historically been sent directly to an offsite landfill. Hence, use of the transfer station by LANL's environmental restoration project may be minimal.) The number of trucks would depend not only on the quantities of wastes shipped, or tuff delivered, but on routing decisions (for example, trucks stopping at the borrow pit from East Jemez Road may, once loaded, continue in the same direction or return in the original direction).

If all industrial solid waste under the Capping Option passes through the transfer station at the county landfill, then about 3,600 trucks containing this waste could transit East Jemez Road over 10 years, averaging 360 per year.[78] If all tuff used for capping the MDAs were to originate from the TA-61 borrow pit, and all shipments passed the trailer park, then approximately 59,000 to 155,000 one-way shipments would transit East Jemez Road over 10 years. This would average 5,900 to 15,500 per year. The largest number of one-way shipments would occur during FY 2011, when from 15,000 to 41,000 trucks containing tuff would transit East Jemez Road. Adding solid waste shipments to these tuff shipments could result in a little more than 41,000 one-way shipments in FY 2011 on East Jemez Road, or 165 trucks every working day. This increased truck traffic may be compared to the average number of vehicles on East Jemez Road (11,181 vehicles per day on workdays), as measured near the trailer park in September 2004 (KSL 2004). Assuming all trucks pass the trailer park twice (coming and going), this would be an increase of 3 percent in the number of vehicles traveling the road on a daily basis.

I.5.4.3 Removal Option

I.5.4.3.1 Air Quality

Site Investigations. Site investigations under the Consent Order are expected to have little to no impacts on air quality.

Remediation of MDAs and Other PRSs. The Removal Option may have short-term effects on air quality. Dust and particulate matter would be generated as part of MDA exhumation, backfilling, and final restoration. Release of dust into the air would be controlled using standard techniques.

This alternative would greatly reduce, if not eliminate, the potential for long-term release of volatile organic compounds from the MDAs.

The Removal Option would require use of additional vehicles and construction equipment compared with the Capping Option. Therefore, air emissions from these sources would be increased compared with the Capping Option. Estimated releases from FY 2007 through FY 2016, and from FY 2007 through FY 2011, are listed in **Tables I–90** and **91** in units of tons. The releases were estimated using the procedures outlined in Section I.3.6.4, and no reductions in release were considered for removal operations that could occur under enclosures (see below). The releases estimated in Table I–90 are for complete removal of all MDAs and other remediation activities conducted under the Removal Option, as well as capping the remaining disposal units in the existing Area G footprint, plus some small areas in TA-49. Releases estimated in Table I–91 are for complete removal of MDA G and for combined MDAs A, B, T, and U. A thick cap was assumed for both tables. Partial removal of waste and contamination from MDAs would result in reduced emissions.

[78] *This is unlikely because solid waste is normally sent directly to an offsite industrial landfill.*

Table I–90 Removal Option Projected Pollutant Releases to Air from Heavy-Machinery Operation [a]

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
NO_x	30	64	2,000	2,900	2,500	2,400	2,500	2,600	2,500	470
CO	74	160	5,100	7,300	6,400	6,100	6,300	6,400	6,200	1,200
SO_x	1.9	4.1	130	190	160	160	160	170	160	30
PM_{10}	2.0	4.4	140	200	180	170	180	180	170	33
CO_2	1,200	2,600	82,000	120,000	100,000	99,000	100,000	100,000	100,000	19,000
Aldehydes	0.51	1.1	35	51	44	43	44	45	43	8.2
TOCs	5.5	12	380	550	480	460	470	480	470	88

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.

[a] Includes releases projected from placing a thick evapotranspiration cap over the remaining disposal units, at Area G, and over small areas in TA-49.

Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Table I–91 Projected Pollutant Releases to Air from Heavy-Machinery Operation from Removal of Material Disposal Areas G and Material Disposal Areas A, B, T, and U

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
MDA G [a]										
NO_x	–	–	1,600	2,400	2,400	2,400	2,400	2,400	2,400	440
CO	–	–	3,900	6,100	6,100	6,100	6,100	6,100	6,100	1,100
SO_x	–	–	100	160	160	160	160	160	160	29
PM_{10}	–	–	110	170	170	170	170	170	170	31
CO_2	–	–	64,000	98,000	98,000	98,000	98,000	98,000	98,000	18,000
Aldehydes	–	–	27	42	42	42	42	42	42	7.7
TOCs	–	–	300	450	450	450	450	450	450	83
MDAs A, B, T, and U [b]										
NO_x	–	28	310	370	85	0.10	–	–	–	–
CO	–	7.1	780	930	210	0.24	–	–	–	–
SO_x	–	1.8	20	24	5.5	6.2×10^{-3}	–	–	–	–
PM_{10}	–	2.0	22	26	5.9	6.6×10^{-3}	–	–	–	–
CO_2	–	1,200	13,000	15,000	3,400	3.9	–	–	–	–
Aldehydes	–	0.5	5.4	6.5	1.5	1.7×10^{-3}	–	–	–	–
TOCs	–	5.3	58	70	16	1.8×10^{-2}	–	–	–	–

MDA = material disposal area, NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.

[a] Includes releases projected from placing a thick evapotranspiration cap over the remaining disposal units in the existing Area G footprint.

[b] Includes projected releases from MDA U for completeness. No additional remediation is expected for MDA U.

Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Based on the above projected releases, minor to moderate increases in short-term concentrations of criteria pollutants could occur near MDA remediation activities. For MDA G removal, concentrations at the site boundary near White Rock may exceed the 1-hour and 8-hour ambient standards for carbon monoxide, and the 24-hour and annual standards for nitrogen dioxide. Also, concentrations at the site boundary near the Los Alamos townsite for combined removal of MDAs A, B, T, and U may exceed the 1-hour ambient standard for carbon monoxide and the

24-hour standard for nitrogen dioxide. Tailpipe emissions of PM_{10} from removal of MDA G would be more than 80 percent of ambient standards, conservatively assuming no reductions in release of particulate matter from use of enclosures. Appropriate management controls and scheduling would be used to minimize impacts on the public and to meet regulatory requirements.

The operation causing the largest release would be complete removal of MDA G.

The Removal Option may cause radiological exposures to the public from dispersion of radioactive material into the air and transport by wind to locations occupied by humans. Excavating, sorting, characterizing, and classifying the waste removed from the larger MDAs may be performed within enclosures (see Sections I.3.3.2.6 and I.5.6.3.2). Enclosures may not be needed for many MDAs, particularly the small ones, or for remediating other PRSs. Enclosures may be used for removal of the larger MDAs because of the types and quantities of the wastes to be exhumed and the proximity of the MDAs to occupied areas.

Exposures to the public were estimated by: (1) establishing a source term for release from each MDA, and (2) assuming that releases into the air would be transported to locations occupied by members of the public using standard sector-averaged Gaussian plume dispersion models and joint distribution frequencies appropriate for the LANL area. Estimated radiological doses are presented in Section I.5.6.3.2.

Borrow Pit. Operation of heavy equipment at the borrow pit is conservatively projected, using the procedures outlined in Section I.3.6.4, to release pollutants listed in **Table I–92**.

Table I–92 Removal Option Projected Pollutant Releases to Air from Technical Area 61 Borrow Pit Heavy Machinery Operation [a]

Pollutant (tons)	*Fiscal Year*									
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
NO_x	6.6	16	110	130	90	86	88	89	87	21
CO	17	40	280	340	230	220	220	220	220	53
SO_x	0.43	1.0	7.1	8.8	5.9	5.6	5.7	5.7	5.6	1.4
PM_{10}	0.46	1.1	7.7	9.4	6.3	6.0	6.1	6.2	6.1	1.5
CO_2	270	640	4,500	5,500	3,700	3,500	3,600	3,600	3,500	860
Aldehydes	0.12	0.28	1.9	2.4	1.6	1.5	1.5	1.6	1.5	0.37
TOCs	1.3	3.0	21	25	17	16	17	17	16	4.0

NO_x = nitrogen oxides, CO = carbon monoxide, SO_x = sulfur oxides, PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 micrometers, CO_2 = carbon dioxide, TOCs = total organic compounds.

[a] Includes releases projected from placing a thick evapotranspiration cap over the remaining disposal units at Area G, and over small areas in TA-49.

Note: To convert tons to metric tons, multiply by 0.90718. Numbers have been rounded.

Dust levels at the borrow pit were estimated using the methods discussed in Section I.5.4.1.1, assuming complete removal of waste and contamination from MDAs, and assuming that all material needed to backfill the excavated MDAs would be obtained from this borrow pit. The TA-61 borrow pit was also assumed to be the source for crushed tuff for capping the remaining disposal units within the existing Area G footprint and the small areas in TA-49. Assuming no controls or mitigation measures, the largest release of PM_{10} (700 pounds [320 kilograms]) would occur during FY 2010. Emissions of dust and particulate matter would be mitigated, however, using dust control measures such as water sprays.

Localized emissions of criteria pollutants, particulates, and dust would be further reduced if some material was obtained from other sources.

I.5.4.3.2 Noise

The Removal Option could have larger noise impacts compared with the Capping Option. The Removal Option would require more heavy equipment than the Capping Option, and there would be increased vehicle traffic. Both factors would increase background noise near the work areas.

With respect to vehicular traffic, assuming all waste generated under the Removal Option is shipped offsite, the total number of one-way waste shipments from FY 2007 through FY 2016 would be approximately 109,000, an average of 10,900 per year. The largest number of one-way waste shipments (about 22,000 shipments) would be during FY 2010. Shipments of backfill and topsoil would number up to 160,000 shipments over 10 years, or an average of 16,000 per year.[79] Thus, the Removal Option could increase traffic noise at LANL compared to the Capping Option.

Trucks on East Jemez Road may be heard in the trailer park. If all solid waste from the Removal Option passes through the transfer station at the county landfill (which is unlikely, given the existing practice of sending solid waste from environmental restoration directly to an offsite landfill), then about 9,700 one-way shipments containing this waste could transit East Jemez Road over 10 years, or about 970 per year. This averages 3.9 trucks per working day. If all crushed tuff for the Removal Option came from the TA-61 borrow pit, up to 142,000 one-way shipments of crushed tuff would transit East Jemez Road through FY 2016, assuming a thick cap for Area G and TA-49. This averages 14,200 per year (57 per working day). The largest number of shipments would occur during FY 2010, when about 26,000 one-way shipments of crushed tuff could transit East Jemez Road. As noted for the Capping Option, this increase in traffic can be compared to the average vehicular traffic on East Jemez Road of 11,181 vehicles per day during weekdays (KSL 2004). Adding solid waste shipments through the transfer station, the total shipments on East Jemez Road during the peak year, FY 2010, would approach 56,000 two-way shipments, or roughly 220 trucks per day. Assuming these trucks passed the trailer park twice each day (going and coming), this would be a 2 percent increase in the number of vehicles traveling the road on a daily basis.

I.5.5 Ecological Resources

I.5.5.1 No Action Option

LANL's environmental restoration project would continue to reduce ecological risks associated with the legacy of past LANL operations. As noted in the *1999 SWEIS*, the remaining contamination is the primary contributor to ecological health risk (DOE 1999a). In the *1999 SWEIS*, ecological risk was estimated to be very small, and no significant adverse impacts on

[79] *Includes material for backfilling and covering removed MDAs, and capping the remaining disposal units in the existing Area G footprint, plus small areas in TA-49. A thick cap is assumed.*

ecological and biological resources were projected under the Expanded Operations Alternative. The No Action Option for this appendix represents a continuation of the *1999 SWEIS* Expanded Operations Alternative. Completion of site investigations and cleanups translates to a reduction in ecological risk.

As LANL's environmental restoration project activities are undertaken, limited, short-term impacts on ecological resources are likely. The extent, duration, and intrusive nature of the remedial activity would affect the magnitude of the ecological impacts. Disturbed areas would be revegetated to restore ecological conditions. Because negative impacts are expected to be limited to short durations, the overall impact on ecological resources would be positive as contamination is removed from the environment.

I.5.5.2 Capping Option

Site Investigations. Under the Capping Option, installation of exploratory and monitoring wells (or similar investigative features) in compliance with the Consent Order would cause some impacts such as clearing of vegetation. Well drilling equipment would typically be mounted on trucks that must be positioned at the drilling locations. Well installation could require several days or more. Following well installation, vegetation would return. Sampling of wells would require periodic, but brief, occupation of the sampling locations.

Remediation of MDAs and Other PRSs. Under the Capping Option, terrestrial resources would be disturbed as the MDAs were cleared of vegetation and then capped. At most MDAs, this activity would have minimal direct impact because the MDAs are generally grassy areas enclosed by fencing. However, siting and operation of temporary support facilities could disrupt some nearby habitat over the short term, and noise and human presence during remediation could also disturb wildlife in nearby areas. Proper maintenance of equipment and restrictions preventing workers from entering adjacent undisturbed areas would be implemented, as appropriate, to lessen impacts on ecological resources. Once the MDAs are capped and revegetated, they would provide habitat similar to that existing before remedial actions were implemented: they would be fenced, grassy areas. In the case of MDA G, the current industrial environment could be replaced by an open grassy area more attractive to wildlife. This would be the case whether or not any transuranic waste currently in subsurface storage in TA-54 would be left in place.

Regarding other PRSs, because partial clearing would often be needed, such as at the 260 Outfall, there would be a loss of habitat with an accompanying loss or displacement of wildlife. Upon completion of remedial actions, the sites would be revegetated. In the long, run the sites containing the PRSs would return to a more natural condition absent further development to support LANL operations. Many PRSs such as firing sites in TA-15 may not require substantial clearing to remove contamination; thus, impacts may be restricted to short-term effects resulting from noise and increased human presence as the sites are remediated. Similar conclusions would be derived for other possible corrective reviews such as operation of volatile organic compound removal or groundwater treatment systems.

The Capping Option would have minimal impact, if any, on wetlands or aquatic resources. None of the MDAs contain such resources, as well as few, if any, of the other PRSs. Best management practices would be implemented to prevent erosion and any subsequent sedimentation of downstream wetlands or ephemeral streams.

Although some of the MDAs fall within the core and buffer zones of the Mexican spotted owl (see Section I.4.5), direct impacts on this species are not expected from remediation activities, including capping. This sensitive species would not likely be present because of the disturbed nature of the sites. Additionally, remediation activities would not result in habitat loss. Indirect impacts on the Mexican spotted owl from noise are possible where MDAs are in or near Areas of Environmental Interest. Remedial action could in some cases generate noise levels that would be greater than 6 dBA above background levels. A LANL biological assessment determined that provided reasonable and prudent alternatives were implemented, work at MDAs N, Z, A, and AB may affect, but is not likely to adversely affect, the Mexican spotted owl. Reasonable and prudent alternatives include muted back-up indicators on heavy equipment, keeping disturbance and noise to a minimum, avoidance of unnecessary disturbance to vegetation including not removing trees having a diameter at breast height larger than 8 inches (20 centimeters), reseeding and erosion protection, and ensuring that any new lighting meets the requirements of the New Mexico Night Sky Protection Act. Also, activities involving heavy equipment would not be permitted between March 1 and May 15, or until the completion of surveys for spotted owls. If owls were determined to be present, work restrictions would be extended until August 31. Remediation of other areas evaluated in the biological assessment was determined to not affect the Mexican spotted owl (LANL 2006b). The U.S. Fish and Wildlife Service (USFWS) has concurred with this assessment (see Chapter 6, Section 6.5.2).

Although MDA D is within the Area of Environmental Interest for the bald eagle, no undeveloped habitat would be disturbed. A LANL biological assessment determined that remediation activities would likely result in noise levels exceeding 6 dBA above background levels in the core zone. The biological assessment concluded that provided reasonable and prudent alternatives were implemented, remediation activities may affect, but would not likely adversely affect, the bald eagle. Reasonable and prudent alternatives include reducing noise levels, not removing trees having a diameter at breast height greater than 8 inches (20 centimeters) (that is, roost trees), and providing erosion protection and prompt reseeding of disturbed areas. For other MDAs evaluated in the biological assessment, remediation activities were determined to not affect the bald eagle (LANL 2006b). The USFWS has concurred with this assessment (see Chapter 6, Section 6.5.2).

Although TA-54 includes a portion of the southwestern willow flycatcher Area of Environmental Interest, MDAs G and L are no closer than about 450 feet (137 meters) from the core habitat. Thus, there would be no direct loss of foraging or nesting habitat. Also, a LANL biological assessment determined that noise levels should not exceed 6 dBA above background levels in the core zone. Provided reasonable and prudent alternatives were implemented, the biological assessment concluded that the project may affect, but would not likely adversely affect, the southwestern willow flycatcher. Reasonable and prudent alternatives include designing all lighting so that it would be confined to the site, keeping disturbance and noise to a minimum, implementing appropriate erosion and runoff controls, avoiding unnecessary disturbance to vegetation (including wetland vegetation) and re-vegetating when needed with native plant species, and continuing to perform annual surveys adjacent to the project area before and during remediation. The biological assessment determined that the other remediation projects that were evaluated would not affect the southwestern willow flycatcher (LANL 2006b). The USFWS has concurred with this assessment (see Chapter 6, Section 6.5.2).

Ecological risks from contaminants being reintroduced into the environment by ecological processes would be reduced. Caps over MDAs would be designed to prevent or reduce intrusion by roots or burrowing animals. The capped sites would be maintained in grassy states; shrubs and trees would be prevented from becoming established. Penetration of the waste by burrowing animals would be prevented by the design of barriers within final MDA covers. Ecological risks from contaminants at other PRSs (for example, the 260 Outfall and the firing sites) would be eliminated, if not reduced, because contamination would be stabilized, if not removed.

Borrow Pit. A portion of the 43 acres (17.4 hectares) containing the borrow pit is wooded. Greatly increased withdrawal of material from the pit may require clearing of additional acreage, thus eliminating wildlife habitat in the cleared areas. Expansion of the cleared area could also result in the removal of undeveloped buffer and core habitat for the Mexican spotted owl. Although the area is not within Areas of Environmental Interest for the bald eagle, the loss of potential foraging habitat could affect this species. The southwestern willow flycatcher Area of Environmental Interest is over 2.5 miles (4 kilometers) from the borrow pit; thus, impacts to this species are unlikely. Because expansion of the borrow pit was not evaluated in the DOE biological assessment (LANL 2006b), such an assessment, as well as consultation with the USFWS, would have to be undertaken before the expansion took place.

I.5.5.3 Removal Option

Site Investigations. Under the Removal Option, installation of exploratory and monitoring wells (or similar investigative features) in compliance with the Consent Order would cause some temporary environmental impacts such as clearing of vegetation.

Remediation of MDAs and Other PRSs. Impacts on ecological resources under the Removal Option would be similar to those described for the Capping Option. Although little habitat exists within the MDAs themselves, siting and operation of temporary remediation support facilities could disrupt some nearby habitat over the short term, and noise and human presence could disturb wildlife. This would probably occur whether removals are complete or partial. Yet once remediation actions are complete, the sites would be recontoured and revegetated. Because wastes would have been removed from the MDAs, there would be few restrictions on the types of plants that could be reintroduced. This would permit the establishment of more natural conditions that would, in turn, provide additional habitat for area wildlife.

Although remedial actions would create a disruptive environment for local wildlife in the short term, long-term impacts would be beneficial. With the removal of wastes and contamination from the MDAs and PRSs, deep-root penetration and burrowing animals would not reintroduce contamination to the environment. Thus, this option would result in long-term benefits because of reductions in contaminants.

Borrow Pit. Operation of the borrow pit would cause impacts on ecological resources that would be comparable to those under the Capping Option.

I.5.6 Human Health

This resource area addresses possible health impacts on workers and the public. Workers could be impacted by exposure to radionuclides or hazardous chemicals. Impacts on the public could result from future exposure to radionuclides from either PRS radionuclide releases or from future accidental occupation of DOE property resulting from temporary disruptions in institutional control.

Impacts on workers and the public could also result from transportation of waste or materials or from possible accidents at remediation sites. Possible transportation accidents are addressed in Section I.5.10; while accidents at remediation sites are addressed in Section I.5.12.

I.5.6.1 No Action Option

This option would continue the current program of environmental restoration.

I.5.6.1.1 Worker Impacts

There would be continuing risks to workers from exposure to ionizing radiation and hazardous chemicals. It is unlikely that these risks would be significantly larger, if at all, than current impacts and risks (see Section I.4.6). Worker radiation doses associated with the No Action Option were estimated using the procedures outlined in Sections I.3.5 and I.3.6.4. Personnel radiation exposures were estimated by calculating worker hours required to remove contaminated material and then multiplying these hours by an assumed average radiation dose environment. To these exposures were added those from waste processing and loading onto trucks. From FY 2007 through FY 2016, the total worker dose using this procedure was estimated to be 0.25 person-rem, or an LCF risk of 1.5×10^{-4}. From FY 2007 through FY 2011, the total worker dose was estimated to be 0.24 person-rem, or an LCF risk of 1.4×10^{-4}. In addition, workers could receive radiation doses from proximity of the PRSs being addressed to other LANL radiation sources. The total dose experienced by an environmental restoration worker could range up to several tons of millirem per year.

I.5.6.1.2 Public Impacts

There would be essentially no risk to the public from waste disposed of in the MDAs and contamination in the other PRSs for as long as DOE maintains control of the property and continues its surveillance and monitoring programs. But at some time in the future, there could be lapses in institutional controls and surveillance and monitoring programs. If this occurs, the largest risks to the public would result from accidental improper or unauthorized use of the property. Analyses for operation of low-level radioactive waste disposal facilities have long included assessments of radiological impacts on persons (inadvertent intruders) that have temporarily used property for activities such as housing construction or backyard gardening. In these assessments, intruders are assumed to excavate into the waste, thus contacting it and bringing it to the surface where it could be incorporated into the soil. Exposures could occur while the waste is inadvertently excavated and afterwards as persons use the property contaminated with radionuclides or organic or inorganic chemicals.

Inadvertent intruder scenarios are commonly addressed in performance assessments for low-level radioactive waste disposal facilities, including those performed for Area G in TA-54 (LANL 1997). Impacts on potential future inadvertent intruders have also been addressed as part of a No Action Alternative for the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997a). As addressed in Section I.3.3.2.1.2.2, this No Action Alternative (not proposed or adopted by DOE) considered leaving all buried and stored transuranic waste in place at DOE generator-storage sites, including LANL. Impacts on intruders were assessed and included impacts of nonretrieval of remote-handled waste such as that in shafts 200 through 233 in Area G in TA-54.

I.5.6.2 Capping Option

I.5.6.2.1 Worker Impacts

There would be somewhat increased radiological doses received by site workers compared to the No Action Option. Worker doses from implementing the site investigations program under the Consent Order should be very small. Compared to the No Action Option, additional worker doses could result from capping the MDAs and annually remediating several PRSs. Using the procedures for estimating worker doses outlined in Sections I.3.5 and I.3.6.4, for FY 2007 through FY 2016, the total additional worker dose ranged from 9.7 to 13 person-rem, depending on whether a thin or thick cap was emplaced. This worker dose corresponds to an LCF risk ranging from 5.8×10^{-3} to 7.8×10^{-3}. For FY 2007 through FY 2011, the total additional worker dose ranged from 4.6 to 6.3 person-rem, and the LCF risk ranged from 2.8×10^{-3} to 3.8×10^{-3}.

In addition, small radiation doses to workers may result from actions associated with grouting the General's Tanks in MDA A or optionally stabilizing in place the transuranic waste currently stored in shafts 200-232 in Area G.[80] Operation of the TA-61 borrow pit to support MDA capping would not cause radiation exposures to borrow pit workers.

Risks to workers from possible exposure to hazardous or toxic chemicals would continue to be minimized through training, administrative controls, monitoring, and proper use of equipment.

I.5.6.2.2 Public Impacts

Site Investigations. Site investigation under the Consent Order should have no effects on public health.

Remediation of MDAs. Although the waste and contamination in the MDAs would remain in place, future risks to the public would be reduced. The improved covers would reduce infiltration of water into the waste, which would reduce the potential for release of radionuclides and hazardous constituents into the environment. The improved covers would also reduce the

[80] *In neither case are large worker doses expected. For example, the contents of a buried 50,000-gallon tank were mixed and removed at Oak Ridge National Laboratory using a fluidic pulse jet mixing system similar to the system considered for the General's Tank in MDA A. Although the tank contained sludge that had a larger inventory of activation and fission products than that expected to be in the General's Tanks (the sludge was, in fact, considered to be remote-handled material), the total radiation dose received by workers for the entire removal project was 1.23 person-rem, which was smaller than the planned dose of 4 person-rem estimated in the projected ALARA (as low as reasonably achievable) plan (ORNL 1998).*

potential for dispersion of contaminated materials currently existing as hotspots in soil, and as brought to the surface from burrowing animals.

The Capping Option would generally result in increased thicknesses of rock, tuff, and soil over the MDAs. This would reduce the risk to future potential inadvertent intruders. A larger thickness of cover implies less chance of contaminated material being contacted from future inadvertent intrusion into disposal units; if the contaminated material is contacted, less would be brought to the surface for dispersal and possible human exposure.

However, capping the MDAs would require the use of heavy equipment that would result in emissions of air pollutants, including criteria and hazardous contaminants. Particulate matter would be dispersed into the air from grading, earthmoving, and compaction at the MDA sites. These emissions could result in minor-to-moderate increases in short-term concentrations of criteria pollutants near the MDAs.

Remediation of Other PRSs. The Capping Option would result in removal of contaminated materials at numerous PRSs. At other PRSs, existing contamination would be fixed in place. Recovery of contamination at various PRSs at LANL may cause small quantities of radionuclides being released to the air that would cause public exposures to radiation. These exposures were estimated using the procedures described in Section I.5.6.3.2. The results of this assessment are an annual MEI dose of up to 7.5×10^{-3} millirem and an annual population dose of up to 1.8×10^{-2} person-rem. Operation of heavy equipment to remove contamination would release small quantities of nonradioactive pollutants into the air.

Borrow Pit. Operation of the borrow pit will entail the use of heavy equipment that would cause the emission of pollutants such as those addressed in Section I.5.4.2.1. In addition, particulate matter would be dispersed into the air from excavating bulk materials for MDA capping. These emissions may result in increases in short-term concentrations of pollutants near the boundary of the borrow pit.

I.5.6.3 Removal Option

I.5.6.3.1 Worker Impacts

Possible risks to site workers from the site investigations program from possible exposure to radiation or chemically toxic or hazardous materials would again be small.

Regarding remediation of MDAs and PRSs, the Removal Option would result in larger radiation doses to site workers than the Capping Option. Worker doses were estimated using the procedures outlined in Sections I.3.5 and I.3.6.4. Compared to the No Action Option, for FY 2007 through FY 2016, the total additional worker dose was estimated as 1,400 person-rem, assuming a thick cap over the remaining disposal units in the existing Area G footprint, and over small areas in TA-49. This results in an LCF risk of 0.84. For FY 2007 through FY 2011, the total additional worker dose was estimated as 580 person-rem, resulting in an LCF risk of 0.35. These estimates reflect the assumption of complete removal of waste from MDAs. Partial removal of waste from MDAs would result in smaller doses and risks to workers. Doses and risks could be reduced in practice using standard radiation protection techniques. The bulk of the doses and LCF risks would be from complete removal of MDA G. Operation of the borrow pit to support MDA removal would not result in radiation doses to borrow pit workers.

Compared with the Capping Option, the Removal Option could result in increased risks to site workers from exposure to hazardous or toxic chemicals. These risks would be minimized through training, administrative controls, monitoring, and proper use of equipment.

I.5.6.3.2 Public Impacts

The Removal Option would reduce long-term risks to members of the public from either contaminants released slowly over time or inappropriate uses of the sites assuming temporary future accidental breakdowns in institutional control. The bulk of the contamination within and near the MDAs would be removed, and remaining contamination would be stabilized in place. Contamination at other PRSs would also be removed or stabilized in place.

Site Investigations. The site investigations programs under the Consent Order should not affect public health.

Radiological Emissions from Remediation of MDAs and Other PRSs. MDA removal would cause short-term radiological doses to the public from release of radionuclides into the air. To estimate these radiological doses:

- Transport through the air pathway to the public was modeled using the Clean Air Act Assessment Package – 1988 (CAP88-PC), Version 3.0. (See Appendix C of the SWEIS for further information on the CAP88-PC model.)
- Radiological doses and risks to the public were modeled using exposure and environmental transfer assumptions embedded in CAP88-PC. Exposures included external exposures from immersion in a radiological plume, inhalation and ingestion exposures, and exposures following deposition of contamination on the ground and surfaces, including resuspension and food transfer pathways. The public was assumed to take no measures to avoid radiation doses.
- Air emissions from removal of large MDAs were modeled as individual release sites. These MDAs included MDA A, B, T, U, AB, C, and G. Schedules for removal of these MDAs were conservatively assumed to comply with the remedy completion schedules in the Consent Order. Complete removal of waste and contamination was assumed.
- Remediation needs and schedules for other LANL PRSs are uncertain. Airborne releases were modeled by assuming that contamination is removed from an assumed area of property at LANL annually. The mechanical stresses imposed on the contaminated property were assumed to disperse contamination into the air.

It was assumed that during removal, a fraction of the radioactive inventory within the MDAs would be released into the air. The total source term for release was given as:

$$\text{Source Term (picocuries per year)} = \text{Total MDA Inventory (curies)} \times \text{Fraction Released}$$

The inventories for the MDAs were developed using several information sources. For some MDAs, although historical information indicated that particular isotopes may have been disposed of, disposed quantities were lacking. In these cases, the inventories were estimated by scaling to known inventories in MDA G. In addition, a documented safety analysis was issued in 2004 for nuclear environmental sites (LANL 2004l). The analysis performed for this documented safety analysis reconsidered earlier information, and better accounted for the initial presence of plutonium-241 and the ingrowth of its progeny, americium-241. Where different inventories from different references could be assumed for some MDAs, doses (MEI and population within 50 miles) were calculated for each inventory, and the more conservative inventory (the one resulting in the larger dose) was used. In addition, because many MDAs have several radionuclides in their inventories, a screening process eliminated those radionuclides that contributed minimally (less than 1 percent) to the total dose. This screening resulted in those radionuclides having the largest health impacts being modeled. The postscreening inventories for each of the MDAs (and the combined PRS area) are listed in **Table I–93**.

The fraction of the inventory that would be released was generally assumed to be represented by PM_{10}. A conservative release fraction of 10^{-4} was assumed. Volatile radionuclides such as C-14, radon isotopes, and iodine were conservatively assumed to be all released (release fraction = 1). The release fraction for tritium was assumed to be 0.01 for MDA G and unity for other MDAs.

It is believed that very little of the tritium disposed of in the MDAs was disposed of in a gaseous form (as in vials of tritium gas). Rather, most tritium was disposed of as an absorbed liquid (generally tritiated water) or otherwise solid objects such as pumps. The great bulk of the tritium disposed of at LANL was disposed of within shafts within Area G at TA-54. Early disposals of large quantities of tritium were within asphalt-lined drums that were emplaced, rather than dropped, within the shafts (Rogers 1977). The largest quantities of tritium were double-packaged (one asphalt-lined and sealed drum within another). Shafts containing large quantities of tritium were asphalt-lined (Rogers 1977). Starting in the 1990s, disposal was within stainless steel containers.

Although many of the drums containing the tritium may have corroded to the point that there are leak paths from the drum interior to the environment, it is expected that the drums would still be sufficiently intact that widespread gross wall failures would be uncommon. Hence, the drums would largely retain their overall integrity during removal. In addition, it is expected that removal of waste from those shafts containing large quantities of tritium would be controlled in a manner sufficient to safeguard worker and public safety and the environment.

A release fraction of unity was assumed for tritium disposed of in other MDAs because of uncertainties about the form of the waste and the packaging used (if any).

All MDAs were modeled assuming that removal occurred with and without enclosures. For those MDAs assumed to be exhumed without enclosures, an area source was modeled. For such MDAs, it was assumed that, at any given time in the exhumation of an MDA, an area no larger than 100 square meters would be disturbed. The area source was modeled with zero velocity and zero height to the air emissions.

Table I–93 Screened Inventories of Radionuclides Within Large Material Disposal Areas and the Combined Potential Release Site Area [a]

Radionuclide (curies)	*MDA A (TA-21)*	*MDA B (TA-21)*	*MDA T (TA-21)*	*MDA U (TA-21)*	*MDA AB (TA-49)*	*MDA C (TA-50)*	*MDA G (TA-54)*	*Combined PRS*
Americium-241	6.14	6.55	3,740		6,570	140	2,140	0.130
Cobalt-60	–	–	–	–	–	8.42	480	
Cesium-137	–	–	–	–	–	–	726	4.7×10^{-4}
Plutonium-238	0.266	9	31.3	0.414	2,990	6.7×10^{-9}	3,590	0.14
Plutonium [b]	55.5	7.65	161	6.59	2,830	–	2,370	0.335
Plutonium-241	78.9	–	37,400	–	3,370	82.9	–	–
Strontium-90	–	–	–	–	–	12	1,040	0.013
Tritium	–	252	–	4.34	0.917	16,800	472,000	0.047
Uranium [c]	3.95	0.22	6.9	–	0.258	29.5	68	0.442

MDA = material disposal area, TA = technical area, PRS = potential release site.

[a] The screening process eliminated those radionuclides contributing less than one percent of the total dose.

[b] Plutonium may include plutonium-239 and plutonium-240.

[c] Uranium may include uranium-233, uranium-234, uranium-235, uranium-236, or uranium-238.

Inventory sources:

MDA A – LANL 2004l for General's Tanks. For Eastern and Central Pits, available information (for example LANL 1991) identifies disposed radionuclides but not quantities. Hence, for these pits, the radionuclide inventories were scaled from known inventories in MDA G (LANL 1997).

MDA B – For plutonium-239, assumed 6.22 curies from LANL 1999b, DOE 1999g, and LANL 2004l, and added an estimated 1.45 curies of plutonium-240. For plutonium-240 and other radionuclides, because available information (Rogers 1977; LANL 1991, 1999b, 2004d) did not provide quantities, inventories were scaled from known inventories in MDA G (LANL 1997). A 2007 document estimates a plutonium-239 inventory ranging from 1.5 to about 15 curies, with an estimated 7.08 curies at the 50th percentile and 10.6 curies at the 90th percentile. The inventory in interstitial soil and backfill is estimated to be 4.53 curies at the 50th percentile and 5.87 curies at the 90th percentile. The remaining inventory is distributed among gloves, personal protective equipment, glassware, lab debris, and liquid containers (LANL 2007g), and would be expected to be less subject to airborne dispersal during normal removal operations than the inventory in the interstitial soil and backfill.

MDA T – LANL 2004l.

MDA U – The original inventory was estimated from available information (LANL 1991, 2004k). Some radionuclides were scaled from known inventories in MDA G (LANL 1997). Two-thirds of the original inventory was assumed removed in 1985. The Removal Option for MDA U is unlikely, because NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).

MDA AB – Most radionuclides estimated from *RFI Work Plan for Operable Unit 1044* (LANL 1992b). Americium-241 was decayed from the cited inventory of plutonium-241. Inventories of plutonium-238 and plutonium-242 were scaled from known inventories in MDA G (LANL 1997).

MDA C – Radionuclide inventories were developed from data from LANL 1992c, LANL 2003k, Rogers 1977, and DOE 1999g.

MDA G – LANL 1997.

Combined PRS – Scaled from known inventories of contaminated soil disposed of into MDA G (LANL 1997).

Release of radionuclides from enclosures was modeled as a point source assuming a representative enclosure for all MDAs.[81] (Enclosures would be relocated as needed.) The assumed enclosure has dimensions of 150 by 300 feet (46 by 91 meters), with a minimum height of 20 feet (6.1 meters) at the structure eaves. Assuming an elliptically domed roof having flat sides and a maximum height under the dome of about 40 feet (12 meters), the interior volume of the structure would be 1.25×10^6 cubic feet (35,400 cubic meters).

[81] *Additional engineering work would be needed to arrive at optimum numbers, sizes, configurations, and relocation schedules for the removal enclosures.*

The ventilation system for the enclosure would be designed to provide sufficient air exchange to ensure that airborne concentrations would not exceed derived air concentration limits over a given period of time, based on a conservative estimate of entrainment of contaminants from the digface. It was assumed that the ventilation system would exhaust through a roughing filter and at least one HEPA filter before discharge through a 20-foot-high (6.1-meter-high), 36-inch-diameter (0.91-meter-diameter) stack. A 99.95 percent removal efficiency was assumed.[82] The flow rate out the stack was assumed to be 20,000 cubic feet per minute, corresponding to an average air exchange rate within the enclosure of once per hour. This flow rate was converted to 14.4 meters per second by dividing by the cross-sectional area of the stack.

When determining the distance and direction from each MDA to the MEI, the land parcels that are designated as "To Be Conveyed" were considered. For additional CAP88-PC input, the same meteorological, population, and agriculture values and data were used here as in Appendix C of this SWEIS. (The location [latitude and longitude] that was used for each MDA is available in the administrative record.)

In addition to the MDAs addressed above, it was assumed that each year from FY 2007 through FY 2016, several small PRSs would be remediated at different locations within LANL. There may be several options for remediation, including removing, treating, or stabilizing contamination at a site. It was assumed that some of these remediation activities would annually cause release of radionuclides to the air from mechanical disturbance of soil, sediment, or other property. To estimate this release, a single PRS combined area was assumed to represent the annual remediation of several PRSs. The radioactive inventory subject to disturbance was estimated by extrapolating the radionuclide inventory in "contaminated soil," as reported disposed of in Area G from 1971 through September 25, 1988 (LANL 1997). The average radionuclide concentrations from this inventory, which was contained within 47,000 cubic yards (36,000 cubic meters) of disposed contaminated soil, was extrapolated to an assumed annual radiologically contaminated volume of 5,200 cubic yards (4,000 cubic meters). [83] Because of the large number of PRSs within TA-35 (see Section I.2.7.7), the location of the combined PRS area was assumed to be within TA-35.

The results of the analysis are presented in **Table I–94** for complete removal of waste from the large MDAs. The annual dose was calculated by dividing the total dose from MDA removal by the number of years needed to exhume the entire MDA. Smaller doses are expected from partial removal of waste from the MDAs. The annual MEI dose associated with the combined PRS area would be 7.5×10^{-3} millirem, and the annual population dose would be 1.8×10^{-2} person-rem.

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[82] A single HEPA filter has a nominal rating of 99.97 percent efficiency for particulate removal, as designed and tested for 0.3-micrometer (1.2×10^{-6}) aerodynamic-equivalent diameter. This is equivalent to a leak rate of 3×10^{-4}. In practice, however, a lower level of efficiency is often assumed. Assuming an efficiency of 99.8 percent for one HEPA filter, and an efficiency of 99.7 percent for a second HEPA filter, the particulate release rate for two filters would be 6×10^{-6}. For purposes of this analysis, a more conservative release rate of 5×10^{-4} (99.95 percent efficiency) was used.

[83] Pit inventories from 1971 through September 1988 are provided in Table 3-8 of Appendix 2e of the 1997 Area G performance assessment and composite analysis (LANL 1997). Contaminated soil inventories were obtained from this table, and disposed volumes were obtained from Table 3-7 of this reference. The estimate of 5,200 cubic yards (4,000 cubic meters) was estimated assuming annual waste generation rates from remediating several PRSs. The inventory used for the analysis conservatively reflect the possibility that all waste removed from PRSs in any single year may be radioactively contaminated.

Table I–94 Annual Dose Estimates from Complete Removal of Large Material Disposal Areas

MDA	*Removal Period (years)*	*Individual MDA MEI Dose (millirem per year)* [a]	*Dose to LANL MEI* [b, c] *(millirem per year)*	*Population Dose (person-rem per year)* [c]
MDA A	1.8	0.0013 to 7.1	0.000097	0.00066
MDA B [d]	2.4	0.062 to 50	0.0081	0.024
MDA T	2.0	0.064 to 310	0.0043	0.036
MDA U [e]	0.8	0.0025 to 1.9	0.047	0.31
MDA AB	2.1	0.030 to 85	0.0017	0.056
MDA C	1.8	0.45 to 1.2	0.34	5.5
MDA G	6.8	0.18 to 97	0.012	0.25
Total	Not applicable	Not applicable	0.42	6.2

MDA = material disposal area, MEI = maximally exposed individual.
[a] A different MEI was assumed for removal of each MDA. The smaller dose for each MDA is for removal assuming use of an enclosure; the larger dose is for removal assuming no use of an enclosure.
[b] Total dose of the LANL MEI was conservatively estimated by assuming that all listed MDAs would be removed during an overlapping period of time, which would probably not actually occur.
[c] Doses are based on using enclosures except at MDAs C and U.
[d] Due to the high potential dose to the MEI, an enclosure would be used at MDA B. Consequently, even if the plutonium inventory were higher (see Table I–93), the offsite doses would be low.
[e] The Removal Option for MDA U is unlikely, because NMED has issued a Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).
Note: Numbers have been rounded.

The MEI location for each MDA was calculated separately. Those MEI locations for the four MDAs at TA-21 are very close. The other MDAs are relatively distant from one another. In this table, the "Individual MDA MEI Dose" is to the MEI associated with each MDA removal. The smaller dose would be received if the MDA is removed under an enclosure. If the MDA is exhumed without an enclosure, the MEI would receive the larger dose.

Because the MEI locations for the TA-21 MDAs are so close, the total dose to that MEI (MDAs A, B, T, and U) was assessed assuming that all removals occurred at the same time under enclosures (0.13 millirem per year). If removal of MDA U occurred, which is unlikely (see footnote c to Table I–94), and without use of an enclosure, the dose to the TA-21 MEI would increase to 2 millirem (1.9 millirem for MDA U plus the lower doses for MDAs A, B and T) in a year assuming the release assumptions and the inventory presented in Table I–93. If MDA A was also exhumed without the use of an enclosure, the dose to the TA-21 MEI could potentially exceed the 10-millirem public dose limit (7.1 millirem for MDA A plus 1.9 millirem for MDA U plus 1.5 millirem dose to TA-21 from operations at LANSCE). Notwithstanding this assessment, LANL would be operated, and remediations conducted, to ensure compliance with the 10-millirem public dose limit.

In addition to addressing doses to each MEI associated with large-MDA removal, the impacts of MDA removal on the LANL site-wide MEI were analyzed. Each MDA could add to the LANL site-wide MEI dose. In Table I–94, the doses to the LANL site-wide MEI were calculated separately. Doses from removal of MDA U and MDA C were calculated without use of enclosures because their contribution to the LANL site-wide MEI dose would be small. (Total doses to the LANL MEI from all sources are summarized in Chapter 5 of the SWEIS.)

When calculating the dose to the population within 50 miles (80 kilometers) of each MDA, it was assumed that MDA U and MDA C would be exhumed using no enclosures. All other large MDAs would be removed under enclosures. As much as an additional 6.2 person-rem per year would be attributed to the LANL population dose if all large MDAs were exhumed at the same time.

Nonradiological Emissions from Remediating MDAs and Other PRSs. The Removal Option would require the use of heavy equipment, resulting in emission of pollutants to the air, including criteria and hazardous pollutants. At some MDAs, these activities would be of longer duration than typical LANL construction activities and could involve extensive movement of materials. The overall emissions from heavy equipment under the Removal Option would be more than 20 times those under the Capping Option. As noted in Section I.5.4.3.1, emissions of some pollutants could be above 1-hour and 8-hour ambient standards. These emissions could be reduced by management controls such as scheduling so that public impacts would be minimized.

Borrow Pit. Operation of the borrow pit under the Removal Option could result in emissions of pollutants and particulate matter that would be comparable to those estimated for the Capping Option. Particulate emissions would be controlled using standard dust control techniques such as water sprays. Emissions could be controlled by management controls such as scheduling.

I.5.7 Cultural Resources

A variety of cultural resources are present within or near LANL boundaries, including archaeological resources, historic buildings and structures, and traditional cultural properties.

I.5.7.1 No Action Option

Under the No Action Option, there would be small risks to cultural resources at any of the TAs within which MDAs and PRSs are located, as the LANL environmental restoration project continues. These small risks would be managed using existing procedures.

I.5.7.2 Capping Option

Site Investigations. Installation of monitoring wells or other site investigation equipment under the Consent Order would be coordinated with LANL personnel responsible for preservation of cultural resources, with the objective of avoiding impacts on cultural resources. Usually there is sufficient flexibility in the selection of sites for investigation equipment so that impacts on cultural resources can be avoided.

Remediation of MDAs and Other PRSs. Under this option, the MDAs would be cleared of vegetation before being capped. Because no archaeological resources are within any of the MDAs, the Capping Option would not directly impact such sites. This would also be the case for actions involving grouting the General's Tanks in MDA A (see Section I.3.3.2.2.5) or actions performed to provide additional stabilization to any transuranic waste left in place in TA-54, if this option is implemented (see Section I.3.3.2.1.2.2).

Risks to cultural resources for other PRSs would depend on the PRS. In most cases, there would be few or no risks to cultural resources. At sites where there may be questions about risks, remediation operational plans and procedures would be coordinated with LANL personnel responsible for preservation of cultural resources. For example, one building eligible for listing in the National Register of Historic Places is within the R-44 firing site (SWMU 15-006(c)); however, this building would not be disturbed by remediation activities involving surface recovery of contamination.

Indirect impacts on cultural resources of remedial actions are possible because of increased erosion resulting from capping operations or PRS remediation and from workers or equipment occupying the work area. In those cases where archaeological resource sites and historic buildings and structures are located near work areas, LANL personnel responsible for preservation of cultural resources would be notified so that site boundaries could be marked and fenced, as needed (LANL 2006l). Fencing would prevent accidental intrusion and disturbance to the site. Best management practices would control erosion.

Borrow Pit. There are no archaeological resources in the immediate vicinity of the borrow pit in TA-61.

I.5.7.3 Removal Option

Site Investigations. Possible impacts on cultural resources of site investigations under the Consent Order would be the same as those under the Capping Option.

Remediation of MDAs and Other PRSs. Potential impacts under this option would be similar to those addressed for the Capping Option. Direct impacts on cultural resources would be unlikely. The potential for indirect impacts also would be similar to that under the Capping Option. As with that option, LANL personnel responsible for preservation of cultural resources would be notified so that any resource sites located near the affected areas would be protected. These conclusions would apply whether complete or partial removal occurred at the MDAs.

Borrow Pit. There are no archaeological resources in the immediate vicinity of the borrow pit in TA-61.

I.5.8 Socioeconomics and Infrastructure

I.5.8.1 No Action Option

Under the No Action Option, existing employment practices for LANL's environmental restoration project would continue, with contractor labor providing much of the support for site investigation and remediation. LANL's environmental restoration project currently employs 45 to 50 University of California and captive contractors,[84] along with 250 subcontractors who support various tasks at various levels (LANL 2006a). This may be compared with the total employment at LANL, which is currently about 13,500 employees (see Section I.4.8.1). Using the procedures outlined in Sections I.3.5 and I.3.6.4, total personnel hours were estimated through FY 2016 for removal of contaminated material from PRSs as part of the No Action Option. This estimate is 50,000 person-hours through FY 2016 (48,000 person-hours through FY 2011). Utility usage (electricity, natural gas, water) would not be significantly affected by

[84] *A DOE captive contractor is one that engages in little or no commercial business outside its work for DOE.*

continuing environmental restoration project operations. Roughly 75,000 gallons (280,000 liters) of liquid fuel (diesel and gasoline) would be required to operate heavy equipment for continuing site remediation through FY 2016.

I.5.8.2 Capping Option

Under the Capping Option, a higher density of remedial activities would occur through FY 2016 compared to the No Action Option. Including operations at the TA-61 borrow pit, carrying out the Capping Option is projected to require 1,400,000 to 2,200,000 person-hours through FY 2016 (680,000 to 1,100,000 person-hours through FY 2011). Assuming 2,000 hours per year per worker, the Capping Option would require the full-time efforts of an average of 70 to 110 workers per year.

Use of electricity or natural gas would likely be only marginally increased compared to the No Action Option. Roughly 3.9 to 6.7 million gallons (15 to 25 million liters) of liquid fuel (diesel and gasoline) may be needed through FY 2016 to operate heavy equipment under the Capping Option.

Compared to the No Action Option, additional water would be required, mainly for soil compaction at the MDAs and dust suppression at the MDAs and borrow pit. Implementing the Capping Option could require from 20 to 53 million gallons (76 to 200 million liters) of water from FY 2007 through FY 2016, with the largest annual quantity of water (roughly 5 to 14 million gallons [19 to 53 million liters]) needed during FY 2011.

I.5.8.3 Removal Option

Under the Removal Option, a very high density of remedial activities would conservatively occur through FY 2016 compared to the No Action Option. Under the Removal Option, complex and cost-intensive excavation processes would provide local economic benefits.

Including operations at the TA-61 borrow pit, and capping areas in TA-54 and TA-49, carrying out the Removal Option is projected to require up to 36 million person-hours through FY 2016 (16 million person-hours through FY 2011), assuming complete removal of waste from MDAs and covering the remaining disposal units in the existing Area G footprint with a thick cap. Assuming 2,000 hours per year per worker, the Removal Option would require the full-time efforts of an average of 1,800 workers per year.

Utility use may be affected. Significant additional volumes of waste would be generated, and it may be necessary to develop additional capacity to sort, characterize, treat, and package all the waste to be removed (see Section I.3.3.2.8 and Section I.5.9.3). Use of this additional capacity would increase utility infrastructure demands at LANL. Operation of heavy equipment for exhuming MDAs and performing other actions under the Removal Option is projected to require use of up to 70 million gallons (260 million liters) of liquid fuel (diesel and gasoline) through FY 2016. Water use through FY 2016 would be comparable to that under the Capping Option, or up to 58 million gallons (220 million liters).

I.5.9 Waste Management

I.5.9.1 No Action Option

The quantities of solid, chemical, and radioactive wastes to be generated would generally be consistent with, if not smaller than, previous projections of waste for continued operation of LANL. There should be no difficulty in accommodating the waste in existing on- and offsite low-level radioactive waste treatment and disposal facilities. Solid waste disposal capacity exists in nearby locations in New Mexico. Chemical waste treatment and disposal capacity exists at several locations within 600 miles of LANL. Low-level radioactive waste disposal capacity exists at LANL, and offsite capacity exists for the relatively small quantities of mixed low-level radioactive waste projected from LANL's environmental restoration project.

The expansion of low-level radioactive waste disposal operations into Zone 4 would accommodate the low-level radioactive wastes to be generated by LANL's environmental restoration project for the foreseeable future. Using the onsite disposal capacity in conjunction with possible use of offsite disposal capacity would allow flexibility to address short-term increases in waste generation from planned environmental restoration activities.

Only very small quantities of transuranic waste would be generated by LANL's environmental restoration project. Quantities of environmental restoration project wastes contaminated with high explosives are expected to be small compared to other sources at LANL.

Otherwise, LANL's environmental restoration project is not expected to generate liquid wastes (industrial, hazardous, radioactive) in volumes that would impact existing LANL treatment capacity. Because the No Action Option is not expected to significantly increase personnel needs at LANL, there would be no impact on LANL's capacity to treat sanitary wastes.

I.5.9.2 Capping Option

Although the Capping Option may cause generation of somewhat larger quantities of solid, liquid, and sanitary wastes compared with the No Action Option, impacts on LANL's waste management infrastructure should be small. Solid waste disposal capacity exists in nearby locations in New Mexico. Chemical wastes would be transported offsite for treatment and disposal. Quantities of environmental restoration wastes contaminated with high explosives should be small compared to several other sources at LANL.

Low-level radioactive waste disposal capacity exists at LANL and offsite, and would not be significantly impacted by the expected waste volume under this option. Offsite capacity exists for the relatively small quantities of mixed low-level radioactive waste projected from LANL's environmental restoration project. Only small quantities of transuranic waste would be generated by LANL's environmental restoration project and would not significantly increase current transuranic waste generation rates. Impacts on WIPP would hence be small.

Otherwise, compared to the No Action Option, LANL's environmental restoration project would generate somewhat larger quantities of liquid wastes (industrial, hazardous, radioactive), but not in quantities that by themselves would tax existing LANL treatment capacity. Because the

Capping Option is not expected to significantly increase personnel requirements, compared to the No Action Option, LANL's capacity to treat sanitary wastes should not be impacted.

I.5.9.3 Removal Option

The Removal Option would result in large quantities of wastes being excavated, requiring sorting, characterization, classification, treatment, packaging, shipment, and disposal. The material would include physically or chemically hazardous materials, and some would present external exposure or inhalation hazards. This may require development of additional waste management capacity as discussed in Section I.3.3.2.8. Development and use of this capacity would require increased use of utilities such as gas, water, or electricity, increased use of natural resources, and larger personnel requirements. These impacts would occur for the time required to remove and process the waste from the MDAs. Any structures constructed and used for this purpose would have to be safely decommissioned, which could generate additional quantities of waste to be treated, packaged, shipped, and disposed of.

Compared with the Capping Option, the Removal Option would generate much larger quantities of low-level radioactive waste—about 1 million cubic yards of bulk, alpha-contaminated, and remote handled wastes. About 180,000 cubic yards of mixed low-level radioactive wastes would also be generated. Low-level radioactive wastes would be generated from the environmental restoration program at annual rates that would exceed current plans for annual waste acceptance at Zone 4 of TA-54. The Zone 4 disposal capacity could be used within a shorter period of time than planned, requiring sooner expansion into Zone 6. Use of offsite disposal capacity would alleviate these impacts.

The amount of transuranic waste that would be exhumed from the MDAs is significant. WIPP personnel would need to review this potential waste stream to determine if its acceptance would remove future flexibility for WIPP to manage other new waste streams.

The significantly increased volumes of solid and chemical wastes would be transported offsite for treatment or disposal. In addition, compared to existing levels, the greatly increased personnel requirements for waste removal would cause increased sanitary system loads.

I.5.10 Transportation

Risks to the public could result from transportation of waste or bulk materials. Risks from transporting waste could include those from radiation exposures under normal transport conditions or from possible accidents resulting in physical injury or radiation exposure from release of radioactive material.

I.5.10.1 No Action Option

There would be continuing use of transportation systems within and near LANL. The transportation implications of continuing the LANL environmental restoration project would generally be comparable with those projected under the Expanded Operations Alternative of the *1999 SWEIS* (DOE 1999a).

I.5.10.1.1 Onsite Impacts

The No Action Option should not significantly affect existing traffic patterns within LANL. There would be some impacts associated with transporting low-level radioactive waste to onsite disposal facilities. These impacts are addressed in Section I.5.10.1.2.

I.5.10.1.2 Offsite Impacts

Transportation impacts were determined for the No Action Option using the annual projected waste volumes set forth in Section I.3.6 and the analysis assumptions described in Section I.3.5. Shipment crew and population radiation doses and risks from incident-free transportation and radiological and nonradiological risks from possible transportation accidents are presented in **Table I–95**. The table presents total doses and risks from FY 2007 through FY 2016, total doses and risks from FY 2007 through FY 2011, and the doses and risks for the peak year (2008).

These impacts were determined assuming that all nonradioactive wastes would be sent to offsite facilities, all transuranic wastes would be sent to WIPP, and all low-level and mixed low-level radioactive wastes would be sent to an offsite commercial disposal facility such as the one in Utah. Impacts of incident-free transport are presented in terms of the collective dose in person-rem resulting in excess LCFs. Excess LCFs are the number of cancer fatalities that may be attributed to the proposed project that are estimated to occur in the exposed population over the lifetime of the individuals. If the number of LCFs is smaller than one, the subject population is not expected to incur any LCFs. Impacts of possible transportation accidents are presented in terms of population risks (LCFs) from exposure to releases of radioactivity and fatalities anticipated from traffic accidents. Accident fatalities were estimated from exposure to radiation (LCFs) and from nonradiological injuries caused by collisions.

Table I–95 No Action Option Transportation Impacts Summary

	Crew Dose and Risk		*Population Dose and Risk*		*Accidents*	
Time Period	***Person-Rem***	***LCF***	***Person-Rem***	***LCF***	***Radiological (LCF)***	***Nonradiological (traffic fatalities)***
FY 2007 through FY 2016	2.2	0.0013	0.61	0.00037	0.0000072	0.019
FY 2007 through FY 2011	1.8	0.0011	0.49	0.00030	0.0000067	0.018
Peak Year (FY 2008)	0.75	0.00045	0.20	0.00012	0.0000027	0.0074

LCF = latent cancer fatality, FY = fiscal year.
Note: Numbers have been rounded.

However, low-level and mixed low-level radioactive wastes may be optionally transported to a DOE facility such as the Nevada Test Site or disposed onsite (assuming that mixed low-level radioactive waste capacity would be developed at LANL). Comparative impacts considering these options are presented in **Table I–96** for FY 2007 through FY 2016. The risks of developing excess LCFs are highest for workers under the offsite disposal options. This is because the dose is proportional to the duration of transport, which in turn is proportional to travel distance. Disposal at the Nevada Test Site, which is farthest from LANL, would cause the highest dose and risk, although the dose and risk would be low under all disposal options. Because all LCFs shown in the table are smaller than unity, the analysis indicates that no excess fatal cancers would result, either from dose received from packaged waste on trucks or potentially received from accidental release. Likewise, no fatalities are expected from traffic accidents.

Table I–96 No Action Option Comparison of On- and Offsite Radioactive Waste Disposal Transportation Impacts (Fiscal Year 2007 through Fiscal Year 2016)

Low-Level and Mixed Low-Level Waste Destination [a]	*Total Distance Traveled (million kilometers)*	*Crew Dose and Risk*		*Population Dose and Risk*		*Accidents*	
		Person-Rem	*Risk (LCF)*	*Person-Rem*	*Risk (LCF)*	*Radiological (LCF)*	*Nonradiological Traffic (fatalities)*
LANL [b]	0.21	0.56	0.00034	0.18	0.00011	7.9×10^{-10}	0.0043
DOE [c]	1.97	2.5	0.00015	0.69	0.00041	9.6×10^{-6}	0.022
Commercial [d]	1.72	2.2	0.0013	0.61	0.00037	7.2×10^{-6}	0.019

LCF = latent cancer fatality.

[a] All nonradiological wastes would be shipped offsite and all transuranic wastes would be shipped to WIPP.

[b] Modeled by assuming an average one-way distance of nine kilometers from the point of generation to the disposal site such as that in Technical Area 54.

[c] Modeled by assuming shipment to the Nevada Test Site.

[d] Modeled by assuming shipment to the EnergySolutions site in Utah.

Note: To convert kilometers to miles, multiply by 0.62137. Numbers have been rounded.

I.5.10.2 Capping Option

I.5.10.2.1 Onsite Impacts

Site Investigations. Although the site investigation program under the Consent Order may slightly increase vehicular traffic in and near LANL, this additional traffic should not significantly impact current traffic patterns. For example, installation of boreholes or monitoring wells would require the mobilization of equipment to the investigation site, followed by demobilization once installation is completed. Additional traffic would be associated with delivery of supplies and transport of personnel. Thereafter, periodic investigation site visits may be needed to collect samples. Sampling monitoring wells may involve the collection and temporary storage of purged groundwater and decontamination water before approved disposal. Collected water may need to be trucked to treatment facilities.

Remediation of MDAs and Other PRSs. The Capping Option would cause additional traffic in and near LANL. Additional workers would be needed to cap the MDAs, which would mean additional personal vehicles in the LANL vicinity. Additional radioactive and nonradioactive wastes could be sent to LANL treatment and disposal facilities. (Impacts associated with transporting low-level and mixed low-level radioactive waste to onsite disposal facilities are addressed in Section I.5.10.2.2.) Onsite risks from transporting this material could be mitigated or reduced through measures such as traffic control (site security), road closures, or transportation infrastructure improvements.

In addition, the Capping Option would require numerous shipments of tuff, rocks, and similar bulk materials from sources either on the LANL site or within the surrounding community. There could be some additional shipments of materials needed to grout the General's Tanks in MDA A. In addition, depending on remediation decisions, wastewater may be generated from groundwater treatment programs or from decontamination of equipment. There could be an increase in traffic to transport the wastewater to onsite treatment facilities. This larger number of shipments compared with the No Action Option presents an increased short-term risk to the public and LANL personnel from possible accidents. Risks from transporting this material to onsite personnel could be reduced by measures such as temporary road closures. There would also be small increases in traffic volumes to move equipment, modular structures, or other materials needed to support stabilization and capping operations.

As addressed in Section I.5.4.2.2, compared to the No Action Option, the Capping Option may increase traffic on East Jemez Road if solid waste from LANL's environmental restoration project is processed through the solid waste transfer station on East Jemez Road and tuff and similar material are procured from the TA-61 borrow pit. It is expected, however, that solid waste from LANL's environmental restoration project would be sent directly to a landfill without passing through the transfer station.

Another consideration is traffic into and out of DP Mesa for remediation of the TA-21 MDAs. Capping MDAs A, B, T, and U is projected to require slightly over 4 years. The total number of waste, soil, and similar bulk material shipments is shown in **Table I–97** for FY 2007 through FY 2016, as well as FY 2007 through FY 2011. Shipments are two way—for example, trucks delivering tuff and then leaving. Shipments would use DP Road, which intersects with Trinity Road at its western end.

Table I–97 Capping Option Shipments of Waste and Bulk Materials into and out of Technical Area 21 [a]

Waste and Material Shipments [b]	*Fiscal Year*				*Total Shipments*
	2009	*2010*	*2011*	*2012*	
Waste shipments [b]	1	260	300	1	560
Soil and Other Materials [b]					
Minimum cap	1,200	8,400	5,300	39	15,000
Maximum cap	3,200	23,000	15,000	110	41,000
Total Shipments					
Minimum cap	1,200	8,700	5,600	40	16,000
Maximum cap	3,200	23,000	15,000	110	41,000
Total Shipments per Day [c]					
Minimum cap	4.7	35	22	0.2	Not applicable
Maximum cap	13	93	59	0.4	Not applicable

[a] Assuming two-way shipments—that is, trucks entering and leaving Technical Area 21 via DP Road.
[b] Conservatively includes shipments for capping MDAs B and U. Current plans are to remove waste from MDA B and capping MDA U may be unlikely considering NMED's 2006 Corrective Action Complete with Controls certification for SWMUs comprising MDA U (NMED 2006b).
[c] Assuming 250 working days per year.
Note: Numbers have been rounded.

Traffic congestion could be reduced by redesigning the intersection of DP Road and Trinity Road.

Borrow Pit. See above discussion.

I.5.10.2.2 Offsite Impacts

Site Investigations. The site investigations program under the Consent Order should have few, if any, offsite impacts.

Remediation of MDSs and Other PRSs. Compared with the No Action Option, there would be additional shipments of radioactive and nonradioactive wastes to offsite treatment and disposal facilities. These shipments would occur over public roads and could therefore present risks to the public. These risks would be managed by packaging and shipping wastes in compliance with U.S. Department of Transportation requirements for shipment of radioactive materials.

Transportation impacts were estimated for the Capping Option using annual projected waste volumes estimated in Section I.3.6 and the assumptions and analysis described in Section I.3.5. Shipping crew and population radiation doses and risks from incident-free transportation and radiological and nonradiological risks from possible transportation accidents are presented in **Table I–98**. The table presents total doses and risks from FY 2007 through FY 2016, total doses and risks from FY 2007 through FY 2011, and doses and risks for the peak year (2008).

Table I–98 Capping Option Transportation Impacts Summary

Time Period	*Crew Dose and Risk*		*Population Dose and Risk*		*Accidents*	
	Person-Rem	*LCF*	*Person-Rem*	*LCF*	*Radiological (LCF)*	*Nonradiological (traffic fatalities)*
FY 2007 through FY 2016	3.9	0.0023	1.0	0.00062	0.000015	0.076
FY 2007 through FY 2011	2.8	0.0017	0.75	0.00045	0.000011	0.048
Peak year (FY 2008)	0.87	0.00052	0.23	0.00014	0.0000033	0.012

LCF = latent cancer fatality, FY = fiscal year.
Note: Numbers have been rounded.

The impacts for Table I–98 were determined assuming that solid and chemical wastes would be shipped to offsite facilities, transuranic wastes would be shipped to WIPP, and low-level and mixed low-level radioactive wastes would be sent to an offsite commercial facility such as the one in Utah. However, low-level and mixed low-level radioactive wastes may be optionally transported to a DOE facility such as the Nevada Test Site or disposed onsite (hypothetically assuming that mixed low-level radioactive waste capacity would be developed at LANL). Comparative impacts considering these options are presented in **Table I–99** for FY 2007 through FY 2016. The risks of developing excess LCFs are again highest for workers under the offsite disposal options. Disposal at the Nevada Test Site, which is farthest from LANL, would cause the highest dose and risk, although the dose and risk would be low under all disposal options. Because all LCFs would be much smaller than unity, no excess fatal cancers would result from this activity, either from dose received from packaged waste on trucks or potentially received from accidental release. Likewise, no nonradiological fatalities are expected from traffic accidents.

Borrow Pit. Operation of the borrow pit in TA-61 would have no offsite impacts from material transport.

Table I–99 Capping Option Comparison of On- and Offsite Radioactive Waste Disposal Transportation Impacts (Fiscal Year 2007 through Fiscal Year 2016)

Low-Level and Mixed Low-Level Radioactive Waste Destination [a]	*Total Distance Traveled (million kilometers)*	*Crew Dose and Risk*		*Population Dose and Risk*		*Accidents*	
		Person-Rem	*Risk (LCF)*	*Person-Rem*	*Risk (LCF)*	*Radiological (LCF)*	*Nonradiological Traffic (fatalities)*
LANL [b]	2.67	0.76	0.00045	0.24	0.00014	1.1×10^{-9}	0.0044
DOE [c]	6.45	4.4	0.0026	1.2	0.00070	2.0×10^{-5}	0.082
Commercial [d]	5.92	3.9	0.0023	1.0	0.00062	1.5×10^{-5}	0.076

LCF = latent cancer fatality.
[a] All nonradiological wastes would be shipped offsite and all transuranic wastes would be shipped to WIPP.
[b] Modeled by assuming an average one-way distance of 9 kilometers from the point of generation to the disposal site such as that in Technical Area 54.
[c] Modeled by assuming shipment to the Nevada Test Site.
[d] Modeled by assuming shipment to the EnergySolutions site in Utah.
Note: Numbers have been rounded.

I.5.10.3 Removal Option

I.5.10.3.1 Onsite Impacts

Site Investigations. Impacts of site investigations under the Consent Order would be the same as those under the Capping Option.

Remediation of MDAs and Other PRSs. Compared to the Capping Option, this option would cause additional traffic in and near LANL. Additional workers would be needed to remove the wastes from the MDAs and to carry out sorting, characterization, treatment, and packaging activities. This indicates a larger number of personal vehicles in the LANL vicinity, which could cause traffic congestion in some areas, such as on Pajarito Road and other roads near TA-54 or near the intersection of DP and Trinity Roads. There would be additional radioactive and nonradioactive wastes sent to LANL treatment and disposal facilities (see Section I.5.10.3.2). Onsite risks from transporting this material could be mitigated or reduced through measures such as traffic control (site security), road closures, and transportation infrastructure improvements.

In addition, the Removal Option would require numerous shipments of crushed tuff for backfilling excavations. These shipments would be accompanied by shipments of topsoil or soil amendment to promote revegetation. There may also be shipments transporting wastewater generated from groundwater treatment programs or from decontaminating equipment. This larger number of material shipments compared with the No Action Option presents an increased short-term risk to the public and LANL personnel associated with possible accidents. Risks to onsite personnel could be reduced by appropriate road closures and other traffic control measures or transportation infrastructure improvements.

As addressed in Section I.5.4.3.2, compared to the No Action Option, the Removal Option may increase traffic on East Jemez Road if solid waste from LANL's environmental restoration project is processed through the solid waste transfer station on East Jemez Road and tuff and similar material are procured from the TA-61 borrow pit. It is expected, however, that industrial solid waste generated from LANL's environmental restoration project would be sent directly to a landfill without passing through the transfer station.

Regarding TA-21, complete removal of MDAs A, B, T, and U is projected to cause two-way shipments of waste, soil, and similar bulk materials, as summarized in **Table I–100**. Average daily shipments for the peak year (2010) would be in the range of those estimated for the Capping Option. As for the Capping Option, traffic congestion could be reduced by measures such as redesigning the intersection of DP Road with Trinity Road.

Table I–100 Removal Option of Wastes and Bulk Materials into and out of Technical Area 21 [a]

Waste and Material Shipments [b]	*Fiscal Year*					
	2008	*2009*	*2010*	*2011*	*2012*	*Total Shipments*
Waste shipments	4,000	7,300	5,500	1,700	10	19,000
Soil and Other Materials						
Crushed tuff	3,400	6,200	4,600	1,500	10	16,000
Additional material	230	440	3,209	100	1	1,100
Total shipments	7,600	14,000	10,000	3,300	21	35,000
Total shipments per day [c]	31	56	42	13	Less than 1	

[a] Assuming two-way shipments – that is, trucks entering and leaving Technical Area 21 via DP Road.
[b] Conservatively includes shipments for removing MDA U. Removing MDA U may be unlikely considering NMED's 2006 Corrective Action Complete with Controls certification for the SWMUs comprising MDA U (NMED 2006b).
[c] Assuming 250 working days per year.
Note: Because all numbers have been rounded, the sums may not equal indicated totals.

Borrow Pit. See above discussion.

I.5.10.3.2 Offsite Impacts

Site Investigations. The site investigations program under the Consent Order should have few, if any, offsite impacts.

Remediation of MDAs and Other PRSs. Compared with the No Action Option, there would be additional shipments of radioactive and nonradioactive wastes to offsite disposal facilities. These shipments would occur over public roads and could therefore present risks to the public. These risks would be managed by packaging and shipping wastes in compliance with U.S. Department of Transportation requirements for shipment of radioactive materials.

Transportation impacts were determined for the Removal Option using annual projected waste volumes estimated in Section I.3.6 and the assumptions and analysis described in Section I.3.5. Shipping crew and population radiation doses and risks from incident-free transportation and radiological and nonradiological risks from possible transportation accidents are presented in **Table I–101**. The table presents total doses and risks for FY 2007 through FY 2016, doses and risks from FY 2007 through FY 2011, and doses and risks for the peak year during this 10-year period. Smaller doses and risks would occur under the assumption of partial rather than complete removal of waste from MDAs.

Table I–101 Removal Option Transportation Impacts Summary

Time Period	Crew Dose and Risk		Population Dose and Risk		Accidents	
	Person-Rem	LCF	Person-Rem	LCF	Radiological (LCF)	Nonradiological (fatalities)
FY 2007 through FY 2016	630	0.38	190	0.12	0.0012	2.2
FY 2007 through FY 2011	390	0.23	120	0.071	0.00064	1.2
Peak year (FY 2010)	160	0.10	50	0.030	0.00025	0.46

LCF = latent cancer fatality, FY = fiscal year.
Note: Offsite shipments of low-level and mixed low-level radioactive wastes (low-activity, remote-handled, and alpha) would be split between disposal facilities. Numbers have been rounded.

The impacts for Table I–101 were determined assuming that solid and chemical wastes would be shipped to offsite facilities, transuranic wastes would be shipped to WIPP, and low-activity low-level and mixed low-level radioactive wastes would be sent to an offsite commercial facility such as the one in Utah. The remaining low-level radioactive wastes (remote-handled and alpha wastes and mixed remote-handled and mixed wastes) would be sent to a DOE facility such as the Nevada Test Site. However, options were considered of shipping all low-level radioactive and mixed low-level radioactive wastes to a DOE facility such as the Nevada Test Site, or disposing of all such waste on the LANL site. Note that the commercial facility in Utah cannot accept wastes having characteristics similar to those assumed in this appendix for remote-handled and alpha-contaminated low-level radioactive and mixed wastes. In addition, there is no current mixed low-level radioactive waste disposal capacity at LANL.

Comparative impacts considering these options are presented in **Table I–102** for FY 2007 through FY 2016. The risks of developing excess LCFs are highest for workers under the offsite disposition options. Disposal at the Nevada Test Site, which is farthest from LANL, would result in the highest dose and risk. Transportation of radioactive wastes would not result in any excess LCFs among the exposed truck crew or population. The largest risk to the population from radioactive waste transport could result from (nonradiological) traffic fatalities resulting from accidents. Considering that the transportation activities would occur over a 10-year period and that the average number of traffic fatalities in the United States is about 40,000 per year, the total traffic fatalities (about two to three) estimated under the Removal Option are small.

Borrow Pit. Operations of the borrow pit would have no offsite impacts from material transport.

Table I–102 Removal Option Comparison of On- and Offsite Radioactive Waste Disposal Transportation Impacts (Fiscal Year 2007 through Fiscal Year 2016)

Low-Level and Mixed Low-Level Radioactive Waste Destination [a]	*Total Distance Traveled (million kilometers)*	*Crew Dose and Risk*		*Population Dose and Risk*		*Accidents*	
		Person-Rem	*Risk (LCF)*	*Person-Rem*	*Risk (LCF)*	*Radiological (LCF)*	*Nonradiological Traffic (fatalities)*
LANL [b]	11.1	65	0.039	20	0.012	8.6×10^{-8}	0.16
DOE [c]	241	660	0.40	200	0.12	1.5×10^{-3}	2.4
Commercial [d]	220	630	0.38	190	0.12	1.3×10^{-3}	2.2

LCF = latent cancer fatality.
[a] All nonradiological wastes would be shipped offsite and all transuranic wastes would be shipped to WIPP.
[b] Modeled by assuming an average one-way distance of 9 kilometers from the point of generation to the disposal site such as that in Technical Area 54.
[c] Modeled by assuming shipment to the Nevada Test Site.
[d] Modeled by assuming shipment of bulk low-level and mixed low-level radioactive wastes to the EnergySolutions site in Utah, and the remaining low-level and mixed low-level radioactive wastes to the Nevada Test Site.
Note: Numbers have been rounded.

I.5.11 Environmental Justice

I.5.11.1 No Action Option

The primary route designated by the State of New Mexico to be used for radioactive and other hazardous material shipments to and from LANL is the approximately 40-mile (64-kilometer) corridor between LANL and I-25 at Santa Fe. This route passes through the Pueblos of San Ildefonso, Pojoaque, Nambe, and Tesuque and is adjacent to the northern segment of Bandelier National Monument. This primary transportation route bypasses the city of Santa Fe on New Mexico 599 to I-25. Minority populations dominate these communities. Total waste shipments under the No Action Option, assuming all environmental restoration project waste is shipped offsite, are estimated at 1,050 shipments, or 2,100 total truck trips. (Half of the total trips would consist of empty returning trucks.) The highest number of waste shipments is projected to be 400 shipments (800 total truck trips) in 2008, or approximately 3 truck trips per working day (assuming 250 working days per year).

Table 4–52 in Chapter 4 of this SWEIS shows average daily vehicle trips eastbound on NM 502 east of its intersection with NM 4. Eastbound trips averaged 10,100 per day, while westbound trips averaged 7,765 per day (totaling 17,865 vehicle trips). Waste shipments consisting of about 3 truck trips per working day under the No Action Option would represent 0.02 percent of the total traffic (17,865 vehicle trips) on NM 502.

I.5.11.2 Capping Option

Additional wastes would be generated at LANL under the Capping Option, and, to the extent that the wastes must be trucked offsite for treatment or disposal, additional impacts could potentially occur on minority communities through which these waste shipments would pass. Assuming that all waste is shipped offsite through these affected communities, there would be approximately 7,200 waste shipments, or 14,400 total truck trips via NM 502 through 2016. (Half of the total trips would consist of empty returning trucks.) The largest number of waste shipments is projected to be 970 shipments (1,940 total truck trips) in 2008, or approximately 8 truck trips per working day (assuming 250 working days per year). Waste shipments consisting of 8 truck trips per working day under the Capping Option would represent 0.04 percent of the total traffic (17,865 vehicle trips) on NM 502.

I.5.11.3 Removal Option

Additional wastes would be generated at LANL under the Removal Option, and to the extent that the wastes must be trucked offsite for treatment or disposal, additional impacts could potentially occur on minority communities through which these waste shipments would pass. Assuming that all waste is shipped offsite through these affected communities, there would be approximately 110,000 waste shipments, or 220,000 total truck trips via NM 502 through 2016, an average of 11,000 shipments (22,000 truck trips) per year. (Half of the total trips would consist of empty returning trucks.) The highest number of waste shipments is projected to be 22,000 shipments (44,000 total truck trips) in 2010, or approximately 180 truck trips per working day (assuming 250 working days per year). Fewer shipments would occur if partial, rather than full, removal of MDAs took place, or if onsite disposal is used for some waste. Waste shipments consisting of 180 truck trips per working day under the Removal Option would represent about 1 percent of the total traffic (17,865 vehicle trips) on NM 502.

I.5.12 Accidents

The primary focus of this section is the risk-dominant accidents under the Removal Option.

Before any of the corrective measure options described in this appendix take place, appropriate planning and safety reviews would occur. The extent of the planning, safety review, and related preparatory activities would be commensurate with the size of the task and the extent of the possible hazard. Preparatory activities would include assessments similar to those conducted for remediation of MDA H by Omicron, Inc. (Omicron 2001). In this study, slightly more than 150 potential accident scenarios were postulated for the proposed MDA H corrective measure options. Process hazard analyses were performed on postulated accidents that were not screened out based on the likelihood of their occurrence and their potential effect on human health. Unmitigated and mitigated public, worker, and transportation risks associated with excavating MDA H were assessed. Activities included site preparation; site excavation; sorting and segregation of waste; declassification, packing, and loading of waste; waste transportation; and site restoration. The spectrum of hazards considered included industrial hazards, fires, explosions, spills, and penetrating radiation (DOE 2004b).

The Omicron assessment concluded that accidents involving the exposure of the public to radioactive or hazardous materials left in place at MDA H were not credible (a chance of occurrence of less than 1 in 1 million). Excavation and removal corrective measure options (including associated transportation) posed the greatest risk to members of the public, albeit a small one. The risk to the public from all other activities was negligible. The risk to workers was dominated by standard industrial accidents, followed by possible explosion accidents (Omicron 2001).

Safety analyses consistent with the likely level of hazard and the scope of the corrective measure contemplated would be performed for each of the MDAs and PRSs considered in this SWEIS.

I.5.12.1 Risks to Public

There would be low risks to the public from accidents involving radioactive or hazardous materials left in place in the MDAs. For neither the No Action Option nor the Capping Option would waste and hazardous constituents within the MDAs be disturbed. Materials that could be present in sufficient concentrations to potentially react in a manner involving violent dispersal of contamination (for example, chunks of high explosive, pyrophoric uranium, uranium hydride) are buried. The buried materials would generally lack sufficient oxygen to support combustion or ignition. In addition, most of the MDAs are relatively distant from residential areas. The MDAs closest to a residential area are in TA-21. Of these MDAs, MDA B is about 0.2 miles distant, and the remaining MDAs in TA-21 are typically about 0.4 miles distant. (MDA B, however, is near businesses on DP Road in TA-21.)

The principal risk to the public from accidents under the Capping Option would be from transportation accidents involving shipments of bulk materials and waste. Much of the transportation of materials and waste would take place within LANL, as crushed tuff is trucked from onsite borrow areas. Some materials may be acquired from locations nearby, but outside of, LANL. In this case, there could be small levels of increased risks to the public from transportation accidents. These risks could be mitigated by measures such as those described in Section 1.5.10.2.1.

Risks to the public from accidents from shipments of waste to locations outside of LANL have been addressed in Section I.5.10.1.2 for the No Action Option and Section I.5.10.2.2 for the Capping Option.

In addition to the risks from waste and bulk material transportation, removing waste from the MDAs would disturb buried materials and possibly cause conditions that would increase the likelihood of an undesired chemical reaction or release of materials. Materials such as high explosive and pyrophoric uranium may be present. The assessment for excavation of MDA H determined that of the 33 hazards analyzed (most with two or more initiating events), only an offsite transportation accident posed a credible threat to the public. The most serious effects were death or serious injury from the physical force of the accident. Risks from accidents involving transporting waste under the Removal Option to locations away from LANL have been addressed in Section I.5.10.3.2.

Site-specific assessments would consider the potential for such risks and mitigative actions. But for purposes of this appendix, bounding accidents that might occur during complete removal of two MDAs were addressed. Accidents involving airborne dispersal of radioactive materials were considered for MDA G because it has the largest estimated radionuclide inventory at LANL. Accidents involving airborne dispersal of radiological materials and toxic chemicals were considered for MDA B because of its proximity to the LANL site boundary.

Accidents Involving Release of Radioactive Materials. Removal of waste and contamination from MDAs would probably occur under enclosures for which any contaminant that may be dispersed into the air during removal would be passed through HEPA filtration systems before release. An explosion was assumed to occur at MDA G that breaches the enclosure and bypasses the HEPA filters. It was assumed that accident mitigation would not be completed for 24-hours; thus, suspension of the waste for this time period was included with the initial explosive release.

Although several fires occurred while operating MDAs B and C, and in one reported event several cartons gave off minor explosions, there is no experience at LANL with explosions associated with MDA remediation or removal. The documented fires and minor explosions involved packages of fresh waste containing unauthorized or reactive materials before their burial. Materials postulated for removal from MDAs B and G will have been covered and mixed with soil for up to 60 years. Therefore, past occurrences of fires and minor explosions during MDA operation are not an indication of the frequencies of fires and explosions that could occur during removal. In addition, the documented fires and explosions during past operations all involved far smaller quantities of materials at risk that those assumed for the SWEIS (see below). Also as noted below, removal operations would be conducted so that the quantities of materials at risk being removed at any one time would be smaller than those quantities assumed for the accident analysis.

The potential for explosive blast accidents associated with operations at LANL facilities that process high explosives was assessed, and, again, as of the *1999 SWEIS*, no such experience was identified at LANL (DOE 1999a). (High explosive processing includes storage, synthesis, formulation, pressing, machining, assembly, quality assurance processes, shipping and receiving of high explosives, and disposal at facilities in several LANL TAs.) Based on site-specific experience at Pantex, an annual accident frequency range of 10^{-3} to 10^{-2} was assumed for the No Action Alternative for the *1999 SWEIS* (DOE 1999a). An annual accident frequency of 10^{-2} was assumed for possible explosive accidents under the MDA G Removal Option.

It is believed that MDA B does not contain a sufficient quantity of explosives that could result in a significant release (LANL 2006c). At the time MDA B was operating, explosives production and test areas used what is now called MDA R in TA-16 for disposal of explosive waste (LANL 2007g). The chosen accident scenario for this MDA is a fire that results in releases that breach the enclosure and the HEPA filters. The specific materials and quantities of chemicals and fire sources in the MDA are poorly known, and, therefore, so is the frequency of occurrence of the hypothesized scenario. The frequency used for the explosion scenario at MDA G was ascribed to the fire at MDA B to facilitate radiological risk calculations.

Radiological accident impacts were determined using the MELCOR Accident Consequence Code System, Revision 2, Version 1.13.1 (MACCS2), using parameter assumptions appropriate for the LANL region. The impacts estimated from the analysis are presented in terms of consequences and risks. All consequences were determined assuming that the accident does occur and, therefore, the frequency or probability that the accident occurs was not taken into account. The risks of the accident do reflect the frequency of occurrence and were calculated by multiplying the accident's frequency (1×10^{-2} per year) by its consequences. Dose consequences, in rem for an individual or person-rem for a group of individuals, were estimated for the MEI located at the site boundary (390 yards [355 meters] from MDA G and 49 yards [45 meters] from MDA B), the offsite population out to a distance of 50 miles (80 kilometers), and a noninvolved worker located about 110 yards (100 meters) from the accident. Consequences are also expressed in terms of the likelihood of an LCF for the MEI and noninvolved worker and in terms of the number of additional fatalities for the surrounding populations. A conversion factor of 0.0006 LCFs (or number of LCFs) per rem (or person-rem) was used to convert dose to health effects; this factor is doubled for dose to an individual in excess of 20 rem.

For MDA G, the source term was assumed to be given by one of the early disposal pits in which transuranic-contaminated waste was disposed of. This waste was disposed of before the 1970 decision to place transuranic-contaminated material into retrievable storage. The radionuclide inventory for pits 1 through 6 at MDA G has been estimated in the performance assessment and composite analysis for the Area G low-level radioactive waste disposal site (LANL 1997). Because there was no information about the distribution of radionuclides between pits, a material at risk corresponding to one-sixth of the inventory in pits 1 through 6 was assumed, reflecting the assumption that no more than a single pit would be involved in the accident.[85]

MDA B was one of the earliest disposal sites at LANL and operated when radioactive material, particularly plutonium, was scarce and expensive. The estimated plutonium inventory in MDA B (about 100 grams) is considered to be conservative (LANL 2006i). The distribution of radionuclide contamination throughout MDA B is unknown. As noted in Section I.3.3.2.7, MDA B may consist of several (up to six) small disposal pits plus two chemical trenches and two areas of contamination. The material at risk was conservatively assumed to consist of one-half of the total estimated MDA B inventory to reflect the possibility that the contamination in MDA B may be concentrated in only a few small pits.

For both of these MDAs, the radionuclides considered in the analysis were limited in accordance with a screening process to the principal dose-contributing radionuclides. **Table I–103** shows the list of radionuclides plus other analytical parameters used in the accident analysis.

The estimated consequences and annual risks from an explosion at MDA G or a fire at MDA B are shown in **Tables I–104** and **I–105**. These tables include doses and risks as calculated for a noninvolved worker assumed to be 109 yards (100 meters) from the accident.

MDA G consequences and risks bound those of MDA B because of the larger source term in MDA G (see Table I–103). For the MEI, the difference in doses and risks between these two MDAs is smaller than would be expected from the source term difference because of the much closer distance to the MEI for MDA B than for MDA G.

[85] *It may be argued that the radionuclide inventory may be concentrated in a few of the six pits. However, there is little information with which to estimate this possibility. In any event, if the MDA was removed, only a small portion of any pit would be exposed at any one time. Also note that the early pits at MDA G were large in size (far larger in size than those projected for MDA B). Hence, it is very unlikely that the entire contents of any single pit at MDA G would be involved in any accident involving an explosion or similar reactive event.*

Table I–103 Analytical Parameters for Assumed Accidents at Material Disposal Area G and Material Disposal Area B

MDA	*Accident Phase*	*Nuclide*	*MAR (Ci)*	*DR* [a, b]	*ARF* [b]	*RF* [b]	*ARR (/hr)* [b]	*LPF*	*ST-Ci*	*DEL T (min)*
MDA G	Explosion	Americium-241	352	0.02	0.005	0.3		1	0.014	1
		Gadolinium-148	0.466	1	0.005	0.3		1	0.000699	1
		Thorium-230	2.67	1	0.005	0.3		1	0.00401	1
		Actinium-227	0.0430	1	0.005	0.3		1	0.0000645	1
		Plutonium-238	591	0.88	0.005	0.3		1	0.780	1
		Plutonium-239	319	0.96	0.005	0.3		1	0.459	1
		Plutonium-240	74.7	1	0.005	0.3		1	0.112	1
		Plutonium-241	219	1	0.005	0.3		1	0.329	1
		Uranium-233	1.03	0 [c]	0.005	0.3		1	0	1
		Uranium-234	0.392	1	0.005	0.3		1	0.000588	1
		Uranium-238	1.72	1	0.005	0.3		1	0.00258	1
	Suspension	Americium-241	352	0.02		1	4.00×10^{-6}	1	0.000659	1,440
		Gadolinium-148	0.464	1		1	4.00×10^{-6}	1	0.0000445	1,440
		Thorium-230	2.66	1		1	4.00×10^{-6}	1	0.000255	1,440
		Actinium-227	0.0428	1		1	4.00×10^{-6}	1	4.11×10^{-6}	1,440
		Plutonium-238	588	0.88		1	4.00×10^{-6}	1	0.0497	1,440
		Plutonium-239	318	0.96		1	4.00×10^{-6}	1	0.0292	1,440
		Plutonium-240	74.3	1		1	4.00×10^{-6}	1	0.00714	1,440
		Plutonium-241	218	1		1	4.00×10^{-6}	1	0.0209	1,440
		Uranium-233	1.03	0 [c]		1	4.00×10^{-6}	1	0	1,440
		Uranium-234	0.390	1		1	4.00×10^{-6}	1	0.0000374	1,440
		Uranium-238	1.71	1		1	4.00×10^{-6}	1	0.000164	1,440
MDA B	Fire	Actinium-227	0.000159	1	0.0005	1		1	7.95×10^{-8}	1
		Americium-241	3.01	1	0.0005	1		1	0.00151	1
		Tritium	116	1	1	1		1	116	1
		Plutonium-238	4.15	1	0.0005	1		1	0.00208	1
		Plutonium-239	3.10 [d]	1	0.0005	1		1	0.00155	1
		Plutonium-240	0.671	1	0.0005	1		1	0.000336	1

MDA	Accident Phase	Nuclide	MAR (Ci)	DR [a, b]	ARF [b]	RF [b]	ARR (/hr) [b]	LPF	ST-Ci	DEL T (min)
		Plutonium-241	0.428	1	0.0005	1		1	0.000214	1
		Uranium-233	0.0211	1	0.0005	1		1	1.06×10^{-5}	1
		Uranium-234	0.00712	1	0.0005	1		1	3.56×10^{-6}	1
		Uranium-238	0.0687	1	0.0005	1		1	3.44×10^{-5}	1
	Suspension	Actinium-227	0.000159	1		1	4.00×10^{-6}	1	1.53×10^{-8}	1440
		Americium-241	3.01	1		1	4.00×10^{-6}	1	0.000289	1440
		Tritium	0	1		1	4.00×10^{-6}	1	0	1440
		Plutonium-238	4.15	1		1	4.00×10^{-6}	1	0.000398	1440
		Plutonium-239	3.10	1		1	4.00×10^{-6}	1	0.000297	1440
		Plutonium-240	0.671	1		1	4.00×10^{-6}	1	0.0000644	1440
		Plutonium-241	0.428	1		1	4.00×10^{-6}	1	0.0000411	1440
		Uranium-233	0.0211	1		1	4.00×10^{-6}	1	2.02×10^{-6}	1440
		Uranium-234	0.00712	1		1	4.00×10^{-6}	1	6.83×10^{-7}	1440
		Uranium-238	0.0687	1		1	4.00×10^{-6}	1	6.59×10^{-6}	1440

MDA = material disposal area, MAR = material at risk (units of curies); DR = damage ratio; ARF = airborne release fraction; RF = respirable fraction; ARR = airborne release rate; LPF = leakpath factor; ST-Ci = source term (units of curies); DEL T = time period of exposure (minutes).

[a] DR smaller than unity indicates presence of nondispersable (concrete and sludge) waste forms.

[b] Values for DR, ARF, ARR, and RF were assumed from information in the DOE handbook for airborne release fractions and rates (DOE 1994), and from comparison to other environmental statements addressing similar accidents involving plutonium-contaminated materials (DOE 1998a, 1999f).

[c] DR is zero for uranium-233 because all uranium-233 was disposed within nondispersable (concrete and sludge) waste forms.

[d] A 2007 document estimates a total plutonium-239 inventory in MDA B ranging from 1.5 to about 15 curies, with an estimated 7.08 curies at the 50th percentile and 10.6 curies at the 90th percentile. The inventory distributed among gloves, personal protective equipment, glassware, lab debris, and liquid containers is estimated to be 2.55 curies at the 50th percentile and 4.73 curies at the 90th percentile (LANL 2007g). For accident analysis purposes, the balance of the inventory distributed in interstitial soil and fill would be less likely to disperse in a fire than the inventory distributed in the other material. If all of the other material was involved in the fire, the plutonium-239 material at risk would be about 50 percent higher at the 90th percentile than that assumed for the analysis.

Table I–104 Material Disposal Area Explosion or Fire: Radiological Accident Consequences

Accident Location	*Maximally Exposed Individual*		*Offsite Population to 80 Kilometers*		*Noninvolved Worker (at 100 meters)*	
	Dose (rem)	*Latent Cancer Fatality* [a]	*Dose (person-rem)*	*Latent Cancer Fatality* [b, c]	*Dose (rem)*	*Latent Cancer Fatality* [a]
MDA G	55	0.066	770	0.46	410	0.49
MDA B [d]	7.1	0.0043	7.8	0.0047	1.6	0.00095

MDA = material disposal area.
[a] Increased risk of an LCF to an individual, assuming the accident occurs.
[b] Increased number of LCFs for the population, assuming the accident occurs.
[c] Offsite population size out to a 50-mile (80-kilometer) radius is approximately 343,000 from MDA G and 271,600 from MDA B.
[d] The calculated impact could be up to 50 percent higher (see Table I–103).

Table I–105 Material Disposal Area Explosion or Fire: Radiological Accident Risks

Accident Scenario	*Latent Cancer Fatality Risk per Year of Operation*		
	Maximally Exposed Individual [a]	*Offsite Population (to 50 Miles)* [b, c]	*Noninvolved Worker (at 100 meters)* [a]
MDA G	0.00066	0.0046	0.0049
MDA B [d]	4.3×10^{-5}	4.7×10^{-5}	9.5×10^{-6}

MDA = material disposal area.
[a] Increased risk of an LCF to an individual per year. Risks were determined by conservatively assuming an accident frequency of 1×10^{-2} per year.
[b] Increased number of LCFs for the population per year.
[c] Offsite population size out to a 50-mile (80-kilometer) radius is approximately 343,000 from MDA G and 271,600 from MDA B.
[d] The calculated impact could be up to 50 percent higher (see Table I–103).

The MEI for MDA B is a hypothetical maximally exposed individual assumed to be positioned 45 meters from the accident at MDA B. Because this individual is hypothetical and certain very conservative assumptions are attributed to him (see Appendix D), he is not included in the calculation of population dose.

These calculated doses and risks are conservative. For example, the assumed airborne release and respirable release fractions for MDA B are the same as those used in other analyses for fires involving newly generated combustible materials (for example, DOE 1998a, 1999f), an assumption that discounts the effects of decades of exposure of the buried waste to the environment. Furthermore, before removal would actually occur at any MDA, thorough safety reviews would take place with the intent of identifying hazard scenarios and the barriers associated with preventing or mitigating each postulated hazard scenario. If it is determined that a possible hazard would actually be credible and significant, then measures would be taken to address the hazard. For example, if an explosion or similar reactive event was deemed credible and significant, exhumation could take place in an inert atmosphere, as has been considered as an option for MDA H (DOE 2004b). For removal of MDA B, several technical and administrative controls will be imposed to ensure safety, including visual inspections, use of several or remote sensing tools to monitor for radiation or hazardous constituents, and controls that limit the plutonium equivalent that may be present in different areas associated with MDA B removal. These areas and their plutonium equivalent include the dig face and excavation enclosure

(2.4 grams [0.15 curies]); the Definitive Identification Facility and field laboratory (7.0 grams [0.43 curies]); onsite transportation (2.4 grams [0.15 curies]); waste container storage area number 1 (7.0 grams (0.43 curies); and waste container storage area number 2 (28.0 grams [1.7 curies]) (LANL 2006a). The plutonium equivalent limits for each of these areas are smaller than the material at risk for the accident analysis presented here for MDA B removal. For the dig face and excavation enclosure the limit is 5 percent of the assumed material at risk.

Accidents Involving Release of Toxic Chemicals. A toxic chemical accident analysis for the MDAs was performed using the ALOHA code[86] and a conservative accident scenario postulated to result in the maximum human health effects of the atmospheric release of toxic chemicals. MDA B was chosen for this analysis because of its proximity to members of the public. Chemical releases from possible accidents at other MDAs having chemical inventory uncertainties equivalent to MDA B (see below) are expected to result in smaller impacts because of their greater distances to members of the public.

LANL staff have postulated that over 200 different chemicals may have been placed in MDA B for disposal of substances prior to its closure. There are no definitive records of the types or quantities of chemicals that were disposed of in MDA B. Therefore, conservative assumptions were made about the presence and quantity of toxic chemicals in the MDAs. That is, a hazardous chemical accident analysis was developed based on selecting the more toxic chemicals that could be present at MDA B and a quantity commensurate with current knowledge of the historical uses of these chemicals. The release scenario, a fire that breaches the enclosure and bypasses the HEPA filter, is consistent with that used to analyze radiological releases. The thermal energy that would accompany such a fire and that would tend to loft the plume over potential nearby receptors was conservatively ignored. (An explosion would also loft chemicals over potential nearby receptors.)

Within the context of the aforementioned data limitations, the list of possible chemicals was evaluated in terms of their potential effects on human health. A number of chemicals, either alone or in combination with others, could cause a fire. A fire is expected to release larger quantities of chemicals to the atmosphere than most other realistic accident initiators.

A measure of a chemical's relative toxicity is the numerical value of its Emergency Response Planning Guideline (ERPG), which is an air concentration value associated with a specific human health response. A lower ERPG indicates a more toxic chemical (see Appendix D). The list of chemicals that may be present in MDA B was reviewed for those chemicals with the lowest ERPG values, in addition to their maximum possible quantity. This review identified gases (sulfur dioxide, hydrogen chloride, hydrogen bromide), liquids (hydrofluoric acid, hydrochloric acid), and a solid (beryllium powder) having restrictive ERPG concentrations. Each of these chemicals was assumed to be disposed of in quantities consistent with their historical use. Sulfur dioxide and beryllium were found to be the most restrictive of these and were considered further. The identification of sulfur dioxide as the most restrictive non-solid-phase chemical was in agreement with a LANL determination, based on a detailed assessment of over 200 chemicals, of the aboveground inventory limits for chemicals to be staged or stored in a DIF

[86] The ALOHA code is a public domain code developed by EPA and the National Oceanic and Atmospheric Administration and used to plan for and respond to chemical emergencies. The code is widely used throughout the DOE complex for safety analysis applications.

and surrounding storage and staging area (LANL 2006c). The DIF will be constructed and operated to support the investigation and remediation program for MDA B.

Given the dearth of information on specific chemicals present, their quantity, degradation over more than 50 years, or environmental transport from the MDA, this accident analysis serves to quantify an approximate distance within which significant human health impacts may occur for relatively conservative quantities and types of chemicals that may be present during MDA B restoration activities. The aforementioned information does not support the estimate of an accident frequency at MDA B.

Table I–106 shows the accident risks posed from these two chemicals during MDA B waste retrieval. As noted, the frequency of an accident involving releases of these chemicals is unknown because the probability of their presence in the MDA is unknown. The direction traveled by the chemical plume will determine what segment of the worker and offsite populations would be at risk of exposure, and this direction will depend upon meteorological conditions at the time of the accident. The ERPG-3 concentration limit is defined in terms of 1-hour exposure and corresponds to the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects (DOE 2004a). The exposure duration to releases from an explosion event would be for a much shorter period of time and, therefore, is expected to result in smaller health effects than that indicated by the ERPG value.

Table I–106 Material Disposal Area B Waste Retrieval Chemical Accident Consequences

Chemical	*Frequency (per year)*	*Quantity Released*	*ERPG-2* [a]		*ERPG-3* [b]	
			Value	*Impact*	*Value*	*Impact*
Sulfur dioxide	unknown	1 pound (454 grams)	3 ppm	Risk of workers or public within 90 yards (83 meters) of facility receiving exposures in excess of limit. Public access is at 49 yards (45 meters) and beyond this limit.	15 ppm	Risk of workers within 37 yards (34 meters) of facility receiving exposures in excess of limit. Public access is at 49 yards (45 meters).
Beryllium powder	unknown	0.0013 pounds (0.6 grams) [c]	0.025 mg/m^3	Risk of workers within 25 yards (23 meters) of facility receiving exposures in excess of limit. Public access is at 49 yards (45 meters).	0.1 mg/m^3	Risk of workers within 10 yards (9 meters) of facility receiving exposures in excess of limit. Public access is at 49 yards (45 meters).

ERPG = Emergency Response Planning Guideline, ppm = parts per million, mg/m^3 = milligrams per cubic meter.

[a] ERPG-2 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action (DOE 2004a).

[b] ERPG-3 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects (DOE 2004a).

[c] Based on a respirable release fraction of 6×10^{-5} of the total powder at risk and under thermal stress (DOE 1994), and on consideration of respiration release fractions assumed in other environmental statements (DOE 1998a, 1999f).

I.5.12.2 Risks to Workers

Workers would carry out tasks under the No Action and Capping Options that would be little different than those that have taken place for years at LANL. Continued work under LANL's environmental restoration project would subject workers to risks such as exposure to radioactive and hazardous constituents and standard industrial accidents. Workers receive training to recognize and avoid hazards and would wear personal protective equipment as appropriate. Capping the MDAs could result in slightly increased levels of risks because of extensive use of heavy construction machinery.

The most significant risks to workers would come from complete excavation and removal of the MDAs. Accidents that could result in severe worker injuries could include vehicle accidents, explosions, equipment failures, lightning strikes, electrocution, and operator errors. Removal procedures would be developed for the MDAs based on the experience and technology developed at LANL, Idaho National Laboratory, Hanford, and other DOE sites. Hazards associated with removal of waste and materials from the MDAs could be avoided or mitigated using techniques such as personal protective equipment, water sprays to separate high explosive from a waste matrix, excavation under an inert atmosphere, remotely controlled or shielded excavators, remotely controlled or shielded manipulators for waste sorting, designated safe areas and explosion shields, and other techniques.

Section I.5.12.1 summarizes the radiological consequences and risks to members of the public and, for convenience, to noninvolved workers from two bounding radiological accidents involving removal of wastes from MDAs G and B. Section I.5.12.1 also addresses possible public and worker consequences from two hypothetical accidents at MDA B involving release of chemicals.

Risks to workers from industrial accidents were determined using the procedures outlined in Section I.3.6.4. Industrial accident risks are summarized in **Table I–107** for each of the three options assuming statistical information pertaining to DOE construction workers and the general construction industry. **Table I–108** presents similar risks only for operation of the TA-61 borrow pit. Risks are presented as summed for FY 2007 through FY 2016 and for FY 2007 through FY 2011. DOE statistics indicate a favorable safety record compared to the construction industry as a whole.

The activities resulting in the largest industrial accident risks are those associated with removal of the MDAs, particularly MDA G. Risks for removal of MDA G are listed in **Table I–109**, along with risks for removal of all MDAs (A, B, T, and U) in TA-21.

I.5.13 Cumulative Effects

Several resource areas would not be appreciably affected by any of the options in this project-specific analysis and, therefore, would not contribute significantly to cumulative effects because they would not have major long-term or irreversible effects. These resource areas include: cultural, visual, and biological resources; air quality; noise; human health; transportation; environmental justice; and socioeconomics. The options could frequently have a negative effect on each of the resource areas, but the effect would be temporary. Resource areas receiving additional consideration are land use, geology, water quality, waste management, and infrastructure.

Land Use. All options would have a net positive effect on land use. Continuing the environmental restoration project under the No Action Option would remove contamination from land and property throughout LANL or fix it in place. This action provides greater freedoms in determining future uses for the land and property. The Capping and Removal Options would have additional positive effects.

Table I–107 Industrial Accident Risks for Remediation Options

Option	*Construction Industry*			*DOE Construction*		
	Recordable Injuries	*Lost Workdays*	*Fatalities*	*Recordable Injuries*	*Lost Workdays*	*Fatalities*
Fiscal Year 2007 through Fiscal Year 2016 [a]						
No Action	1.9	20	0.0045	0.49	1.6	–
Capping [a]						
Thin cap	51	550	0.12	14	45	–
Thick cap	83	900	0.20	22	73	–
Removal [b]	1,300	14,000	3.2	350	1,200	–
Fiscal Year 2007 through Fiscal Year 2011 [a]						
No Action	1.8	19	0.0043	0.47	1.6	–
Capping [a]						
Thin cap	25	270	0.060	6.5	22	–
Thick cap	40	430	0.097	11	35	–
Removal [b]	560	6,000	1.4	150	500	–

[a] Includes borrow pit operations.
[b] Includes borrow pit operations, capping the remaining disposal units in the existing Area G footprint following MDA G removal, and capping areas in TA-49. Thick caps are assumed.
Note: Numbers have been rounded.

Table I–108 Industrial Accident Risks for Technical Area 61 Borrow Pit Operations

Option	*Construction Industry*			*DOE Construction*		
	Recordable Injuries	*Lost Workdays*	*Fatalities*	*Recordable Injuries*	*Lost Workdays*	*Fatalities*
Fiscal Year 2007 through Fiscal Year 2016						
Capping						
Thin cap	12	130	2.9×10^{-2}	3.2	11	–
Thick cap	31	340	7.7×10^{-2}	8.4	28	–
Removal [a]	31	330	7.5×10^{-2}	8.2	27	–
Fiscal Year 2007 through Fiscal Year 2011						
Capping						
Thin cap	5.8	63	1.4×10^{-2}	1.5	5.1	–
Thick cap	15	160	3.6×10^{-2}	3.9	13	–
Removal [a]	15	160	3.7×10^{-2}	4.0	13	–

[a] Includes borrow pit operations, capping the remaining disposal units in the existing Area G footprint following MDA G removal, and capping areas in TA-49. Thick caps are assumed.
Note: Numbers have been rounded.

Table I–109 Industrial Accident Risks for Removal of Material Disposal Area G and Combined Material Disposal Areas A, B, T, and U

Option	Construction Industry			DOE Construction		
	Recordable Injuries	Lost Workdays	Fatalities	Recordable Injuries	Lost Workdays	Fatalities
Fiscal Year 2007 through Fiscal Year 2016						
MDA G	1,200	13,000	2.9	310	1,000	–
MDAs A, B, T, and U	58	630	0.14	16	52	–
Fiscal Year 2007 through Fiscal Year 2011						
MDAs G	450	4,900	1.1	120	400	–
MDA A, B, T, and U	58	630	0.14	16	52	–

MDA = material disposal area.
[a] Includes capping the remaining portion of Area G following MDA removal. A thick cap is assumed.
Note: Numbers have been rounded.

Geology and Soils. All options would have a net positive effect. All options would result in additional contamination being removed from property and soils or stabilized in place. Management of the MDAs under the Capping and Removal Options would be conducted in a manner that addresses mass-wasting concerns such as erosion or cliff retreat.

Water Quality. All options would have a net positive effect. All options would result in additional contamination being removed from property and soils or stabilized in place. These actions would reduce the potential for the contamination to enter surface water pathways and for continued movement of existing contamination in surface water channels. Both the Capping and Removal Options would reduce possible risks to groundwater.

Waste Management Infrastructure. The No Action and Capping Options would not generate wastes in volumes that would significantly tax the existing waste management infrastructure. The Removal Option, however, could impact the waste management infrastructure at LANL and elsewhere. This may require construction of additional and complex waste handling and disposal capacity. Development and use of such capacity would require increased use of utilities such as gas, water, or electricity, increased use of natural resources, and larger personnel requirements. Any structures constructed and used for this purpose would have to be safely decommissioned, which would generate additional quantities of waste to be treated, packaged, shipped, and disposed of. The transuranic waste that would be generated under the Removal Option represents roughly 9 percent of the total transuranic waste volume capacity at WIPP.

I.6 References

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