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Rep

Office of
Fissile Materials Disposition

United States Department of Energy

# Pit Disassembly and Conversion Demonstration Environmental Assessment and Research and Development Activities

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## Preapproval Review

May 1998

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## 1.0 INTRODUCTION

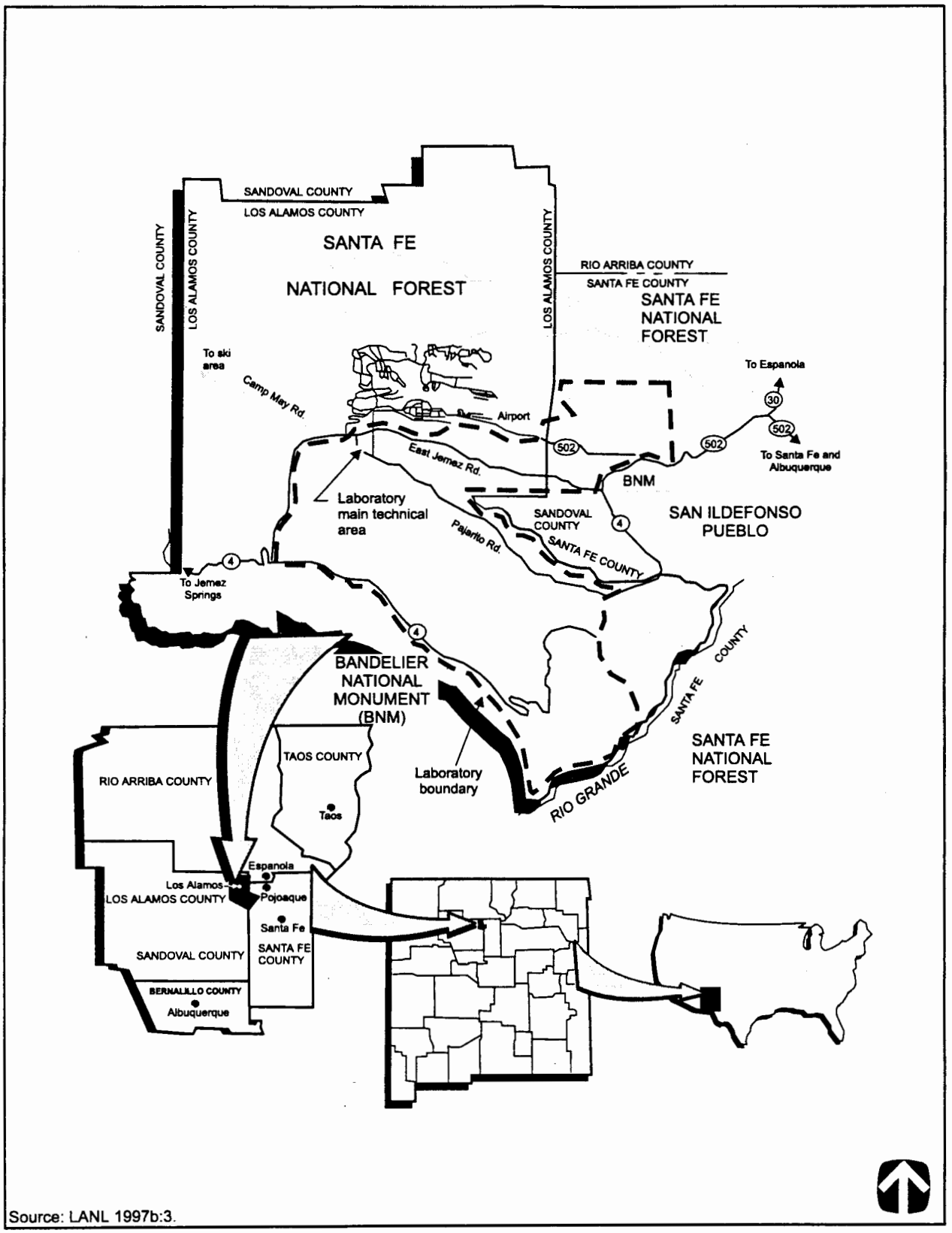
The Department of Energy (DOE) is implementing a long-term program to provide safe and secure storage of weapons-usable fissile materials, and the timely disposition of weapons-usable plutonium declared surplus to national security needs. The program's goal is to ensure that there is a high standard of security and accounting of these materials while in storage, and that the surplus plutonium is never used again in nuclear weapons. The United States has approximately 50 metric tons of plutonium that has been or may be declared surplus.

In January 1997, DOE issued the Record of Decision (ROD) for the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement (PEIS)*. In the PEIS ROD, DOE announced a decision to pursue a dual track strategy to dispose of surplus United States plutonium that allows for two separate approaches: 1) immobilization of some (and potentially all) of the surplus plutonium; and 2) using some of the surplus plutonium as mixed oxide (MOX) fuel in existing commercial reactors. In that decision, DOE explained that the timing and extent to which either or both of the disposition approaches are ultimately deployed will depend in part on a follow-on environmental impact statement (EIS), as well as technology development and research. The *Storage and Disposition Final PEIS* ROD also explained that DOE will continue research and development (R&D), and engage in further testing and demonstrations of plutonium disposition technologies, pursuant to appropriate National Environmental Policy Act (NEPA) review. This environmental assessment (EA) is part of the NEPA review for such proposed and continuing research and demonstration activities, occurring prior to the completion of the follow-on *Surplus Plutonium Disposition Environmental Impact Statement* (SPD EIS), contemplated in the *Storage and Disposition Final PEIS* ROD.

A significant portion of the surplus plutonium is in the form of nuclear weapons pits. Pits are composed of plutonium which is sealed in a metallic shell. These pits would need to be safely disassembled and permanently converted to an unclassified form that would be suitable for long-term disposition and international inspection. To determine the feasibility of an integrated pit disassembly and conversion system, a Pit Disassembly and Conversion Demonstration is proposed to take place at the Los Alamos National Laboratory (LANL). LANL is located about 40 kilometers (25 miles) northwest of Santa Fe, New Mexico (see Figure 1–1). This demonstration would be done in existing buildings and facilities, and would involve the disassembly of up to 250 pits and conversion of the recovered plutonium to plutonium metal ingots and plutonium oxide. This demonstration also includes the conversion of up to 80 kilograms of clean plutonium metal to plutonium oxide because, as part of the disposition process, some surplus plutonium metal may be converted to plutonium oxide in the same facility as the surplus pits. The demonstration would start during June 1998 and continue for up to four years.

In addition, small scale R&D activities are currently underway as part of the overall surplus plutonium disposition program. These R&D activities are related to pit disassembly and conversion, MOX fuel fabrication, and immobilization (in glass and ceramic forms). They are described in Section 7.0.

On May 19 1997, the Office of Fissile Materials Disposition (MD) notified potentially affected states and tribes that this EA would be prepared in accordance with NEPA. This EA has been prepared to provide sufficient information for DOE to determine whether a Finding of No Significant Impact (FONSI) is warranted or whether an EIS must be prepared.




Source: LANL 1997b:3.

**Figure 1–1. Regional Location of Los Alamos National Laboratory**

## 1.1 Related National Environmental Policy Act Reviews

The *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE/EIS-0229, December 1996; ROD, January 1997), analyzed the environmental impacts of alternatives for the long-term storage (up to 50 years) and disposition of weapons-usable fissile materials under the responsibility of DOE. The ROD encompasses two categories of decisions: (1) the sites and facilities for the storage of non-surplus weapons-usable plutonium and highly enriched uranium (HEU), and storage of surplus plutonium and HEU pending disposition; and (2) the programmatic strategy for disposition of surplus weapons-usable plutonium. This ROD does not encompass the final selection of sites for plutonium disposition facilities, nor the extent to which the two plutonium disposition approaches (immobilization or MOX fuel) will ultimately be implemented. Those decisions will be made pursuant to a follow-on EIS (the SPD EIS). However, DOE does announce in the ROD that the list of candidate sites for plutonium disposition has been narrowed.

The *Surplus Plutonium Disposition Environmental Impact Statement* (DOE/EIS-0283, in preparation), will examine reasonable alternatives and potential environmental impacts of the proposed siting, construction and operation of three types of facilities for plutonium disposition: a facility to disassemble and convert pits into plutonium oxide suitable for disposition; a facility to immobilize surplus plutonium in a glass or ceramic form for disposition in a geologic repository pursuant to the Nuclear Waste Policy Act; and a facility to fabricate plutonium oxide into MOX fuel. One of the alternatives being studied is the fabrication of lead MOX fuel assemblies at LANL.

The *Site-Wide Environmental Impact Statement on the Continued Operation of the Los Alamos National Laboratory* (DOE/EIS-0238, in preparation), will examine the environmental impacts of continuing operation of LANL in support of DOE missions including operations at Technical Area-55 (TA-55) and the proposed demonstration.

The *Environmental Assessment for the Parallex Project Fuel Manufacture and Shipment*, Predecisional Draft, (DOE/EA-1216, August 1, 1997) examined DOE fabrication of a limited amount of MOX test fuel and its delivery to the Atomic Energy of Canada Limited National Research Universal test reactor in Canada as part of the Parallex Project at LANL. This proposed action would allow DOE to test and demonstrate the feasibility of burning MOX fuel in Canadian Deuterium Uranium reactors as part of its ongoing mission to evaluate the disposition of surplus weapons-grade fissile materials. DOE has not yet finalized this EA or determined, based on this EA, whether a FONSI is warranted for the Proposed Action or whether an EIS must be prepared.

The *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS), (DOE/EIS-0200-F, May 1997) examined the potential environmental and cost impacts of strategic alternatives for managing five types of radioactive and hazardous wastes that have resulted, and will continue to result, from nuclear defense and research activities at a variety of sites around the United States. The WM PEIS provides information on the impacts of various siting alternatives that DOE will use to decide where to locate additional treatment, storage, and disposal capacity for each waste type. Any waste resulting from actions taken in this EA would be treated, stored, and disposed of in accordance with the decisions resulting from the WM PEIS.

The *Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components* (DOE/EIS-0225, November 1996; ROD, January 27, 1997), is a sitewide EIS that covers current and proposed facilities and activities at the DOE Pantex Plant in Amarillo, Texas, where plutonium pits are currently stored. The EIS analyzed the environmental impacts associated with continuing to conduct nuclear weapons operations at Pantex. Included in the EIS is an analysis of the

effects of increasing the number of pits in interim storage from 12,000 to 20,000. In the ROD, DOE decided to implement the preferred alternative by: 1) continuing nuclear weapon operations involving assembly and disassembly of nuclear weapons at the Pantex Plant; 2) implementing facility projects, including upgrades and construction consistent with conducting these operations; and 3) continuing to provide interim pit storage at the Pantex Plant and increasing the storage level from 12,000 to 20,000 pits.

The *Environmental Assessment for the Proposed Interim Storage of Enriched Uranium Above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee* (DOE/EA-0929, September 1994; FONSI, September 1995) evaluated the continued receipt, prestorage processing, and interim storage of enriched uranium in quantities that would exceed the historic maximum storage level. The Y-12 Plant EA was issued in September 1994 and was followed by a FONSI in September 1995. Based on the EA, DOE determined that the Y-12 Plant would store no more than 500 metric tons of highly enriched uranium and no more than six metric tons of low-enriched uranium.

## 2.0 PURPOSE AND NEED FOR ACTION

### 2.1 Background

Since the early 1990s, the United States has been examining various ways to safely and securely disposition its surplus weapons-usable fissile materials. For the purposes of this EA, the term "disposition" relates to actions taken to meet nonproliferation goals by converting surplus plutonium to a form that meets the "Spent Fuel Standard."[1] To support this effort, in December 1996, DOE published the *Storage and Disposition Final PEIS* which assessed the environmental impacts of various disposition technologies for surplus weapons-usable plutonium.

In the *Storage and Disposition Final PEIS* ROD, DOE announced that it had decided to pursue a plutonium disposition strategy that allows for both immobilization of surplus weapons plutonium in glass or ceramic forms and the use of some of the surplus plutonium as MOX fuel in existing commercial reactors. (DOE 1997c:1) The ROD also committed to a subsequent EIS, the SPD EIS, which is evaluating the site-specific impacts associated with pursuing these disposition alternatives. Additionally, the ROD stated, "Based on appropriate NEPA review, DOE anticipates demonstrating the Advanced Recovery and Integrated Extraction System (ARIES) concept at LANL for pit disassembly/conversion ..." (DOE 1997c:20). Accordingly, this EA is being undertaken to determine whether there are any potentially significant environmental impacts associated with conducting, as an interim action before issuance of the SPD EIS ROD, the Pit Disassembly and Conversion Demonstration.

### 2.2 Purpose and Need for Action

The United States has declared 38.2 metric tons of weapons-grade plutonium surplus to national security needs. Additional quantities of plutonium may be declared surplus in the future; therefore, the *Storage and Disposition Final PEIS* analyzed (as will the SPD EIS) the disposition of a nominal 50 metric tons of plutonium (DOE 1997c:2; DOE 1997a:7). Approximately 33 of the 50 metric tons of surplus plutonium are expected to come from clean metal including pits from dismantled nuclear weapons. The remainder will consist of plutonium in other forms (e.g., oxides, alloyed metal, residues).

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[1] The "Spent Fuel Standard" is defined by DOE as follows: The surplus weapon-usable plutonium should be made as inaccessible and unattractive for weapons use as the much larger and growing quantity of plutonium that exists in spent nuclear fuel from commercial power reactors (DOE 1996a:1-5).

DOE is continuing to dismantle nuclear weapons (separating the plutonium pits from the rest of the weapons components), thereby, increasing the inventory of surplus weapons pits. While these additional surplus pits are placed in safe, secure storage, the plutonium metal contained therein could readily be reused in nuclear weapons. Therefore, safe, secure storage alone will not meet the nonproliferation goals of the fissile materials disposition program.

Disposition of surplus plutonium metal either through immobilization or through use as MOX fuel in commercial reactors, requires that it first be converted to an oxide form. Because it will be subject to international safeguards, the material must be unclassified. Therefore, for disposition, the surplus pits must be disassembled and converted to an unclassified oxide form.

DOE is currently dismantling a limited number of pits as part of weapons surveillance and rebuild efforts. However, the existing DOE infrastructure is only capable of dismantling a very limited number of pits and does not include the capability of converting the resulting plutonium metal to an unclassified oxide. Additionally, because of this limited throughput, the existing pit disassembly process was never optimized and consists of a series of operations in a variety of separate (non-integrated) gloveboxes which results in a burdensome, man-hour intensive operation and higher than desirable radiation exposure to involved workers.

DOE needs to develop the capability to disassemble a large number of surplus pits and convert the surplus plutonium metal to a suitable oxide form safely and efficiently. In order to develop this capability in a timely manner, safety and operational design information must be obtained from the actual disassembly of up to 250 representative pits and the conversion of the recovered plutonium to plutonium metal ingots and plutonium oxide. A complicating factor is that there are many different types of pits of varying ages and therefore, the dose to which the workers would be exposed could vary considerably. In order to adequately protect workers in the potential pit disassembly and conversion facility, a wide range of spacing and shielding specifications needs to be developed, integrated, and tested. Concurrently, process parameters must be developed for the conversion of different pits to produce an unclassified oxide form that could be used in MOX fuel or immobilized.

The basic objectives of this demonstration are to:

- Demonstrate the feasibility of the pit disassembly and conversion process;
- Test various processes for the different parts of the pit disassembly and conversion process to optimize procedures and parameters and reduce dose to workers (as the number of pits to be dismantled would significantly increase);
- Develop processes, procedures and equipment for the disassembly of all types of surplus pits; and
- Demonstrate that the plutonium metal from pits of varying types and ages can be consistently converted to an oxide form that is suitable for use as feed for MOX fuel and for immobilization.

The resulting experience would be applied to expedite the design of the production disassembly and conversion facility should it be decided to construct this facility in the SPD EIS ROD.

## 3.0 PROPOSED PIT DISASSEMBLY AND CONVERSION DEMONSTRATION

In order to meet the purpose and need for the action described in Section 2.2, DOE proposes to test an integrated pit disassembly and conversion process on a relatively small sample of pits and plutonium metal

at LANL. The pits processed as a part of this demonstration would represent the diverse range of pits that DOE proposes to disassemble over the coming years.

The demonstration would be accomplished at LANL's Plutonium Facility-4 (PF-4) in TA-55, see Figure 3–1. No new facilities are needed to support this demonstration; however, minor internal modifications were made to existing facilities. These minor modifications relating to the installation of new gloveboxes did not involve worker exposure.

Most work would be performed in a series of interconnected gloveboxes using remote handling, automation and computerized control systems to minimize operator exposure where possible, increase safety, and minimize the amount of waste generated by the process. The demonstration would include the following nine steps:

- removing any external features from pits
- cutting the pits into halves (hemishells) and decontamination if the pits are shown to be contaminated with tritium
- processing the hemishells to separate the plutonium from other materials that may be present
- converting the plutonium to metal ingots or an oxide
- thermally processing the plutonium oxide to remove gallium and other impurities
- sealing the recovered plutonium in an appropriate container for storage
- decontaminating the container
- performing nondestructive assays on all components for material accountability purposes
- storing the resulting oxide until a disposition decision has been made as a result of the SPD EIS

TA-55 has historically performed plutonium processing activities similar to those required in this demonstration, and currently disassembles pits in a series of individual gloveboxes. The plutonium to be used in the demonstration would be taken from storage at LANL or shipped from the Pantex Plant near Amarillo, Texas, the Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado, the Idaho National Engineering and Environmental Laboratory (INEEL) near Idaho Falls, Idaho, the Savannah River Site (SRS) near Aiken, South Carolina, or the Lawrence Livermore National Laboratory (LLNL) in Livermore, California.

During the Pit Disassembly and Conversion Demonstration, plutonium would be decontaminated if it is contaminated with tritium, converted to an oxide, and placed in storage until a disposition decision is made as a result of the SPD EIS. Plutonium pits, metal, and oxide would be stored in existing nuclear facilities and special nuclear materials storage areas at LANL until the materials are ultimately dispositioned. It is not expected that the plutonium products from this demonstration will come under international safeguards. No new nuclear materials storage facilities would be constructed to accommodate the proposed action. In addition, HEU would be recovered from some of the pits during the disassembly process and shipped to DOE's Oak Ridge Reservation (ORR) for storage in accordance with DOE's Y-12 Plant EA[2] and the *Storage and Disposition Final PEIS*.

Currently, routine waste is produced at LANL in the following categories: transuranic waste (TRU), low-level waste (LLW), mixed low-level waste (MLLW), and hazardous waste. It is expected that small amounts of these types of waste will be produced by the proposed Pit Disassembly and Conversion Demonstration. In addition, small amounts of plutonium, americium and tritium may be released to the atmosphere.

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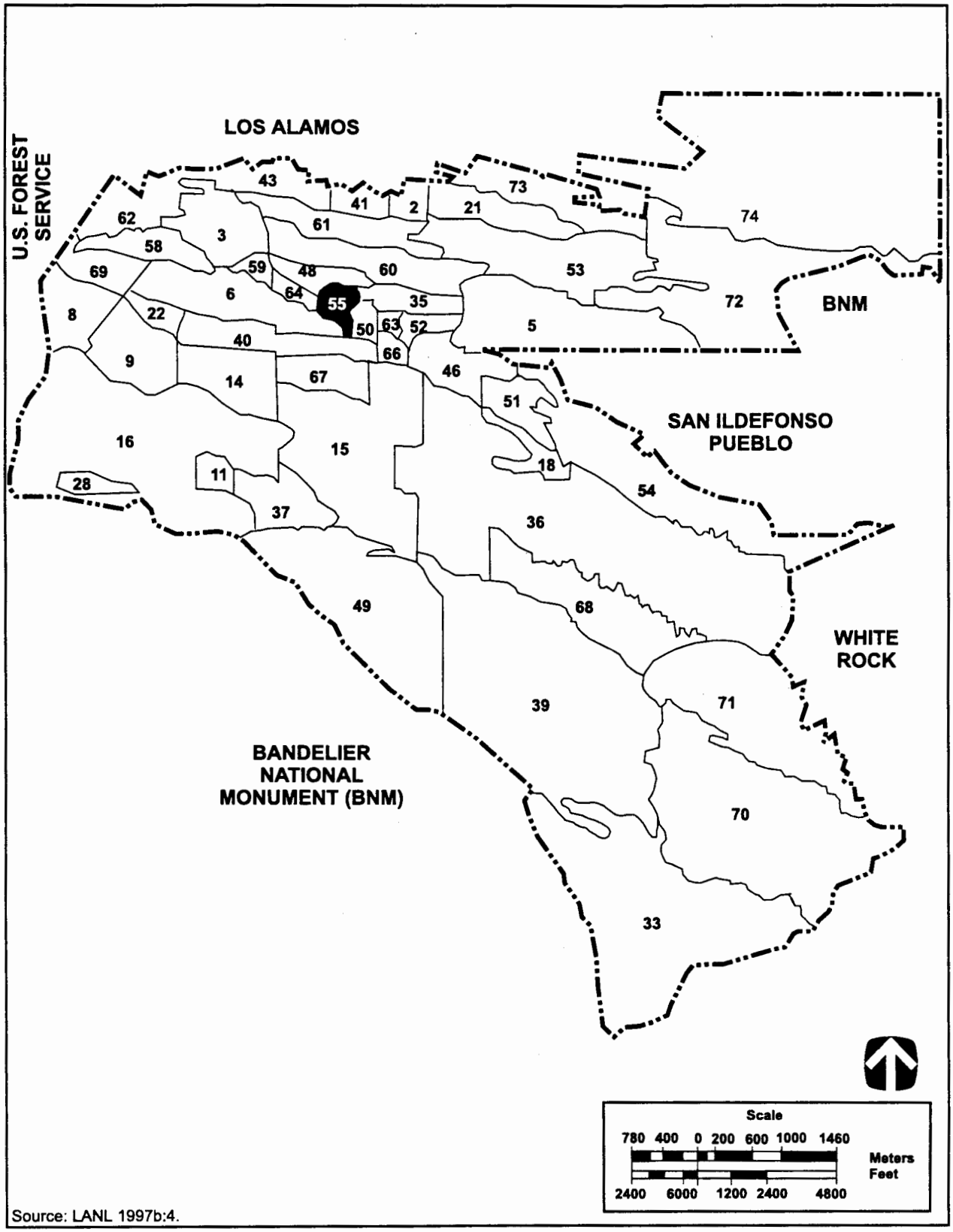
[2] The amount of HEU to be shipped to ORR for storage is within the bounding limit of 1.9 metric tons of HEU from LANL as set forth in the Y-12 Plant EA (DOE 1994b:3-3).




Source: LANL 1997b:4.

**Figure 3-1. Technical Areas of Los Alamos National Laboratory**

## 4.0 NO ACTION ALTERNATIVE

Under the No Action Alternative, an integrated pit disassembly and conversion line would not be demonstrated at LANL. Research related to these activities would continue to be performed in a series of individual gloveboxes. Information which would be generated as a result of the proposed Pit Disassembly and Conversion Demonstration (e.g., specifications for the main operating line and information needed to optimize the layout in terms of shielding, residence time in the gloveboxes, and distance between gloveboxes) would not be available under the No Action Alternative.

Other DOE sites were considered for this proposed demonstration. The only other site that was deemed a potential alternative was LLNL because it is the only other DOE national laboratory with extensive, currently operating plutonium facilities that could be used to conduct the demonstration. LLNL was eliminated from further consideration because the capabilities at LANL were readily available during the time frame in which DOE needed the work to be conducted. The LLNL Superblock is down for a safety review. Also, the majority of the gloveboxes that would be used in the demonstration were already at LANL (there would be no need to decontaminate LANL gloveboxes for the express purpose of sending them to LLNL for use in the demonstration).

## 5.0 AFFECTED ENVIRONMENT

### 5.1 History and Current Mission of Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos, New Mexico, located on a remote plateau high above the Rio Grande River for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. By 1945, when the first nuclear device was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Scientific Laboratory, which became LANL in 1981. LANL is owned by DOE and operated by the University of California under contract with DOE.

LANL's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, United States priorities, and the world community have changed over time. It is now a multi-disciplinary science and technology research facility. DOE programs supported by LANL include nuclear weapons stockpile stewardship and management; fissile materials disposition; environmental management; nonproliferation and international security, verification R&D, nuclear safeguards and security, arms control and intelligence; energy research and energy technologies; and work for other government agencies such as the Department of Defense and the Nuclear Regulatory Commission (NRC), (DOE 1996a:3-304).

### 5.2 Project Area, Facilities, and Infrastructure

The Pit Disassembly and Conversion Demonstration line would be installed and operated within PF-4 in TA-55 at LANL. The facilities at TA-55 are located on a 40-acre site about one mile southeast of LANL's core technical area, TA-3. TA-55 is situated adjacent to a LANL-owned and -controlled roadway, Pajarito Road, that is accessible to the public and passes along one side of and below TA-55.

Most of TA-55, including the main complex, is situated inside a restricted area surrounded by a double security fence and is considered a Category I safeguards and security facility[3]. The TA-55 main complex

[3] Category I safeguards and security facilities are required to meet the highest security standards in the DOE complex. These facilities are used to house assembled weapons or pure products, such as pits and directly convertible plutonium materials in quantities of two kilograms or higher.

has several major connected buildings: the Support Building; the Warehouse; the Plutonium Facility (PF-4), and the Calcium Building (see Figure 5–1). Various administrative, support, storage, security, and training structures are located throughout the main complex. The cornerstone R&D facility at TA-55 is PF-4. Plutonium processing and research on plutonium metallurgy occurs in this facility, which is a two-story laboratory of approximately 151,000 square feet. Work in PF-4 includes:

- plutonium recovery (converting recovered material to plutonium metal)
- disassembly of weapons components
- fabrication of ceramic-based reactor fuels (including MOX fuel) [4]
- processing plutonium-238 to produce heat sources for use in space among other uses
- development of materials control and accountability techniques
- activities related to pit surveillance
- plutonium component fabrication
- materials and properties R&D

PF-4 is a reinforced concrete structure that complies with all required seismic standards. The overall design concept for PF-4 separates the building in halves, each of which contains its own ventilation systems and electrical substations. Half of the building is comprised of Areas 100 and 200 that contain the plutonium research and development laboratories, plutonium-238 operations, and the personnel decontamination area. Areas 300 and 400 constitute the remainder of the building and contain plutonium recovery, metal preparation and fabrication, and nondestructive assay laboratories. Large central corridors span the length of the four main areas of PF-4. Each of the processing areas is divided into rooms that contain gloveboxes for working with plutonium. The ventilation systems supporting the gloveboxes and all other building-related utilities are located in the basement of the facility, which also contains the packing/unpacking room, the waste-handling areas, and the plutonium storage vault. This arrangement provides flexibility in meeting the ever changing needs of a R&D facility (LANL 1996b:1).

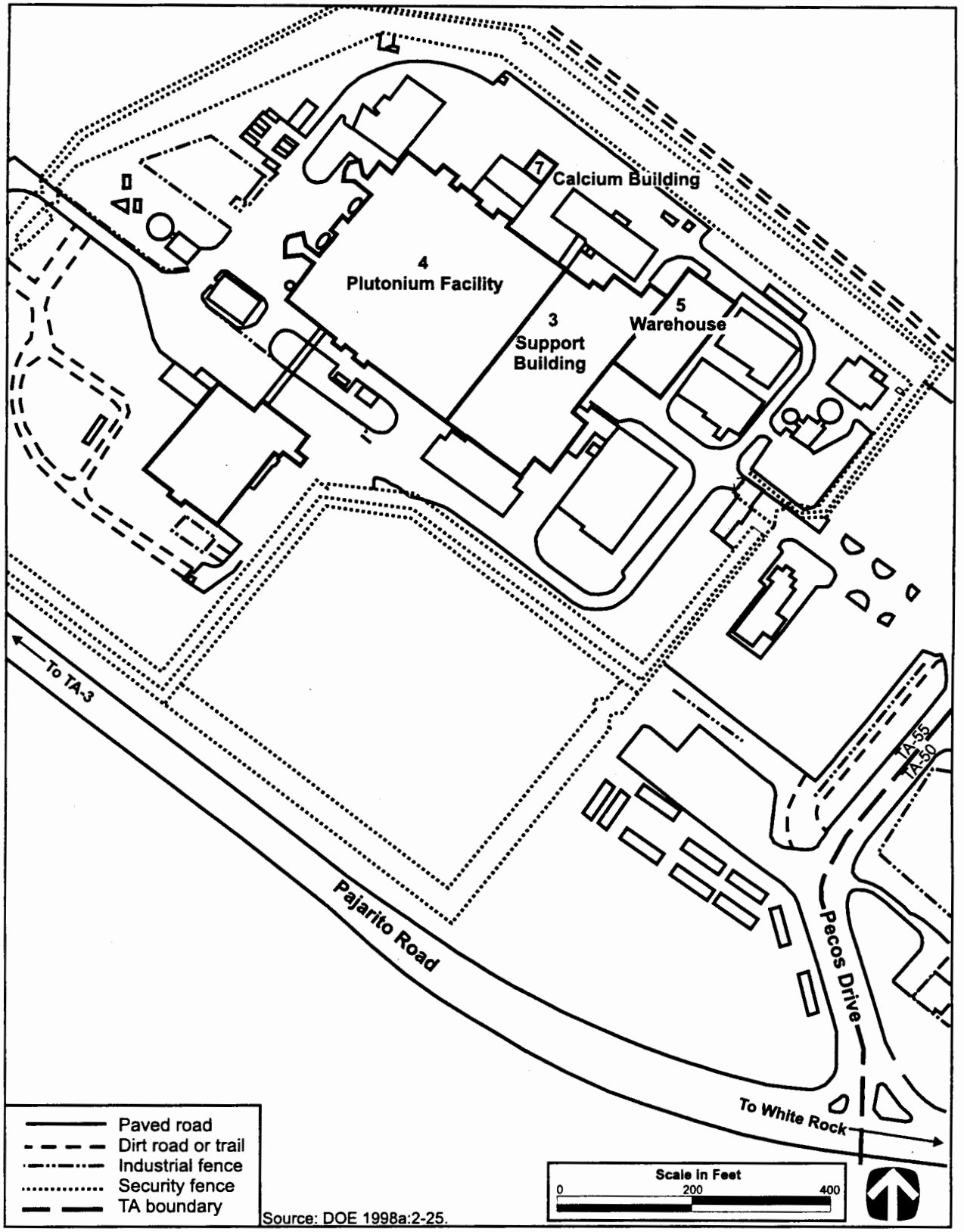
The Pit Disassembly and Conversion Demonstration required minor modifications to PF-4, relating to the installation of new gloveboxes, which did not involve worker exposure. The demonstration would utilize approximately 1,500 square feet of PF-4. Existing facility infrastructure at PF-4 would be used, including: utilities, environmental systems, systems for incoming pit assay, vault storage, special pit handling, and materials control and accountability. Analytical laboratory work on small samples (10 grams or less) from the demonstration would be conducted in the Chemical and Metallurgy Research (CMR) facility at LANL. It is expected that a total of 2,000 samples will be analyzed in TA-55 and CMR during the demonstration.

Infrastructure and supporting systems at TA-55 are required for the operating reliability, safety, and environmental integrity of PF-4. The supporting systems for PF-4 include:

- a confinement system that consists of three layers of confinement to prevent accidental releases of nuclear materials; these layers are gloveboxes, laboratory rooms, and the building (PF-4),

- a ventilation system with appropriate high-efficiency particulate air (HEPA) filtering that contains four zones, all of which are maintained at a lower pressure than outside air to ensure that leaks are contained within the building and not released to the atmosphere,

[4] The fabrication of such MOX fuel is discussed in the upcoming *Environmental Assessment for the Parallex Project Fuel Manufacture and Shipment* and the *Site-Wide Environmental Impact Statement on the Continued Operation of the Los Alamos National Laboratory*.




Source: DOE 1998a:2-25.

**Figure 5-1. Technical Area-55 Facilities at Los Alamos National Laboratory**

- a conveyor system that transports contaminated materials and equipment to almost any point on the first floor, thereby limiting worker contact and exposures,

- a criticality detection system that monitors operations on the main processing floor of the plutonium facility, as well as in the basement vault, to detect gamma energy released from any fission of special nuclear material and to alert personnel to immediately evacuate PF-4,

- a continuous air monitoring system that samples and analyzes air from multiple points throughout PF-4 laboratory areas, basement, ductwork, and exhaust stacks to ensure that personnel are warned of the release of radioactive material, and

- a radioactive liquid waste piping system that allows liquid low-level radioactive waste to be shipped directly to LANL's treatment facility at TA-50.

Additional supporting systems for the entire TA-55 site, including PF-4, that enhance the overall safety of PF-4 include:

- two water storage tanks with capacities of 100,000 and 500,000 gallons,

- a fire detection system consisting of smoke detectors, thermal detectors, manual pull stations, and drop-box alarm stations,

- a fire suppression system consisting of a wet-pipe, automatic sprinkler protection system fed by two 150,000 gallon tanks,

- chilled-water systems for air tempering, heat absorption, and glovebox cooling,

- a glovebox vacuum system consisting of wet vacuum, dry vacuum, and ultrahigh vacuum,

- separate acid, caustic, industrial, and sanitary waste lines connected directly to LANL's waste treatment facilities, and

- process gas control systems (i.e., argon, helium, oxygen, nitrogen, hydrogen) (LANL 1996b:23).

## 5.3 Environmental Resources

The proposed Pit Disassembly and Conversion Demonstration would be located within an existing building, PF-4. Therefore, there would not be any new construction that could affect floodplains, wetlands, biological resources, or cultural resources. The following descriptions are focused on providing sufficient information on the resources that could be affected during operation of the demonstration or in the event of an accident. LANL is not listed on the Environmental Protection Agency's (EPA) National Priorities List (LANL 1997b:22).

### 5.3.1 Water Quality

LANL is required to meet effluent limitations under the National Pollutant Discharge Elimination System (NPDES) permit program. These permits establish specific chemical, physical, and biological criteria that an effluent must meet before it can be discharged. Overall compliance for the sanitary and industrial waste discharges during 1996 was 98.8 percent and 97.9 percent respectively. Based on a performance audit

inspection conducted by EPA on September 16-17, 1996, the overall NPDES compliance program was rated superior (LANL 1997b:26, 30-31).

In 1996, LANL had 15 NPDES permits: one covering the effluent discharges at LANL, one covering the Hot Dry Rock Geothermal Facility (located 30 miles west of Los Alamos), and 13 covering storm water discharges. In January 1996, LANL's NPDES outfall permit included two sanitary wastewater treatment facilities and 95 industrial outfalls. By the end of 1996, LANL had eliminated nine permitted industrial outfalls in the NPDES permit. The University of California and DOE are co-permittees of the NPDES permits for LANL operations (LANL 1997b:26).

The Utility Building is the only permitted industrial outfall in TA-55. Liquid waste from TA-55 processing buildings is transferred to TA-50 where it is treated. Building 1, the Radioactive Liquid Waste Treatment Facility, in TA-50 also has a permitted industrial outfall. Both the TA-50 and TA-55 outfalls discharge into the Mortandad Canyon (DOE 1998a: 4-55).

Under LANL's existing NPDES permits, samples are collected for analysis on a weekly basis and reported to the United States EPA and the New Mexico Environment Department, as required. During 1996, effluent limits were exceeded two times in 165 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 32 times in the 1,559 samples collected from the industrial outfalls. There were no exceedances for the TA-55 outfall. For the TA-50 outfall, on two occasions the daily chemical oxygen demand concentrations exceeded the permit limit. A chemical oxygen demand sampling program was implemented for this outfall (LANL 1997b:27).

### 5.3.2 Air Quality

Baseline concentrations at LANL for hazardous and toxic air pollutants are in compliance with concentration limits and guidelines approved by the New Mexico Environmental Improvement Board. Nonradiological criteria pollutants were monitored for several years at LANL without any detectable increases above typical regional background levels, so ambient monitoring was discontinued (LANL 1996a:95). Over 90 percent of all LANL's nonradiological air pollutant emissions are associated with industrial sources, such as power plants and the asphalt plant (LANL 1997b:69). These plants will continue to operate whether or not the Pit Disassembly and Conversion Demonstration is conducted at LANL, and therefore, are not evaluated as part of this EA. EPA limits the effective dose equivalent to any member of the public from radioactive airborne releases from DOE facilities to 10 millirem (mrem) per year. In 1996, the effective dose equivalent from LANL operations to the maximally exposed members of the public was estimated to be 1.93 mrem (LANL 1997b:23).

In 1991 and 1992, LANL received two Notices of Noncompliance from EPA for not meeting all provisions of the Code of Federal Regulations (CFR) "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (EPA 1997). Specific findings included deficiencies in LANL's identification and evaluation of release sources, noncompliant stack monitoring equipment on all point release sources, using a shielding factor without previous EPA approval, and exceeding the 10 mrem per year standard. DOE negotiated a National Emission Standards for Hazardous Air Pollutants (NESHAP) Federal Facility Compliance Agreement (FFCA) with EPA Region 6, which was signed in June 1996. LANL is meeting the terms of this FFCA and had achieved full compliance in June 1996 with the radionuclide NESHAP, as defined in the FFCA (LANL 1997b:42).

### 5.3.3 Radiation Exposure

LANL has an extensive air monitoring program in place on the site and in regional locations surrounding the site to detect radiological air releases. Because some of LANL's research involves radioactive materials that may enter the atmosphere through a stack, many of the stacks on the site are continually monitored in accordance with the CFR, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (EPA, 1997).

Due to ongoing work at LANL, very small amounts of radioactive elements, such as plutonium (Pu), tritium, americium (Am), and uranium (U), are released to the atmosphere. As shown in Table 5–1, LANL's emission of these radioactive isotopes as measured on a regional basis is significantly lower than EPA Public Dose Limits.

**Table 5–1. Mean Annual Concentrations of Radioactivity Measured by LANL**

| Elements | Units | Annual Regional Mean[a] | Highest for Any Monitoring Location[a] | EPA Public Dose Limit[b] | Highest Mean as a Percentage of EPA Limit |
|---|---|---|---|---|---|
| $^{238}$Pu | aCi/m$^3$ | 0.1 | 19.8 | 2,100 | 0.9 |
| $^{239}$Pu | aCi/m$^3$ | 0.7 | 706.6 | 2,000 | 35.3 |
| Tritium | pCi/m$^3$ | 0.3 | 400.3 | 1,500 | 26.7 |
| $^{241}$Am | aCi/m$^3$ | 2.1 | 478.2 | 1,900 | 25.2 |
| $^{234}$U | aCi/m$^3$ | 35.6 | 64.5 | 7,700 | 0.8 |
| $^{235}$U | aCi/m$^3$ | 2.2 | 3.7 | 7,100 | <0.1 |
| $^{238}$U | aCi/m$^3$ | 24.7 | 50.6 | 8,300 | 0.6 |

[a]LANL 1997b:Tables 4–4 thru 4-10, 80-93.
[b]Each EPA limit equals the amount of radioactivity that would have to be released into the atmosphere to cause the general public to receive an effective dose equivalent of 10 millirem per year (LANL 1997b:Table 4–1, 75).

#### 5.3.3.1 Perimeter Monitoring

**$^{238}$Pu.** In 1996, the mean annual concentration of $^{238}$Pu recorded at perimeter locations, including numerous stations in Los Alamos and White Rock, was 0.2 aCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.001 mrem per year. At the monitoring station recording the highest offsite concentration, Royal Crest Trailer Court, the mean annual concentration was 1.0 aCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.01 mrem per year (LANL 1997b:Table 4–5, 82).

**$^{239}$Pu.** In 1996, the mean annual concentration of $^{239}$Pu recorded at perimeter locations was 1.0 aCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.01 mrem per year. At the monitoring station recording the highest offsite concentration, the Los Alamos Airport, the mean annual concentration was 2.9 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.01 mrem per year (LANL 1997b:Table 4–6, 84).

**Tritium.** Tritium is released by LANL in curie amounts. In addition, tritium is present in the environment as a result of aboveground nuclear weapons tests and is also produced naturally. In 1996, the mean annual concentration recorded at perimeter locations was 1.3 pCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.01 mrem per year. At the monitoring stations recording the highest offsite concentrations, the McDonald's Restaurant in Los Alamos and the White Rock Church of the Nazarene, the mean annual concentration was 2.2 pCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.01 mrem per year (LANL 1997b:Table 4–4, 80). Recently, it has been discovered by LANL that the reporting associated with tritium releases from the laboratory (set forth above) may be

underestimating actual tritium levels by a factor of two to three times. In the worst case, the level of tritium released could be as high as five times greater than reported (Eberhart, 1998). At the point of highest offsite concentration, the estimated mean annual concentration would be 11 pCi/m$^3$ (i.e., 2.2×5). This would be equivalent to an effective dose of approximately 0.07 mrem per year.

**$^{241}$Am.** Americium is released from LANL in microcurie amounts. In 1996, the mean annual concentration of $^{241}$Am recorded at perimeter locations was 1.8 aCi/m$^3$, which is less than an effective dose equivalent of approximately 0.01 mrem per year. At the monitoring station recording the highest offsite concentration, Santa Fe, the mean annual concentration was 2.5 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.01 mrem per year (LANL 1997b:Table 4–7, 86).

**$^{234}$U.** All of the isotopes of uranium are released from LANL in microcurie amounts and occur naturally in rocks and soils. In 1996, the mean annual concentration of $^{234}$U recorded at perimeter locations was 10.2 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.01 mrem per year. At the monitoring station recording the highest offsite concentration, Española, the mean annual concentration was 49.1 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.06 mrem per year (LANL 1997b:Table 4–8, 88).

**$^{235}$U.** In 1996, the mean annual concentration of $^{235}$U recorded at perimeter locations was 0.9 aCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.01 mrem per year. At the monitoring station recording the highest offsite concentrations, Española, the mean annual concentration was 3.1 aCi/m$^3$, which is equivalent to an effective dose equivalent of less than 0.01 mrem per year (LANL 1997b:Table 4–9, 90).

**$^{238}$U.** In 1996, the mean annual concentration of $^{238}$U recorded at perimeter locations was 10.5 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.01 mrem per year. At the monitoring station recording the highest offsite concentration, Jemez Pueblo-Riverside, the mean annual concentration was 38.3 aCi/m$^3$, which is equivalent to an effective dose equivalent of approximately 0.05 mrem per year (LANL 1997b:Table 4–10, 92).

In all cases, the maximum individual effective dose equivalents attributable to exposure from airborne LANL emissions were below the EPA limits. Measurements of LANL stack emissions during 1996 totaled 13,790 Ci. Of this total, tritium emissions comprised 680 Ci and air activation products[5] contributed 13,110 Ci. Combined airborne emissions of radioactive materials such as plutonium, uranium, and americium were less than 0.5 Ci (LANL 1997b:64).

In 1996, emissions of radionuclides from TA-55 were as presented in Table 5–2. Exposure to these releases was estimated by the CAP88, EPA's dose assessment model, to result in an effective dose equivalent of 0.000364 mrem to the offsite maximally exposed individual (MEI) (Jacobson 1997:6, 20).

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[5] Nuclear reactions with air cause the formation of air activation products. These include radioisotopes of carbon, nitrogen, and oxygen that have a half-life of seconds up to 20 minutes. The major source of these products at LANL has been as a result of airborne emissions from the Los Alamos Neutron Science Center (LANL 1997b:67).

**Table 5–2. Releases of Radionuclides from TA-55 in 1996**

| Radionuclide | Sampled Release (Ci) |
|---|---|
| Americium 241 | $3.1 \times 10^{-8}$ |
| Plutonium 238 | $2.5 \times 10^{-9}$ |
| Plutonium 239 | $8.6 \times 10^{-8}$ |
| Uranium 234 | $2.6 \times 10^{-8}$ |
| Uranium 238 | $2.9 \times 10^{-8}$ |
| Thorium 234 | $2.9 \times 10^{-8}$ |
| Protactinium 234 | $2.9 \times 10^{-8}$ |
| Tritium | $3.1 \times 10^{+1}$ |

Source: Jacobson 1997:14.

Individuals are constantly exposed to radiation as a result of cosmic radiation from space and natural radiation from radionuclides in the environment (mainly radon). In addition, as people inhale or absorb radionuclides from natural sources they are collected within the body and produce radiation as they decay. Table 5–3 shows the effective dose equivalent for people living in Los Alamos and White Rock as a result of existing sources of radiation.

**Table 5–3. Estimated Background Dose from Natural and Man-Made Sources of Radiation (mrem/year)**

| | Los Alamos | White Rock |
|---|---|---|
| Radon | 200 | 200 |
| Cosmic (corrected for shielding) | 120 | 100 |
| Self-irradiation | 40 | 40 |
| Total effective background dose | 360 | 340 |

Source: LANL 1997b:50.

To estimate the dose above background levels received by the public as a result of penetrating radiation from LANL activities, a network of thermoluminescent dosimeters has been installed around LANL and surrounding areas. During 1996 the maximum dose, or the ninety-fifth percentile value, was equivalent to 13.3 mrem. This dose was 13.3 percent of DOE's public dose limit of 100 mrem effective dose equivalent from all pathways. The median value (fiftieth percentile) for this dose is 4.3 mrem; this dose is approximately one percent of the total annual dose received by persons living around LANL from all sources of radiation as shown in Table 5–2 (LANL 1997b:51). Based on the population living within 80 kilometers (50 miles) of LANL, it is estimated that the total dose to the public in 1996 was 1.2 person-rem. (LANL 1997b:54).

Workers in TA-55 would be expected to receive an additional dose above that received by the general public as a result of their work with nuclear materials. Exposure pathways to LANL workers during normal operations may include inhaling the workplace atmosphere, drinking potable water that could somehow become contaminated, and possibly other contacts with hazardous materials associated with their work assignments. Workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. Although the Federal exposure limit for radiation workers is 5 rem per year (DOE 1997d:sec. 835.202), DOE's Administrative Control Level is 2 rem per year (DOE 1994c:2-3). All facilities at LANL are operating in accordance with the As Low As Reasonably Achievable (ALARA) program to limit worker doses to the extent possible. The average dose that badged workers (radiation workers) in TA-55 received in 1997 was 175 mrem per worker or 3.5 percent of the Federal exposure limit (Graf 1998).

### 5.3.4 Worker and Public Safety

LANL workers are protected by adherence to Occupational Safety and Health Administration and EPA occupational health standards that limit workplace concentrations of potentially hazardous chemicals. Appropriate monitoring, which reflects the frequency and amounts of chemicals utilized in the operation processes, ensures that these standards are not exceeded. Additionally, DOE requirements ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm.

Each DOE site has established an emergency management program that would be activated in the event of an accident. This program has been developed and maintained to ensure adequate response for most accident conditions and to provide response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with emergency planning, preparedness, and response. The LANL Emergency Preparedness Plan is designed to minimize or mitigate the impact of any emergency on the health and safety of employees and the public.

### 5.3.5 Waste Management

LANL routinely produces waste in the following categories: TRU waste, LLW, MLLW, and hazardous waste, that could be impacted by the proposed Pit Disassembly and Conversion Demonstration.

#### 5.3.5.1 Transuranic Waste

TRU waste is generally characterized as waste that is contaminated with alpha-emitting transuranic isotopes with atomic numbers greater than 92 and half-lives greater than 20 years, in concentrations greater than 100 nCi/g at the time of assay. TRU waste generated at TA-55 is taken to TA-54, placed in drums, certified, and stored for ultimate disposal at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. Most of LANL's TRU waste is currently stored on asphalt pads. In 1996, LANL generated about 81 cubic meters of TRU waste (LANL 1997i:4).

#### 5.3.5.2 Low-Level Waste

LLW contains some radioactivity but not enough to be classified as high-level waste, TRU waste, or spent nuclear fuel. After being generated at TA-55, liquid LLW is transferred by a stainless steel pipeline to the Radioactive Liquid Waste Treatment Facility at TA-50 for treatment. The waste water is treated by lime/sulfate precipitation. The treated water is discharged under LANL's NPDES permit. The remaining sludge is dewatered and sent to TA-54 for disposal as LLW. Approximately 521 cubic meters of solid LLW and 11cubic meters of solid LLW that resulted from treating liquid LLW was generated by LANL in 1996 (LANL 1997i:4). This waste is buried in TA-54, Area G, in pits and shafts designed specifically for this purpose.

#### 5.3.5.3 Mixed Low-Level Waste

MLLW contains both hazardous (as defined and regulated by the Resource Conservation and Recovery Act (RCRA)) and low-level radioactive components.[6] MLLW generated at TA-55 is placed in interim storage at TA-55 and collected by LANL waste management personnel. It is then stored at TA-54, Areas L and G, pending the availability of offsite commercial treatment or the development of technologies to treat these wastes. About 7 cubic meters of MLLW was generated by LANL in 1996 (LANL 1997i:4).

#### 5.3.5.4 Hazardous Waste

Hazardous wastes are listed as such in RCRA regulations or defined as hazardous wastes because they exhibit at least one of the following characteristics: (1) ignitability, (2) corrosivity, (3) reactivity, or (4) toxicity. No disposal facility for hazardous waste exists at LANL. Hazardous wastes are shipped off the site for further treatment and disposal at designated facilities in accordance with RCRA. In 1996, LANL generated approximately 90,000 kilograms of hazardous waste from routine operations (LANL 1997i:4).

### 5.3.6 Socioeconomics

Approximately 10,000 people are employed at LANL in permanent special programs and contractor activities. Eighty-eight percent of all LANL employees reside in a three-county area (Los Alamos, Arriba, and Santa Fe), and more than half of the Los Alamos County employees reside in the unincorporated communities of Los Alamos and White Rock. This three-county area has been designated the region of influence (ROI) for the regional economic area (REA) in which LANL is located. The unemployment rate in the REA was 6.2 percent, which was about the same as the overall unemployment rate in New Mexico of 6.3 percent (LANL 1997a:1; DOE 1996a: 3-326).

LANL has a cumulative economic impact on the ROI of more than $3.5 billion annually, making it the dominant economic force in northern New Mexico. The region's per capita income of $17,689 in 1993 was approximately 8.2 percent higher than New Mexico's per capita income of $16,346 (LANL 1997a:1; DOE 1996a: 3-326).

In 1994, the ROI population totaled 166,788. From 1980 to 1994, the ROI population increased by 36.6 percent, compared to 26.9 percent in New Mexico, with Santa Fe County experiencing the largest growth at 48.6 percent. In 1994, seven schools provided public education in the LANL ROI. City, county, and state law enforcement agencies provided police protection to the ROI residents. Fire protection services were provided by 800 paid and volunteer firefighters in 1995. Four hospitals served the ROI in 1994 (DOE 1996a: 3-326, 3-332).

Regional transportation routes provide access to LANL with vehicular access provided by New Mexico Route 502 to the east and Route 4 to the west. There are no planned road improvement projects within one to two years that would affect LANL. While there is no public bus service to LANL, there is non-profit bus service between White Rock, Los Alamos and LANL (DOE 1996a:3-332).

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[6] In accordance with the Federal Facility Compliance Act, LANL has developed a Site Treatment Plan that covers management of all mixed waste at LANL. The State of New Mexico Environment Department issued a compliance order in the Site Treatment Plan for Mixed Waste in October 1995. The compliance order addresses land disposal restricted mixed waste. For mixed waste with identified treatment technologies, the plan provides a schedule for submitting permit applications, entering into contracts, initiating construction, conducting system testing, starting operations, and processing mixed waste. For mixed waste without an identified treatment technology, the plan includes a schedule for identifying and developing technologies, identifying the funding requirements for R&D, submitting treatability study notifications, and submitting R&D permit applications.

### 5.3.7 Environmental Justice

The 1990 minority population, residing within 80 kilometers (50 miles) of LANL, was estimated to be 53.9 percent of the total population. Population data for 1990 was extracted from data published by the U.S. Bureau of the Census for the 1990 census (DOC 1992:Tables P–12, P–121). Minority populations are projected to make up 55.6 percent of the total population in 2001. Projected populations for the year 2001 were obtained from the Bureau of the Census state population projects (Campbell 1997:4-24). It was assumed that minority and majority populations residing within 80 kilometers of LANL would increase at the same rates as projected increases for the statewide minority and majority populations.

Estimates of low-income persons residing in the potentially affected area is shown in Table 5–4 (DOC 1992:Table P–121). In this table, the low-income population is comprised of persons residing within 80 kilometers (50 miles) of the sites whose income is less than the poverty threshold (CEQ 1996:app. A, 16). The percentage of the population with income below the poverty threshold exceeds the 13.3 national average.

**Table 5–4. Low-Income Persons Residing Within 80 Kilometers of LANL**

| Site | Total Population (Thousands) | Low-Income Population (Thousands) | Percent Low-Income Population |
|---|---|---|---|
| LANL | 214.3 | 31.5 | 14.7 |

## 6.0 POTENTIAL ENVIRONMENTAL IMPACTS

### 6.1 Impacts Related to the Proposed Action

### 6.1.1 Water Quality Impacts

Under the proposed action, noncontact water would be used to cool processing equipment. Wastewater discharges would be into the industrial waste lines at PF-4. It is estimated that less than 189 liters (50 gallons) of noncontact water would be discharged from PF-4 as a result of the proposed demonstration. Additionally, a small amount of process water will be used as part of the decontamination module. This process water, less than 100 liters (26 gallons), would be handled in accordance with LANL's procedures for the treatment and disposal of liquid LLW. The overall compliance for sanitary and industrial discharges during 1996 was 98.8 percent and 97.9 percent, respectively (LANL 1997b:26). The proposed action is not expected to affect these compliance rates for surface water quality because the amount of water used in the process is so small. No releases of radionuclides is expected by liquid pathways as a result of the proposed demonstration.

### 6.1.2 Air Quality Impacts

While small amounts of plutonium, americium, and tritium would be released to the atmosphere, as shown in Table 6–1, the projected dose equivalent from all of these releases when combined with continued site operations would be well below the 10 mrem per year NESHAP limit. The MEI is estimated to receive an effective dose equivalent of 0.043 mrem per year from the demonstration and a total dose from all site operations of 4.3 mrem.

**Table 6–1. Estimated Radionuclide Releases Under the Proposed Demonstration**

| Radionuclide | Estimated Releases from Demonstration (in curies) | Annual Releases at LANL in 1996[a] (in curies) | Estimated Releases as a Percent of Annual Releases at LANL |
|---|---|---|---|
| Total plutonium | $1.0 \times 10^{-7}$ | $2.3 \times 10^{-5}$ | <1 |
| Americium 241 | $2.3 \times 10^{-8}$ | $1.3 \times 10^{-6}$ | <2 |
| Tritium | 69 | $6.8 \times 10^{2}$ | 10 |
| Total uranium | None | $3.9 \times 10^{-5}$ | NA |

[a]LANL 1997b:102-103; Jacobson, 1998.
Note: NA, not applicable.

The pit disassembly and conversion process proposed to be demonstrated does not require the use of hazardous chemicals or other potentially hazardous compounds that could be released into the atmosphere in the course of normal operations. Any hazardous compounds released would be very small quantities related to routine, cleaning operations connected with the demonstration.

### 6.1.3 Radiological Impacts

The radiological impacts of normal operations associated with the proposed action were calculated using Version 1.485 of the Hanford Environmental Dosimetry System (GENII) computer code. Site-specific and technology-specific input data were used, including location, meteorology, population, food production and consumption, and source terms. Dose assessments were performed for members of the general public surrounding LANL and for workers who would be involved with the proposed operations.

To calculate the doses, the projected releases were extrapolated based on the data developed for the SPD EIS (LANL 1997d:62). As shown in that report, the dominant radioactive emission is tritium. Using this information, it was estimated that approximately 69 curies of tritium would be released annually during the demonstration. A similar method was used to estimate the other radioactive emissions although they are all relatively small in comparison to tritium (see Table 6–1).

Dose assessments for members of the public were performed for three different types of receptors considered in this EA: the offsite MEI, the offsite average exposed individual, and the general population living within 80 kilometers (50 miles). The MEI was assumed to be located at a position that would yield the highest impacts during normal operations. In the case of the pit demonstration, this would be an individual in the Royal Crest Trailer Court in Los Alamos, which is located at the northern perimeter of LANL above TA-55. For total LANL site operations, this would be an individual near LANL's East Gate. To bound the analyses, the doses to both MEIs were added to provide a hypothetical worst case dose.

The annual average individual worker dose directly associated with the proposed action was estimated at 750 mrem per year. To obtain the annual total workforce dose, the annual average individual worker dose was multiplied by the estimated number of involved workers. Subsequent health risks (i.e., latent cancer fatalities) were calculated for the aforementioned groups by using risk estimators established in the National Academy of Sciences and National Research Council's 1990 *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V* Report.

The pit disassembly and conversion process involves the use of hydrogen, oxygen, and nitrogen, and inert gases such as argon and helium. All of these gases would be fed into the gloveboxes under controlled conditions. Gases exiting the gloveboxes would be filtered through a series of HEPA filters to capture the majority of the radionuclides released during the demonstration. However, a small amount of radionuclides would be expected to enter the atmosphere, if the proposed action were undertaken. As shown in Table 6–1, these releases are estimated to be a small fraction of the radionuclides released by LANL in any given year.

If the demonstration is conducted, the largest releases are estimated to be approximately 69 curies of tritium each year as the pits are dismantled. This amount represents about 10 percent of the total expected tritium releases for LANL. However, even with these releases, total releases would still be lower than either the EPA limit or past releases from LANL. For example, in 1995, LANL released an estimated 1,010 curies of tritium into the atmosphere. If LANL's tritium releases remain at the 1996 levels plus the estimated demonstration releases (i.e., 680+69 or 749 curies), this is over 25 percent less than the amount of tritium released in 1995 and 1995 releases were much lower than previous years. Even at the 1995 levels, the resulting maximum concentration measured at any of LANL's numerous offsite monitoring stations was less than one percent of the EPA limit (LANL 1996a:84).

Radiological impacts on the average and maximally exposed members of the public resulting from normal operations of the proposed action are presented in Table 6–2. Also included in the table are the dose to the population within 80 kilometers (50 miles) in 2000 (mid-year of projected operations for the proposed demonstration), and the projected annual number of latent cancer fatalities in this population. To put operational doses into perspective, comparisons with doses from natural background radiation are also included.

The dose to the maximally exposed member of the public from annual operation of the proposed action would be 0.043 mrem. The corresponding annual risk of latent fatal cancer to this individual would be $2.2 \times 10^{-8}$. That is, the estimated probability of this person dying of cancer at some point in the future from radiation exposure associated with the demonstration is less than three in 100 million. The impacts on the average individual would be less.

**Table 6–2. Potential Radiological Impacts to the Public at LANL**

| Receptor[a] | Pit Disassembly Demonstration | Total Site Without Pit Disassembly Demonstration | Total Site With Pit Disassembly Demonstration |
|---|---|---|---|
| **Maximally exposed individual member of the public** | | | |
| Annual dose (mrem) | 0.043 | 4.30 | 4.34 |
| Percent of natural background[b] | 0.0123 | 1.23 | 1.24 |
| Annual latent cancer fatalities | $2.2 \times 10^{-8}$ | $2.15 \times 10^{-6}$ | $2.17 \times 10^{-6}$ |
| **Population within 80 kilometers for Year 2000** | | | |
| Annual dose (person-rem) | 0.016 | 1.20 | 1.22 |
| Percent of natural background[b] | $1.8 \times 10^{-5}$ | $1.32 \times 10^{-3}$ | $1.34 \times 10^{-3}$ |
| Annual latent cancer fatalities | $8.0 \times 10^{-6}$ | $6.00 \times 10^{-4}$ | $6.08 \times 10^{-4}$ |
| **Average individual within 80 kilometers[c]** | | | |
| Annual dose (mrem) | $6.1 \times 10^{-5}$ | $4.61 \times 10^{-3}$ | $4.67 \times 10^{-3}$ |
| Annual latent cancer fatalities | $3.1 \times 10^{-11}$ | $2.30 \times 10^{-9}$ | $2.33 \times 10^{-9}$ |

[a]Presented impacts to these receptors are associated with releases to the air. There would be no liquid releases associated with the pit disassembly demonstration.
[b]The annual natural background radiation level at LANL is 349 mrem for the average individual; the population within 80 kilometers in 2000 would receive 90,900 person-rem.
[c]Obtained by dividing the population dose by the number of people projected to live within 80 kilometers of LANL (260,360) in 2000.
Source: LANL 1997b: GENII model results (Version 1.485).

As a result of annual facility operations, the total population dose would be 0.016 person-rem. The corresponding annual number of latent cancer fatalities in this population would be $8.0 \times 10^{-6}$. The

*Environmental Surveillance and Compliance at Los Alamos during 1996* report (LANL 1997b:51, 54) states that an annual dose of 4.3 mrem to a MEI and a collective dose of 1.2 person-rem to the surrounding population within 80 kilometers (50 miles) resulted from all 1996 LANL operations. Assuming a similar total site operational status in 2000, radiological impacts associated with the proposed action would increase LANL total site impacts by a small percentage (1.0 percent for the MEI, 1.3 percent for the surrounding population, and 1.3 percent for the average individual).

Doses to involved workers from normal operations are presented in Table 6–3; involved workers are defined as those directly associated with pit disassembly activities. Under this action, the estimated annual average dose to pit disassembly workers would be 750 mrem. The annual dose received by the plutonium workers who would perform these activities would increase by 35 person-rem to 90 person-rem. The annual risk of latent cancer fatalities to involved workers as a result of the doses received from the demonstration would be $3.0 \times 10^{-4}$ or 3 chances in 10,000. Doses to individual workers would be kept to minimal levels by current administrative policies, exposure monitoring, and the ALARA program.

**Table 6–3. Potential Radiological Impacts to Plutonium Workers at LANL**

| Receptor | Pit Disassembly | Other Pit Disassembly Activities |
|---|---|---|
| **Involved workers**[a] | | |
| Average worker dose (mrem/yr) | 750 | 456 |
| Annual risk of latent cancer fatalities | $3.0 \times 10^{-4}$ | $1.8 \times 10^{-4}$ |
| Total dose (person-rem/yr) | 90 | 55 |
| Total annual latent cancer fatalities | 0.036 | 0.022 |

[a]One hundred and twenty badged workers would be required for pit disassembly and conversion facility operations. The radiological limit for an individual worker is 5,000 mrem/year. However, the maximum dose to a worker involved with operations will be kept below the DOE Administrative Control Level of 2,000 mrem per year. An effective ALARA program will ensure that doses will be reduced to levels that are as low as is reasonably achievable.

### 6.1.4 Accident Impacts

The pit disassembly and conversion process proposed to be demonstrated would consist of a number of distinct, sequential processes: bisection and disassembly, oxidation, gallium removal, canning, electrolytic decontamination, and nondestructive assay, each performed in separate gloveboxes. Another glovebox would contain the conveyor system that would transfer the plutonium between the gloveboxes. LANL Process Hazard Analyses serve as the basis for evaluating the potential accidents associated with the proposed action. These Hazard Analyses, intended to provide a screen to identify safety-class equipment requirements, are significantly conservative; they may not take credit for all process or control barriers to an abnormal event or its potential consequences in evaluating consequence liklihoods. For this reason, they form a conservative basis for evaluating accident impacts for this EA. Considering the low-magnitude of the predicted impacts, no effort was taken to further refine the risk evaluations for this EA.

The spectrum of plausible accidents and abnormal events associated with the proposed action was evaluated to identify those with the highest radiological impacts. Because of the physical separation of the various modules in the process, the potential accidents and abnormal events for each step were evaluated independently. It is important to note that both the type and frequency of plausible accidents for the proposed action depend on the specific process involved; for example, processes involving both hydrogen and oxygen along with plutonium would have significantly different risks than would processes involving handling or machining of plutonium components in an inert atmosphere.

The modules associated with the pit disassembly and conversion process at TA-55 have been the subject of Process Hazard Analysis (PrHA) (LANL 1998; LANL 1997c; LANL 1997e; LANL 1997f; LANL 1997g; LANL 1997h). For these PrHAs, the dose to the public was calculated using the Gaussian dispersion model MACCS2. Weather sampling was based on 95$^{th}$ percentile data.

Each hazard was evaluated as to the severity of the consequences and qualitatively assigned a severity category. The severity categories used in the evaluation of accidents and abnormal events are presented in Table 6–4.

**Table 6–4. Consequences Severity Categories**

| Category | Public | Worker | Environment |
|---|---|---|---|
| A | Immediate health effects | Loss of life | Significant offsite contamination requiring cleanup |
| B | Long-term health effects | Severe injury or disability<br>Radiation uptake or dose causing temporary radiation worker restriction | Moderate-to-significant onsite contamination<br>Minor offsite contamination |
| C | Irritation or discomfort but no permanent health effects | Lost-time injury but no disability<br>Radiation uptake or dose causing temporary radiation worker restriction | Significant contamination of originating facility<br>Minor onsite contamination<br>No offsite contamination |
| D | No significant offsite impact | Minor or no injury and no disability | Minor or no contamination of originating facility<br>No onsite contamination<br>No offsite contamination |

Source: LANL 1997c:17.

In assessing the significance of an accident or abnormal event, the frequency of the event must be considered as well as the consequences. Table 6–5 presents the Consequence Likelihood Categories used for the evaluation of hazards associated with the proposed Pit Disassembly and Conversion Demonstration.

**Table 6–5. Consequence Likelihood Categories**

| Frequency | Definition |
|---|---|
| I<br>(1 to 0.1) | Normal Operations: frequency between once per year and 1 in 10 operating-years or at least once in 10 similar facilities operated for 1 year |
| II<br>(0.1 to .01) | Anticipated Events: frequency between 1 in 10 years and 1 in 100 operating-years or at least once in 100 similar facilities operated for 1 year |
| III<br>($10^{-2}$ to $10^{-4}$) | Unlikely: frequency between 1 in 100 years and 1 in 10,000 operating-years or at least once in 10,000 similar facilities operated for 1 year |
| IV<br>($10^{-4}$ to $10^{-6}$) | Very Unlikely: frequency between 1 in 10,000 years and once in 1 million years or at least once in a million similar facilities operated for 1 year |
| V<br>($<10^{-6}$) | Improbable: frequency of less than once in 1 million years |

Source: LANL 1997c:18

Due to design requirements based on reducing the impacts of potential accidents, as the consequences of an event increase, the likelihood of that event occurring decreases. As a result, a Severity Category "A" event would normally be expected to have a frequency of IV or V. Risk, which is the product of consequence and frequency, is one way to evaluate an accident or abnormal event. Table 6–6 shows the way risk is ranked for the evaluation of accidents and abnormal events.

**Table 6–6. Risk Ranking Matrix**

| Severity of Consequence | Likelihood of Consequence | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| A | 1 | 1 | 2 | 3 | 3 |
| B | 1 | 2 | 2[a] | 3 | 4 |
| C | 1 | 3 | 3 | 4 | 4 |
| D | 3 | 4 | 4 | 4 | 4 |

[a]Assign risk rank of 3 if severity category rank of B is based on worker injury and offsite consequences severity is less than B.
Source: LANL 1997c:18.

### 6.1.4.1 Pit Bisection and Disassembly

After a pit arrives at the pit bisector and disassembly module it is weighed; tube appendages are cut off; it is re-weighed; and then it is bisected. The bisection is accomplished using a pit bisector (a rotary shearing assembly much like a tube cutter) or a parting lathe. Using the pit bisector, a beveled-edge parting wheel is placed around the waist of the pit and driven inward toward the center of the pit by a servo-driven lead screw while the pit is slowly rotated. A parting lathe, similar to a standard machine shop lathe, may also be used to cut pits. After bisection is complete, the two hemispheres are separated and weighed. Use of the rotary shearing process minimizes cutting waste while the parting lathe results in a small amount of metal shavings.

The principal hazard associated with this module is the starting of the rotary table before the vacuum hoist is removed, causing the hoist to hit the glovebox window, the loss of glovebox integrity, and a release of contamination to the room. This hazard is a Severity Category "D" to the public, frequency II, (anticipated), risk-ranked 4 event (LANL 1997c:14-18). The pit is in metallic form during this accident, hence the only room contamination could come from contamination on the surface of the pit, which is small. The PrHA for this module indicates that the accidents associated with this module have less significant consequences than those of other modules.

### 6.1.4.2 Oxidation

This module converts plutonium from metal to an oxide. In the hydride-oxidation (HYDOX) process, first, the subassembly is placed in a vacuum chamber inside the module glovebox. After evacuating the chamber, the subassembly is exposed to hydrogen gas at low pressure and temperature, which converts plutonium to plutonium hydride. Small plutonium hydride particles spall from the surface, falling from the subassembly into a heated crucible. Once the hydride reaction has been established, nitrogen is introduced. Nitrogen readily replaces the hydrogen in the plutonium hydride, creating plutonium nitride and giving off hydrogen gas. The released hydrogen gas then reacts with the remaining plutonium metal in the subassembly, continuing the cycle. Once all the plutonium has been converted to plutonium nitride, the hydrogen gas is removed from the reactor, the reactor is flushed with nitrogen, and the chamber is evacuated. Next, oxygen is introduced to convert the plutonium nitride to plutonium oxide. Finally, the chamber is purged with argon

and cooled. The plutonium oxide is transferred to a can by a dustless powder transfer system. The can is then moved to the canning module.

Alternatives to the HYDOX process are hydride/dehydride, which converts hydride powder to a plutonium metal ingot, and direct oxidation which converts plutonium metal to an oxide directly. PrHAs for these processes were conducted, however, they are not discussed here because the consequences of the HYDOX accidents are more severe and therefore envelope process accident consequences.

Two types of hazards exist for the HYDOX module: those that breach the glovebox barrier and criticality. The glovebox barrier could be breached by a fire that burns the gloves, or a hydrogen deflagration or explosion. A number of vessel and glovebox explosion, deflagration, and fire scenarios were evaluated by the PrHA. The deflagration in the reactor vessel was identified as having the highest potential consequences to the public.

In this scenario (a Severity Category "C" for the public, frequency III unlikely, risk-ranked 3 event), the pump-down step following the hydride/nitride recycle sequence is bypassed and oxygen is introduced into the vessel. A deflagration occurs when the hydrogen concentration is reduced to the upper flammable limit. This could only occur with a failure of the system vacuum interlock. The material at risk is 2,500 grams of plutonium nitride. To be conservative, the deflagration was assumed to violate the glovebox integrity and it was also assumed the exhaust HEPA filters on the glovebox were ineffective, though no specific physical cause would be expected to result in this condition.

Using airborne release and the respirable clarifying fractions according to the DOE Handbook, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 1994a), the 2,500 grams of plutonium nitride would result in a maximum source term from the deflagration of 3.75 grams plutonium in plutonium nitride form. Mitigated accident results, where credit is taken for the building's ventilation system, including HEPA filters and other features, result in a source term of $1.4 \times 10^{-8}$ grams of plutonium and a MEI dose at the site boundary, near the Royal Crest Trailer Park, of $2.8 \times 10^{-8}$ rem (LANL 1998:52).

Workers in the room at the time of the deflagration may be injured by flying glass and other missiles depending on their proximity to the deflagration. The radiological dose that a worker would receive from an accident cannot be accurately estimated because of several factors, such as the workers proximity to the accident and the shielding that might be in place. If the worker was close to or in contact with the radioactive material involved in the accident, the dose received would be much greater than if the worker were at the other side of the room. Likewise the shielding (i.e., walls, gloveboxes) between the worker and the accident greatly impact the dose received. Due to the fact that the worker has freedom to move about the area, the physical position of the worker at the time of the accident cannot be known and therefore, an estimated dose cannot be accurately calculated.

Criticality was considered in the PrHA as a possibility from two risk-ranked 3 events, but was not analyzed in detail because the consequences to the public are bounded by the deflagration accident.

#### 6.1.4.3 Gallium Removal

In this module, plutonium oxide is thermally treated in a furnace that operates with a reducing gas to volatilize gallium and other impurities that may be present. The impurities are then captured in a vacuum trap and the plutonium oxide is sent on to the canning module. Possible accidents in this module include fire, a deflagration, or explosion. However, because there would not be any flammable materials present in this module, none of these accidents were considered plausible. Therefore, the consequences of these accidents

were not evaluated separately and are considered to be enveloped by the HYDOX accident discussed in Section 6.1.4.2.

#### 6.1.4.4 Canning

In this module, plutonium metal or plutonium oxide is received in a can which is placed inside a stainless steel inner can, the lid is welded in place with a full penetration weld, the weld is visually inspected, and the can is leak tested with helium. The inner can is then sent to the decontamination module, where it is decontaminated and placed in an outer can. The outer can is then placed inside a bell chamber which is filled with the inert gas, helium. The outer can is welded with a full penetration weld, the weld is visually inspected, and the can is leak tested. Upon successful testing, the cans are sent to the nondestructive assay module.

Based on rigorous drop and crush tests performed on these cans, there are no accidents associated with this module that are expected to generate significant offsite consequences, that is, all of the accidents are a Consequence Severity Category "D" for the public and all are frequency III or IV, and risk-ranking of 3 or lower. (LANL 1997f:19).

#### 6.1.4.5 Electrolytic Decontamination

This module removes radioactive contamination from the outside of a sealed can by rinsing the can with a sodium sulfate solution and establishing an electric potential across the fluid and can. This electrolytic process removes a small amount of the can material (stainless steel) as well as the contamination. After flushing and drying, the can is monitored for alpha contamination, weighed and, if contamination-free, would be released from the glovebox line so it can undergo nondestructive assay in the next module.

The principal hazard of this module is deflagration of hydrogen from the disassociation of water during electrolytic decontamination. The hydrogen deflagration accident, ignited by a spark from the direct current power, was analyzed for the glovebox, the electrolyte tank, and the decontamination chamber, all risk-ranked 3, frequency level III and consequence C. The hydrogen detection system is assumed to fail although the process control system does shut down the system. The deflagration in the electrolyte tank and the decontamination chamber is inconsequential due to the small space available for hydrogen accumulation. In the glovebox, the lower flammable limit (4 percent hydrogen) could be reached in approximately 2.5 hours if the compressed air and ventilation system were off. A hydrogen deflagration of this amount of hydrogen will injure workers with broken glass and could rupture ear drums, but fatalities are not considered likely. Consequences to the public from such an accident are enveloped by the deflagration accident discussed in Section 6.1.4.2 (LANL 1997h:22).

#### 6.1.4.6 Nondestructive Assay

This module uses a calorimeter, a gamma ray isotopic system, a segmented gamma scanner, and an active/passive neutron multiplicity counter to assay the contents of the cans that come out of the decontamination module. The calorimeter measures the heat output of the sample, while the gamma ray isotopic measuring system determines the plutonium isotopic distribution, americium fraction, uranium/plutonium ratio, and neptunium/plutonium ratio. This information will be combined with the calorimetry data (or the neutron counting data) to yield the mass of plutonium. The neutron counter data will be used primarily when the masses of the sample material are low. Cans are hand carried to the nondestructive assay module and moved within the module by robot.

Because these cans have passed rigorous drop and crush tests, there are no accidents associated with this module that are expected to generate significant offsite consequences, that is, all of the accidents are a Consequence Severity Category "D" for the public and all are frequency IV, and risk-ranking of 3 or lower (LANL 1997g:19).

#### 6.1.4.7 Preliminary Integrated Process Hazard Analysis

An integrated PrHA dealing with the potential for an integrated accident associated with the Pit Disassembly and Conversion Demonstration is in preparation. Based on a preliminary analysis by LANL, no additional scenarios have been identified which could potentially impact multiple modules resulting in the release of radioactive materials from more than one module (Ladino 1998).

### 6.1.5 Waste Management Impacts

As discussed in Section 5.3.5, the proposed Pit Disassembly and Conversion Demonstration would generate wastes in the following categories: TRU waste, MLLW, LLW, and hazardous waste. The volume of waste generated by the demonstration would be very small as discussed below. Therefore, the projected increase in the total waste volume for each category would be expected to have little or no impact on current LANL waste management processes and procedures (see Table 6–7). Handling of these wastes would be in accordance with established procedures at LANL, which are compliant with all applicable Federal, and state statutory and regulatory requirements, permits, DOE orders, and RODs associated with the WM PEIS.

#### 6.1.5.1 Transuranic Waste

Crucibles used to contain plutonium during processing and non-fissile pit parts removed during pit disassembly may be sufficiently contaminated to become solid TRU waste. In addition, gloves and glovebox windows and seals would need to be replaced periodically and would be considered TRU waste. Approximately 2 cubic meters of TRU waste would be expected annually from operation of the demonstration. This is appropriately 2.5 percent of the annual TRU waste expected to be generated by all operations at LANL. Solid TRU waste is appropriately packaged and taken by LANL waste management personnel to TA-54, where it is consolidated with other TRU waste generated on the site, placed in drums, certified, and stored for ultimate disposal at WIPP. The small quantities of TRU waste generated by the proposed action would be expected to have minimal impact on storage capacity at LANL.

#### 6.1.5.2 Mixed Low-Level Waste

Cutting the pit cladding may produce some fines and turnings that would be classified as solid MLLW, depending on the cladding materials. However, the estimated quantity of these materials is less than 150 grams per year and would be considered negligible in comparison to the approximately 7 cubic meters of MLLW generated annually at LANL. MLLW is collected by LANL waste management personnel and stored at TA-54, Areas L and G, pending the availability of offsite commercial treatment and disposal or the development of technologies to treat these wastes.

#### 6.1.5.3 Low-Level Waste

The proposed demonstration would be expected to generate less than 100 liters per year of electrolytic decontamination solutions containing traces of plutonium. These solutions would be transferred to the Radioactive Liquid Waste Treatment Facility at TA-50 for treatment where the waste would be treated by lime/sulfate precipitation. The resulting solid waste would be handled with the other solid LLW generated by the demonstration. Other solid LLW expected to be generated by the demonstration would include

**Table 6–7. Comparison of Waste Expected to be Generated by the Pit Disassembly and Conversion Demonstration With Current Waste Management Practices at LANL**

| Waste Category | Examples of Waste Generated During Demonstration | Expected Annual Waste Generated from Demonstration | Current Annual Waste Generated at LANL | Percent of Current Waste Generation (%) | Treatment Capacity | Disposal Method |
|---|---|---|---|---|---|---|
| **TRU** | Gloves; glovebox components, crucibles, HEPA filters | 2 $m^3$ | 81 $m^3$[a] | 2.5 | 1,080 $m^3/yr$[b] | Treated and stored onsite awaiting shipment to WIPP |
| **MLLW** | Solidified solutions, cladding shavings | Negligible[c] | 7 $m^3$[a] | NA | Under development per Site Treatment Plan | Shipped offsite for treatment and disposal |
| **LLW** | Protective clothing, gloves, metal, solidified decontamination solutions | 3 $m^3$ | 521 $m^3$[a] | 0.6 | Varies with waste stream | Buried onsite in pits and shafts designed and engineered for this purpose |
| **Hazardous** | Laboratory solutions, cleaning solvents, hydraulic fluid | <38 kgs | 90,000 kg[a] | <0.1 | Varies with waste stream | Shipped offsite for treatment and disposal |

[a]LANL 1997i: 4.
[b]DOE 1996a:3-338, 3-339.
[c]Less than 150 grams of MLLW is expected to be generated annually during the demonstration.

protective clothing, metal shavings, gloves, solid beryllium, stainless steel, depleted uranium, and aluminum. It is estimated that approximately 3 cubic meters of solid LLW would be generated annually by the demonstration and buried on the site in pits and shafts designed specifically for this purpose in TA-54, Area G. This is approximately 0.6 percent of the LLW expected to be generated annually by all operations at LANL.

#### 6.1.5.4 Hazardous Waste

The demonstration would generate a very small amount of liquid hazardous waste including laboratory solutions, cleaning solvents, and hydraulic fluids. It is estimated that approximately 38 kilograms would be generated annually as a result of the demonstration or less than 0.1 percent of the hazardous waste routinely generated by LANL. No disposal facility for hazardous waste exists at LANL. Hazardous wastes are shipped off the site for further treatment and disposal at RCRA permitted commercial facilities.

### 6.1.6 Transportation Impacts

The Pit Disassembly and Conversion Demonstration could require transportation of pits or plutonium metal from DOE's Pantex Plant, RFETS, INEEL, SRS, and LLNL. Additionally, highly enriched uranium removed from disassembled pits would be shipped from LANL to ORR. All shipments would be packaged in Department of Transportation-approved Type-B containers and use safe secure trailers (SST).

#### 6.1.6.1 Transportation Impacts Analysis Methodology

Representative overland truck routes have been analyzed for the shipments to LANL and ORR. The routes were selected for analysis consistent with current routing practices and all applicable routing regulations and guidelines. However, the routes were determined for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport plutonium and highly enriched uranium in the future. For safety and security reasons, specific routes cannot be publicly identified in advance.

The HIGHWAY (Johnson, et al, 1993) computer code was used for selecting representative highway routes and could be used to help select the actual routes. The HIGHWAY database is a computerized road atlas that currently describes about 386,400 kilometers (240,000 miles) of roads. The Interstate System and all United States-designated highways are included in the database. In addition, most of the principal state highways and many local and community roads are also identified. The code is updated periodically to reflect current road conditions and has been benchmarked against reported mileages and observations of commercial trucking firms. Features in the HIGHWAY code allow the user to select routes that conform to the Department of Transportation regulations. Additionally, the HIGHWAY code contains data on the population densities along the routes. The distances and populations from the HIGHWAY code are part of the information used for the transportation impact analysis.

Since DOE established the Transportation Safeguards Division in 1975, it has accumulated over 110 million kilometers (70 million miles) of experience with no accidents or release of radioactive material (DOE 1996a:G-27). However, there are risks associated with such shipments and in order to quantify the potential risks to the public, DOE-developed RADTRAN (Neuhauser and Kanipe 1993). RADTRAN 4 was developed by Sandia National Laboratories to calculate population risk associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge. This computer code is used for incident-free and accident risk assessments to estimate the impacts on collective populations. RADTRAN 4 population risk calculations take into account both the consequences and probabilities of potential exposure events. The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternatives being considered. As such, the collective population risk is used as the primary means of comparing the various alternatives.

The transportation accident model assigns accident probabilities to a set of accident categories. Eight accident-severity categories defined in NRC's *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977) were used. The least severe categories (Category I and II) represent low magnitudes of crush force, accident-impact velocity, fire duration, and/or puncture-impact speed. The most severe category (Category VIII) represents a large crush force, high accident-impact velocity, long fire duration, and a high puncture-impact speed. The fraction of material released and material aerosolized, and the fraction of that material that is respirable (particles smaller than 10 microns) was assigned based on the accident categories. The analytic approach is consistent with the approach used in the *Storage and Disposition Final PEIS*.

The nonradiological risk factors are also taken from the *Storage and Disposition Final PEIS*. Risk factors are provided for fatalities resulting from hydrocarbon emissions (known to contain carcinogens) and transportation accidents (nonradiological fatalities resulting from impact). The risk of transportation accidents involving escort vehicles are included in the estimates. The risk from hydrocarbon emissions for the escort vehicles is much smaller than those from the trucks.

### 6.1.6.2 Transportation Risks Associated with the Proposed Action

Under the proposed action, plutonium in the form of pits would be shipped to LANL from INEEL, LLNL, RFETS, Pantex, or SRS. Highly enriched uranium recovered from these pits as they are disassembled would be shipped to ORR. As shown in Table 6–8, the greatest risk to the public from these proposed shipments would be from a traffic accident involving the SST or one of its escort vehicles and not from radiological exposure. In terms of the total risk to the public as a result of implementing the proposed action, it is estimated that the proposed action would result in a risk to the public (either as result of a latent cancer or a traffic accident) of less than 0.005 or 5 chances in 1,000 of a fatality.

**Table 6–8. Overland Transportation Risks for All Materials Under the Proposed Action[a]**

| | Routine | | | | Accidental |
|---|---|---|---|---|---|
| | Radiological | | Nonradiological | | |
| Route | Crew[b] | Public | Emissions | Traffic | Radiological |
| Plutonium shipments from Pantex Plant to LANL | 0.0001 | 0.0007 | 0.0001 | 0.001 | $3x10^{-6}$ |
| Plutonium shipments from RFETS to LANL | $3x10^{-5}$ | 0.0002 | $5x10^{-5}$ | 0.0003 | $1x10^{-6}$ |
| Plutonium shipments from INEEL to LANL[c] | $7x10^{-6}$ | $5x10^{-5}$ | $5x10^{-6}$ | $7x10^{-5}$ | $3x10^{-7}$ |
| Plutonium shipments from SRS to LANL[c] | $1x10^{-5}$ | $7x10^{-5}$ | $1x10^{-5}$ | 0.0001 | $7x10^{-7}$ |
| Plutonium shipments from LLNL to LANL[c] | $5x10^{-6}$ | $3x10^{-5}$ | $8x10^{-6}$ | $5x10^{-5}$ | $2x10^{-7}$ |
| Highly enriched uranium shipments from LANL to ORR | $3x10^{-6}$ | $2x10^{-5}$ | $9x10^{-5}$ | 0.0009 | $3x10^{-10}$ |

[a] All risks are expressed in latent cancer fatalities during the implementation of the proposed action, except for the Accidental-Traffic column, which is a number of nonradiological fatalities.
[b] The two individuals in the vehicle.
[c] Includes risks associated with a single SST shipment from this site should the need arise.

Based on the results of the transportation risk analysis, it is unlikely that shipping plutonium pits or highly enriched uranium would result in a fatality. Therefore, no adverse health effects to the public and truck crews would be expected from any scenario involved in the proposed demonstration.

### 6.1.7 Socioeconomic Impacts

The proposed demonstration would not affect employment at LANL because no additional personnel are anticipated to be required to support the demonstration. The demonstration would be similar to many other research efforts normally conducted at LANL. It is standard practice for workers at LANL to move from one project to another without any impact on the overall employment level. The demonstration, if undertaken, would be staffed in this manner. Therefore, no significant socioeconomic effects would be expected to result from the proposed action.

### 6.1.8 Environmental Justice Impacts

As discussed above, implementation of the proposed action would pose no significant risk to the general population including minority and low-income populations. Therefore, no disproportionately high and adverse impacts on minority and low-income populations would result from implementation of the proposed action.

## 6.2 No Action Alternative Impacts

Under the No Action Alternative, an integrated pit disassembly and conversion line would not be demonstrated at LANL. Research related to these activities would continue to be collected through a series of individual gloveboxes because potential data developed as a result of the demonstration would not be available. There would be no change in the current environmental or health effects associated with work done in PF-4 and TA-55, and these facilities would continue to operate as they do currently.

### 6.2.1 Transportation Risks Associated with the No Action Alternative

Under the No Action Alternative, pits would not be shipped to LANL from INEEL, LLNL, RFETS, SRS or Pantex, and there would not be any highly enriched uranium recovered from these pits, so there would be no shipments of highly enriched uranium to ORR. However, DOE has committed to consolidate its inventory of weapons-grade plutonium, so the pits at RFETS would be shipped to Pantex instead of LANL where they would be stored pending a decision on their ultimate disposition in accordance with the ROD that will be issued after the SPD EIS is completed. As shown in Table 6–9, the greatest risk to the public from this alternative would continue to be from a traffic accident involving the SST or one of its escort vehicles and not from radiological exposure. In terms of the total risk to the public as a result of implementing the No Action Alternative, it is estimated that this alternative would result in a risk to the public (either as result of a latent cancer or a traffic accident) of less than 0.001 or 1 chance in 1,000 of a fatality.

**Table 6–9. Overland Transportation Risks for All Materials Under the No Action Alternative[a]**

| | Routine | | | | Accidental |
|---|---|---|---|---|---|
| | Radiological | | Nonradiological | | |
| Route | Crew[b] | Public | Emissions | Traffic | Radiological |
| Plutonium shipments from RFETS to Pantex Plant | 0.00005 | 0.0003 | 0.00007 | 0.0005 | 0.00008 |

[a] All risks are expressed in latent cancer fatalities during the implementation of the policy, except for the Accidental-Traffic column, which is a number of fatalities.
[b] The two individuals in the vehicle.

Based on the results of the transportation risk analysis, it is unlikely that shipping plutonium to Pantex from RFETS under the No Action Alternative would result in a fatality.

### 6.3 Future Utilization of Pit Disassembly and Conversion Demonstration Equipment

After completion of the demonstration, the equipment would be placed in a standby mode and later used for training purposes (i.e, operators, supervisors) for the production pit disassembly and conversion facility, should it be built. The modules for which there is no further mission would be decontaminated and decommissioned. The ultimate disposition of the modules has not yet been determined. However, when DOE decides what action to take regarding the modules, an appropriate NEPA review will be conducted.

## 7.0 RESEARCH AND DEVELOPMENT ACTIVITIES

In the ROD for the *Storage and Disposition Final PEIS*, DOE decided to pursue a strategy for plutonium disposition that allows for the implementation of two different technologies for disposition of the United States' surplus plutonium: one would involve the immobilization of some and potentially all surplus weapons plutonium in a glass or ceramic form surrounded by high-level waste; the other would involve the use of some of the surplus plutonium as MOX fuel in existing commercial light water reactors. The ROD acknowledges that further research, development, and demonstration is needed to provide data for decisions concerning process development, waste characterization, plant design and engineering (for production facilities), and other support activities.

These R&D activities cover each major area of the surplus plutonium disposition program (pit disassembly and conversion, immobilization, and mixed oxide fuel) and consist of a number of small-scale projects which in turn consist of a number of individual experiments. As stated before, all of the R&D activities are ongoing having been started before 1997 with none of the projects currently being complete. However, some individual experiments have been completed and new ones started. Some individual experiments will take several years to complete and therefore, work on R&D activities will continue after the issuance of the SPD EIS ROD. Depending on the decisions made in that ROD, individual experiments as well as some of the projects they support may be canceled.

In the interest of furthering the purposes of NEPA and providing full disclosure to the public, a brief description of each R&D project and the amount and type of nuclear materials involved is being provided in this EA. Some of the project descriptions contain information about individual experiments where that description will provide a better understanding of the work being done and its purpose in the overall surplus plutonium disposition program.

The ongoing R&D projects and experiments described in this section (DOE 1998b; DOE 1997b) have already been reviewed for NEPA compliance by the responsible DOE site/office. At five of the sites (Argonne National Laboratory-East (ANL-E), Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), INEEL, and SRS), these efforts have been categorically excluded from the need for further NEPA review under Category B3.6[7], because they consist of indoor bench-scale research or demonstration work (Dunigan 1998, Elmore 1998, Grainger 1998, Green 1998, Irving 1998). For the most part, the R&D activities described in this section are being conducted without the need for construction or modification of existing facilities. In the few activities where construction or modification of facilities was required, all of the changes were within already developed areas. No adverse impacts are expected during these experiments because of the small quantities of materials being used in these bench-scale R&D projects and because applicable safety and health procedures are in place in these buildings (e.g. HEPA filters, gloveboxes). The R&D activities at these five sites are using plutonium in amounts well below the administrative limits for the facility in which the work is being performed. At the remaining two sites, LANL and LLNL, the R&D projects are covered by sitewide EISs (DOE 1979, DOE 1992). These two sites are using plutonium in amounts ranging from 15 to 50 kilograms. These amounts are well below facility administrative limits for individual experiments.

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[7] As defined in DOE's NEPA Implementing Procedures, Categorical Exclusion B3.6 is applicable to the siting, construction (or modification), operation, and decommissioning of facilities for indoor bench-scale research projects and conventional laboratory operations (e.g., preparation of chemical standards and sample analysis); small-scale research and development projects; and small-scale pilot projects (generally less than two years) conducted to verify a concept before demonstration actions. Construction (or modification) will be within or contiguous to an already developed area (where active utilities and currently used roads are readily accessible) (DOE 1996c:36241).

## 7.1 Immobilization Research and Development

The *Storage and Disposition Final PEIS* analyzed the ability of various immobilization technologies to achieve the Spent Fuel Standard for proliferation resistance. The Notice of Intent for the SPD EIS stated that the preferred alternative for immobilization would be the can-in-canister technology, using the existing high-level waste processing operations at the Defense Waste Processing Facility (DWPF) at SRS. The ROD for the SPD EIS will make the final decision on the immobilization technology to be used for disposition, if it is decided to immobilize some or all of the surplus plutonium.

The proposed can-in-canister demonstration has two stages. The first stage is to immobilize the plutonium in a small can using either a glass or ceramic form. The next step is to place the immobilized cans of plutonium in a rack which is placed in an empty DWPF canister. In the second stage of immobilization, the canister is filled with high-level waste at DWPF, which adds the radiation barrier necessary to meet the Spent Fuel Standard. The same approach is being evaluated for the Hanford Site in Richland, Washington, which is building a vitrification plant similar to DWPF.

Before DOE can make a decision on the technology to be used to immobilize surplus plutonium, immobilization R&D is needed to:

- identify a material formulation that satisfies process and long-term performance requirements;
- develop processing equipment, material flow and process controls, operational strategies, and material accountability procedures that minimize impacts on workers, the environment and the ability to maintain an acceptable implementation schedule;
- demonstrate that individual operations or processing steps fit together seamlessly; and
- demonstrate that the specific immobilized forms meet the Spent Fuel Standard for proliferation resistance (DOE 1996b:3)

Ongoing work is needed to develop data to: determine which immobilized form, glass or ceramic, performs best[8]; develop material forms compatible with processing (including determining effects of impurities and long-term performance requirements); develop immobilization processes for reliably producing these forms; demonstrate these processes using radioactive materials; and enhance overall proliferation resistance. LLNL is serving as the lead laboratory and host for most of the immobilization R&D, and is being supported by efforts at SRS, ANL-E, and PNNL. Table 7-1 shows the immobilization R&D projects that are taking place at specific DOE sites, all of the buildings being utilized for the listed R&D projects at these sites, and the cumulative total plutonium estimated to be used for all the listed projects at each site.

### 7.1.1 Development of Data to Support Selection of Preferred Immobilized Form

To determine the best immobilization form, R&D is being conducted to judge the glass and ceramic forms against established criteria on a consistent basis. These R&D activities are being conducted at LLNL to compare can-in-canister and homogeneous approaches, and the final immobilized form, glass or ceramic. Efforts are focusing on resistance to theft and diversion and retrieval or extraction; technical viability; environmental, safety, and health concerns; timeliness; and cost effectiveness.

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[8] Based on a technical down-selection process, DOE's current research and development efforts are focused on ceramic formulations.

**Table 7–1. Summary of Immobilization R&D Activities**

| Immobilization R&D Projects | Building Number (Administrative Limit)[a] | Quantity of Plutonium Estimated to be Used in These Projects[b] |
|---|---|---|
| **ANL-E** | | |
| Glass Formulation Development, Ceramic Formulation Development, Waste Form Characterization, Proliferation Resistance Tests | Building 205 (400 g) | < 300 g |
| **LLNL** | | |
| Glass Formulation Development, Glass Process Development, Ceramic Formulation Development, Ceramic Process Development, Waste Form Characterization, Proliferation Resistance Tests, Can-in-Canister Technology Demonstrations | Superblock[c] (700 kg) | FY 97–2 kg[d]<br>FY 98–8 kg[d] |
| **PNNL** | | |
| Glass Formulation Development, Glass Process Development, Waste Form Characterization, Proliferation Resistance Tests | Building 325 (2,759 g) | 70 g |
| | Building 326 (18 g) | mg quantities |
| | Building 3720 (18 g) | 3-5 g |
| **SRS** | | |
| Glass Formulation Development, Glass Process Development, Ceramic Formulation Development, Ceramic Process Development, Waste Form Characterization, Proliferation Resistance Tests, Can-in-Canister Technology Demonstrations | Building 773-A (2,000 g) | < 200 g |

[a] The limit on the amount of plutonium allowed in a building at any one time is based on the site-specific safety analysis report; shown are the buildings that will be used for these R&D projects at a specific site.

[b] Amounts listed are cumulative totals for the listed R&D projects at a specific site. The quantities in the building at any one time will be less than the administrative limit.

[c] The Superblock is comprised of Buildings 331, 332, 334, and 335. MD plutonium activities are limited to Buildings 332 and 334. The safety analysis report for Building 334 further restricts the plutonium limit to 12 kg.

[d] These amounts are a subset of the quantity of plutonium being processed through pit disassembly and conversion R&D experiments at LLNL (see Table 7-3).

Source: Pearson 1997; Peko 1998a; Vienna 1997.

### 7.1.2 Formulation Development

The choice of the first stage immobilization form would affect the design of an immobilization facility, because the immobilization processes differ for each. This choice will also influence the extent of characterization necessary for the product, the waste coming from this facility, potential licensing requirements, and the implementation schedule. For example, the maximum allowable plutonium loading (i.e., the percentage of plutonium that can be encapsulated in the glass or ceramic form) for each immobilized form needs to be determined through R&D related to process safety and the long-term performance of the immobilized form. Similarly, the loading factor will affect the size and throughput of the processing facility. Formulas for glass or ceramic materials to be used for immobilization and the measurement of various physical and chemical properties of the immobilized material need to be refined to aid the selection of the

immobilized form, to determine the production processing parameters, and to develop the qualification for potential placement of the immobilized form into a potential Nuclear Waste Policy Act repository.

LLNL is performing ceramic formulation experiments with support from SRS and ANL-E; while SRS and ANL-E are performing glass formulation experiments; and PNNL is providing testing support. The formulation development project at these laboratories include experiments using the glass concept to determine acceptable impurity concentrations: experiments of the solubility of plutonium, uranium and neutron absorbers as a function of particle size and thermal treatment history of the plutonium feed; experiments in static, manually stirred and control agitation melts; and experiments to establish the devitrification properties as well as key physical properties (e.g., viscosity and thermal conductivity).

### 7.1.3 Waste Form Characterization

The main concern about the performance of the immobilized form in a geologic repository is the potential for separation of the fissionable isotopes of plutonium and uranium from neutron absorbers, inside the waste package, in the environment, or both. The concern is that a separation could result in enough of this material coming together to form a critical mass. DOE experiments are being conducted to characterize waste form degradation and radionuclide release in an environment replicating the presumed repository environment.

### 7.1.4 Proliferation Resistance Tests

The goal of the plutonium disposition program is to place the United States' surplus plutonium into a form from which it can not be easily recovered and used again in nuclear weapons. Proliferation resistance tests are being conducted to ensure that the final glass or ceramic form chosen for immobilization will prevent the return of these materials to a form where they can be used in nuclear weapons. Tests are also being conducted to determine the relative difficulty of recovering plutonium from the glass and ceramic forms. Extraction tests are assessing the degree of difficulty and the cost and time requirements for attempted diversion. These experiments include leaching of the plutonium-bearing forms in sub-boiling solutions (e.g., nitric acid, sulfuric acid) and measurements of the quantity of plutonium released as a function of time.

### 7.1.5 Process Development

Process experiments involve the development and demonstration of prototypical systems for a production-scale plutonium immobilization facility. Development of prototypical glass and ceramic formulation equipment, using kilogram quantities of plutonium, provide needed information, such as shielding requirements and glovebox spacing, for the production-scale design.

The glass process requires the development of a suitable melter system which includes both prototype feeders and product loadout systems contained in a glovebox enclosure for safer operation. Using the tilt-pour melter, DOE is evaluating the characteristics associated with fabricating and pouring multi-kilogram quantities of glass containing plutonium, uranium, and a range of impurities that will be similar to those expected to enter the production-scale facility.

The ceramic process also requires the development of a prototypical feed preparation and cold-pressing system coupled to an appropriate heat cycle to sinter the ceramic pellets. Ceramic samples are prepared to determine the extent to which the precursor or binder materials and the plutonium oxide feedstock react to produce stable ceramic forms. The ability of the ceramic formulation to incorporate the expected range of impurities in the plutonium feedstocks is being evaluated and preliminary impurity concentration limits established.

### 7.1.6 Can-in-Canister Technology Demonstrations

Small-scale demonstrations of the various can-in-canister technologies are facilitating the design of a potential production plant. Fabrication of glass and ceramic forms is being demonstrated in a tilt-pour melter that can produce materials that are prototypical of a production melter and experimental plutonium ceramic process line at LLNL. Several cans of plutonium forms may be produced to validate formulation and plant processes.

## 7.2 Reactor-Based and Nuclear Fuels Research and Development

The second disposition technology being pursued by DOE is the use of weapons-grade plutonium in the fabrication of MOX nuclear fuel for use in commercial light water reactors. R&D is needed to resolve technical issues associated with applying the large experience base (existing mainly in Europe) of making MOX fuel with recycled reactor-grade plutonium to the fabrication of MOX fuel using weapons-grade plutonium and to develop the data needed to expedite the implementation of reactor-based alternatives for the disposition of surplus weapons-usable plutonium.

The compatibility of commercial reactor-grade MOX fuel with commercial light water reactor technologies is well established. However, several differences exist between reactor-grade and weapons-grade plutonium that create technical issues that must be resolved. These differences include: variation in powder characteristics because the weapons material is expected to be converted primarily using a dry pyrochemical process as opposed to the chemical dissolution and precipitation process currently used in Europe; the presence of gallium or other potential impurities in the weapons material; and the variation in plutonium isotopics between reactor-grade and weapons-grade material. R&D activities fall into two main categories: MOX fuel fabrication and gallium removal. Table 7–2 shows the reactor-based and nuclear fuels R&D projects that are taking place at specific DOE sites, all of the buildings being utilized for the listed R&D projects at these sites, and the cumulative total plutonium estimated to be used for all the listed projects at each site.

The potential disposition of plutonium as MOX fuel would involve a mixture of weapons-grade plutonium oxide and depleted or natural uranium oxide. Any variation in the fabrication process, including the feed materials, will lead to variations in the final fuel product. It is important to quantify the effect these variations will have on the quality of the MOX fuel. Definition and development of the processes, equipment, and specifications for producing plutonium oxide and uranium oxide feed is essential for qualifying a fuel fabrication process since the proposed MOX fuel fabrication facility may be licensed by the NRC. Ongoing research is required to determine the range of fabrication parameters that will lead to an acceptable fuel product, that is one compatible with use in a commercial reactor.

### 7.2.1 Light Water Reactor In-Pile Testing

ORNL is directing in-pile testing experiments to examine the effects of gallium on prototypic but generic, light water reactor MOX fuel. The in-pile testing complements out-of-pile experiments by providing generic irradiation data to supplement the out-of-pile results. Fuel for these experiments, a small number of fuel pellets, are being fabricated at LANL and shipped to INEEL, where the fuel is irradiated in the ATR.

**Table 7–2. Summary of MOX Fuel R&D Activities**

| MOX Fuel R&D Projects | Building Number (Administrative Limit)[a] | Quantity of Plutonium Estimated to be Used in These Projects[b] |
|---|---|---|
| **INEEL** | | |
| Light Water Reactor In-Pile Testing | Advanced Test Reactor (ATR)-Test Reactor Area (TRA) 670 (none) | 41 g |
| | ATR-C (180 g) | 49 g |
| | ATR Canal (365 g) | 41 g |
| | Hot Cells-TRA 632 (450 g) | 49 g |
| | Test Train Assembly Facility (TTAF)-TRA 603 (15 g) | 49 g |
| | Radiography-TRA 635 (15 g) | 41 g |
| | Chemical Processing Plant (CPP)-695 (15 g) | 41 g |
| **LANL** | | |
| Feed Qualification, Fuel Fabrication Development, Gallium Research, Gallium Removal, Light Water Reactor In-Pile Testing | TA-55/PF-4[c] (none) CMR (2 kg) | 15 kg at PF-4 Note: Gram size samples at CMR |
| **ORNL** | | |
| Light Water Reactor In-Pile Testing | Hot Cells-Building 3525 (320 kg) | 15 g |
| | Shipping-Building 3036 (250 g) | 15 g |
| | Storage-Building 7827 (151 kg) | 15 g |
| Gallium-Clad Interaction | Hot Cells-Building 3525 (320 kg) | <5 g |
| | Shipping-Building 3036 (250 g) | <5 g |
| | Storage-Building 7827 (151 kg) | <5 g |

[a] The limit on the amount of radioactive material allowed in a building at any one time is based on the site-specific safety analysis report; shown are the buildings that will be used for these R&D projects at a specific site.

[b] Amounts listed are cumulative totals for the listed R&D projects at a specific site. The quantities in the building at any one time will be less than the administrative limit.

[c] There are plutonium limits on a large number of individual operations at PF-4. These limits can change depending upon a number of criteria. The amount of plutonium used in the MOX fuel R&D projects is limited by the same criteria used to control other plutonium operations currently conducted at PF-4.

Source: Hodge 1997.

### 7.2.2 Feed Qualification

For the potential disposition of surplus plutonium as MOX fuel[9], pits could be converted to plutonium oxide by hydride-oxidation (HYDOX) of plutonium metal. Characterization of previous batches of plutonium oxide produced by the hydride-oxidation (HYDOX) process has shown that the particle structure is quite different from the particles produced by the conventional aqueous conversion processes. Experimentation is required to demonstrate that the variation in structure as a result of the HYDOX process is acceptable for producing quality fuel. Experiments are being conducted at LANL to: fully characterize the production of plutonium oxide using the HYDOX process; identify modifications to the process and hardware to enable the production of feed that will meet expected specifications for MOX fuel fabrication; and produce plutonium oxide feed for MOX fuel development activities.

### 7.2.3 Fuel Fabrication Development

Variations in the MOX fuel fabrication process, including the feed materials, will lead to variations in the final fuel product. Ongoing experiments are required to determine the range of fabrication parameters that will lead to an acceptable fuel product, that is one compatible with use in a commercial reactor. Fuel fabrication development is also needed to enhance the current techniques available for measurement of fuel characteristics. Analytical capability for measuring properties of weapons-grade MOX fuel is being developed at LANL. Demonstrations being conducted are the implementation of contemporary stoichiometry measurement capabilities, the validation of trace analysis capability, and a sintering study to evaluate the effect that different sintering times and temperatures have on final pellet density.

### 7.2.4 Gallium Research

To fabricate MOX fuel, plutonium oxide and uranium oxide are blended with a ceramic powder and pressed into pellets. The pellets are then placed in a sintering furnace to cause the ceramic powder to bond with the plutonium and uranium. The presence of gallium in weapons material is a key difference between weapons-grade and reactor-grade plutonium which could affect the MOX fuel fabrication process. DOE experiments have shown that gallium oxide could volatilize under MOX fuel sintering conditions, resulting in problems because gallium is corrosive and will deposit on the furnace surfaces. In addition, gallium could affect the MOX fuel ceramic, causing significant operational difficulties if frequent adjustments to operational parameters (i.e., time and temperature) are required. This characteristic could also cause large pellet rejection rates following sintering. Ongoing development is needed to characterize the problems associated with gallium and to develop methods by which gallium can be efficiently removed from plutonium.

### 7.2.5 Gallium Removal

Evaluations of the phase relations in the complex gallium oxides (e.g., $Ga_20_3$-$PuO_2$, $PuO_2$-$UO_2$, $UO_2$-$PuO_2$-$Ga_2O_3$) are being conducted at LANL. These phase diagrams are assessed by collecting and critically evaluating all available thermodynamic data. The resulting information is used to assist in the development and optimization of the Thermally-Induced Gallium Removal (TIGR) process, and would be provided to the potential fuel fabricators to assist them in determining the impact of gallium on process parameters for the fabrication of MOX fuel. The TIGR process will allow the gallium to be collected in a vacuum trap, effectively eliminating gallium from the plutonium.

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[9] DOE is also evaluating the disposition of surplus plutonium in a immobilized form. In which case, the pits would also need to be converted to an oxide.

### 7.2.6 Gallium-Clad Interaction

A series of tests are being conducted at ORNL to determine the effects of gallium on prototypic fuel cladding materials in out-of-pile experiments. These tests involve (1) heating mixed-oxide fuel rods either in a 400°C lead-bismuth bath or a high-flow recirculating water jacket in cells in Building 3525 at ORNL, (2) examining and segmenting the fuel-containing rods as well as the substitute fuel rods (i.e., containing no plutonium) and irradiated fuel rods from INEEL, (3) conducting metallographic/ceramographic examination of the fuel rods, and (4) performing an elemental analysis of the fuel and cladding for gallium and other materials of interest.

## 7.3 Pit Disassembly and Conversion Research and Development

An integral part of implementing either plutonium disposition technology (immobilization or MOX fuel) is the disassembly of pits from surplus nuclear weapons and the recovery of the plutonium. To develop this capability, DOE must test and demonstrate an integrated method for dismantling pits. Once it has been successfully demonstrated, deployment of this process in a potential production facility would allow the resulting plutonium oxide to be further processed for immobilization or to be mixed with uranium oxide to form MOX fuel. The demonstration of an integrated process for pit disassembly and conversion is the subject of this EA. However, R&D activities to develop various glovebox modules of the integrated process, system development to support production mode operations, direct oxidation of bulk plutonium, and a HYDOX program for MOX fuel fabrication are ongoing under the current prototype system project at LANL and LLNL. Both LANL and LLNL are performing this R&D with LANL as the lead laboratory. Table 7–3 shows the pit disassembly and conversion R&D projects that are taking place at specific DOE sites, all of the buildings being utilized for the listed R&D projects at these sites, and the cumulative total plutonium estimated to be used for all the listed projects at each site.

### 7.3.1 Electrolytic Decontamination Module

The electrolytic decontamination module consists of a decontamination system mounted in a glovebox that electrolytically decontaminates the outside of the sealed material can. An existing electrolytic decontamination system is being hot-tested (use of plutonium).

### 7.3.2 Process Development for Unique and Non-Special Nuclear Materials Pit Items

This experiment, at LANL and LLNL, is evaluating and developing disposition processes and equipment for unique constituent pit items and developing processes and equipment for the decontamination and declassification of non-special nuclear materials parts resulting from the disassembly of weapons pits.

### 7.3.3 Pit Disassembly and Conversion Facility Non-Plutonium Product Material and Item Processes

This experiment, at LANL and LLNL, involves evaluating options for shipment and processing of non-plutonium product materials and items that result from operation of the pit disassembly and conversion facility that cannot be readily declassified and disposed of through conventional means.

**Table 7–3. Summary of Pit Disassembly and Conversion R&D Activities**

| Pit Disassembly and Conversion R&D Projects | Building Number (Administrative Limit)[a] | Quantity of Plutonium Estimated to be Used in These Projects[b] |
|---|---|---|
| **LANL** | | |
| Electrolytic Decontamination Module, Process Development for Unique and Non-Special Nuclear Materials Pit Items, Pit Disassembly and Conversion Facility Non-Plutonium Product Material and Item Processes, Direct Oxidation of Bulk Plutonium, Oxide Characterization | TA-55/PF-4[c]<br>(none) | 100 kg |
| **LLNL** | | |
| Pit Bisector Module, Hydride-Oxide (HYDOX) Development and Furnace Module, Direct Oxidation of Bulk Plutonium, Oxide Characterization, Pit Dose Studies | Superblock[d]<br>(700 kg) | FY97–20 kg<br>FY98–50 kg |

[a] The limit on the amount of radioactive material allowed in a building at any one time is based on the site-specific safety analysis report; shown are the buildings that will be used for these R&D projects at a specific site.
[b] Amounts listed are cumulative totals for the listed R&D projects at a specific site. The quantities in the building at any one time will be less than the administrative limit.
[c] There are plutonium limits on a large number of individual operations at PF-4. These limits can change depending upon a number of criteria. The amount of plutonium used in the pit disassembly and conversion R&D projects is limited by the same criteria used to control other plutonium operations currently conducted at PF-4.
[d] The Superblock is comprised of Buildings 331, 332, 334, and 335. MD plutonium activities are limited to Buildings 332 and 334. The safety analysis report for Building 334 further restricts the plutonium limit to 12 kg.
Source: Peko 1998b.

### 7.3.4 Direct Oxidation of Bulk Plutonium

Experiments are being conducted at LANL and LLNL to determine if direct oxidation of bulk plutonium is a reasonable backup approach for the conversion of weapons plutonium by determining the throughput and the resultant product quality of this process.

### 7.3.5 Oxide Characterization

Plutonium from various pit sources is being sampled and analyzed at LANL and LLNL at various stages of the pit disassembly and conversion process to establish a statistically significant database of impurities and to determine the impact of the oxidation process on impurities and oxide particle characteristics. This may involve shipment of samples between LANL and LLNL.

### 7.3.6 Pit Bisection Module

This module consists of a "simple" pit bisection tool mounted in a glovebox that operates like a tubing cutter, swaging (bending and shaping) rather than sawing through the material to prevent the generation of chip waste. A pit bisector is being hot-tested (using nuclear materials) at LLNL. The existing LLNL bisector module design will be upgraded to add process capability and equipment and procedures will be developed to de-nest shells from bisected pits and remove pit components.

### 7.3.7 Hydride-Oxide (HYDOX) Development and Furnace Module

This module consists of the Hydride-Oxide furnace mounted in a glovebox, with associated handling accessories for loading hemishells and crucibles and unloading non-plutonium material hemishell parts and oxide after processing. A Hydride-Oxide furnace is being hot-tested (use of plutonium) at LLNL.

### 7.3.8 Pit Dose Studies

The dose characteristics of various pit types are being analyzed by LLNL for intact pits and for pits at various stages of disassembly to characterize the source term to support the design of the potential pit disassembly and conversion facility.

## 7.4 Site Specific Research and Development Activities

Table 7–4 summarizes the ongoing surplus plutonium disposition R&D activities by DOE facility. This summary is a composite by location of the same R&D projects described in Sections 7.1, 7.2, and 7.3.

### 7.4.1 Argonne National Laboratory-East

All the R&D projects for surplus plutonium disposition being conducted at ANL-E, as shown in Table 7–1, are related to immobilization technologies. The ANL-E is supporting LLNL with ceramic formulations and is performing glass formulations. These projects use Building 205. It is estimated that small amounts of plutonium, less than 300 grams, would be used for these indoor bench-scale R&D projects.

### 7.4.2 Idaho National Engineering and Environmental Laboratory

The R&D projects for surplus plutonium disposition at INEEL, as shown in Table 7–2, involves light water reactor in-pile testing. The tests take place in one of DOE's research reactors, the ATR, which is located in the Test Reactor Area at INEEL, and routinely conducts material irradiation tests for other offices of DOE and the United States Navy. The in-pile testing uses fuel fabricated by LANL. After receiving the fuel from LANL, it is irradiated at the ATR. After irradiation, the fuel is shipped to ORR where it is disassembled and examined. It is estimated that small amounts of plutonium, between 40 and 50 grams, would be used for these R&D projects.

### 7.4.3 Los Alamos National Laboratory

The R&D projects at LANL, as shown in Tables 7–2 and 7–3, involving surplus plutonium disposition are related to the MOX fuel fabrication process and pit disassembly and conversion. MOX fuel fabrication, feed qualification, and gallium research experiments occur within TA-55 at PF-4 where plutonium experiments are routinely conducted. It is estimated that 15 kilograms of plutonium would be used for the MOX R&D projects. In addition, gram size laboratory samples (10 grams or less) are sent to the CMR facility for analytical testing in existing laboratories. For pit disassembly and conversion R&D projects, it is estimated that 100 kilograms of plutonium would be used at PF-4. These R&D projects do not require any upgrade or expansion of the facilities' existing environmental or safety systems.

**Table 7–4. Site Summary of Plutonium Disposition Related R&D Activities**

| Plutonium Disposition R&D Projects | Building Number (Administrative Limit)[a] | Quantity of Plutonium Estimated to be Used in These Projects[b] |
|---|---|---|
| **ANL-E** | | |
| Immobilization | Building 205 (400 g) | < 300 g |
| **INEEL** | | |
| MOX Fuel | ATR-TRA 670 (none) | 41 g |
| | ATR-C (180 g) | 49 g |
| | ATR Canal (365 g) | 41 g |
| | Hot cells-TRA 632 (450 g) | 49 g |
| | TTAF-TRA 603 (15 g) | 49 g |
| | Radiography-TRA 635 (15 g) | 41 g |
| | CPP 695 (15 g) | 41 g |
| **LANL** | | |
| MOX Fuel | TA-55/PF-4[c] (none) | 15 kg at PF-4 |
| | CMR (2 kg) | Gram size samples at CMR |
| Pit Disassembly and Conversion | | 100 kg at PF-4 |
| **LLNL** | | |
| Immobilization | Superblock[d] | FY97–20 kg |
| Pit Disassembly and Conversion | | FY98–50 kg |
| **ORNL** | | |
| MOX Fuel | Hot Cells-Building 3525 (320 kg) | 15 g |
| | Shipping-Building 3036 (250 g) | 15 g |
| | Storage-Building 7827 (151 kg) | 15 g |
| | Hot Cells-Building 3525 (320 kg) | <5 g |
| | Shipping-Building 3036 (250 g) | <5 g |
| | Storage-Building 7827 (151 kg) | <5 g |
| **PNNL** | | |
| Immobilization | Building 325 (2,759 g) | 70 g |
| | Building 326 (18 g) | mg quantities |
| | Building 3720 (18 g) | 3-5 g |
| **SRS** | | |
| Immobilization | Building 773-A (2,000 g) | <200 g |

[a] The limit on the amount of radioactive material allowed in a building at any one time is based on the site-specific safety analysis report; shown are the buildings that will be used for these R&D projects at a specific site.

[b] Amounts listed are cumulative totals for the listed R&D projects at a specific site. The quantities in the building at any one time will be less than the administrative limit.

[c] There are plutonium limits on a large number of individual operations at PF-4. These limits can change depending upon a number of criteria. The amount of plutonium used in the MOX fuel and pit disassembly and conversion R&D projects is limited by the same criteria used to control other plutonium operations currently conducted at PF-4.
[d] The Superblock is comprised of Buildings 331, 332, 334, and 335. MD plutonium activities are limited to Buildings 332 and 334. The safety analysis report for Building 334 further restricts the plutonium limit to 12 kg.
Source: Hodge 1997; Pearson 1997; Peko 1998a,b; Vienna 1997.

### 7.4.4 Lawrence Livermore National Laboratory

The R&D projects at LLNL, as shown in Tables 7–1 and 7–3, are related to immobilization technologies as well as pit disassembly and conversion technology. The R&D projects utilize existing laboratories within Buildings 332 and 334, which are part of the Superblock at LLNL. It is estimated that 20 kilograms and 50 kilograms of plutonium, in Fiscal Years 1997 and 1998 respectively, would be used for these R&D projects. These projects do not require any upgrade or expansion of the facilities' existing environmental or safety systems.

### 7.4.5 Oak Ridge National Laboratory

The R&D projects for surplus plutonium disposition at ORNL, as shown in Table 7–2, involves characterizing the problems associated with gallium. ORNL conducts evaluations of both irradiated MOX fuel and gallium-clad interactions. Once the material has completed its scheduled irradiation run at INEEL, it is shipped to ORNL where it is examined to determine the effects of gallium on prototypic MOX fuel. This work is accomplished in ORNL's hot cells where irradiated material samples are routinely disassembled and examined. It is estimated that small amounts of plutonium, less than 5 grams to 15 grams, would be used for these R&D projects.

### 7.4.6 Pacific Northwest National Laboratory

The R&D projects for surplus plutonium disposition being conducted at PNNL, as shown in Table 7–1, are related to immobilization technologies. These projects occur within Buildings 325, 326 and 3720 where radioactive materials are routinely handled. It is estimated that a small amount of plutonium, between milligrams quantities and 70 grams, would be used for these R&D projects.

### 7.4.7 Savannah River Site

The R&D projects for surplus plutonium disposition being conducted at SRS, as shown in Table 7–1, are related to immobilization technologies. These projects are housed in Building 773-A. The quantities of plutonium and the types of experimental operations being performed fall within the experience of previous R&D programs conducted in Building 773-A. It is estimated that a small amount of plutonium, less than 200 grams, would be used in these R&D projects.

## 8.0 AGENCIES AND PERSONS CONSULTED

No outside agencies or persons were consulted during the preparation of this EA.

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## 10.0 ACRONYMS

| | |
|---|---|
| ALARA | as low as reasonably achievable |
| ARIES | Advanced Recovery and Integrated Extraction System |
| ANL-E | Argonne National Laboratory-East |
| ATR | Advanced Test Reactor |
| CAP88 | EPA dose assessment model |
| CFR | Code of Federal Regulations |
| CMR | Chemistry and Metallurgy Research |
| CPP | Chemical Processing Plant |
| DOE | Department of Energy |
| DWPF | Defense Waste Processing Facility |
| EA | environmental assessment |
| EIS | environmental impact statement |
| EPA | Environmental Protection Agency |
| ESH | Environment, Safety and Health |
| FFCA | Federal Facility Compliance Agreement |
| FONSI | Finding of No Significant Impact |
| FR | Federal Register |
| FY | Fiscal Year |
| GENII | Hanford Environment Dosimetry System, Version 1.485 |
| HEPA | high-efficiency particulate air |
| HEU | highly enriched uranium |
| HYDOX | hydride-oxidation process |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| LANL | Los Alamos National Laboratory |

| | |
|---|---|
| LLNL | Lawrence Livermore National Laboratory |
| LLW | low-level waste |
| MD | Office of Fissile Materials Disposition |
| MEI | maximally exposed individual |
| MLLW | mixed low-level waste |
| MOX | mixed oxide |
| NA | not applicable |
| NEPA | National Environmental Policy Act |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NPDES | National Pollutant Discharge Elimination System |
| NRC | Nuclear Regulatory Commission |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| PEIS | Programmatic Environmental Impact Statement |
| PF | Plutonium Facility |
| PNNL | Pacific Northwest National Laboratory |
| PrHA | Process Hazard Analysis |
| R&D | research and development |
| RCRA | Resource Conservation and Recovery Act |
| REA | regional economic area |
| RFETS | Rocky Flats Environmental Technology Site |
| ROD | Record of Decision |
| ROI | region of influence |
| SPD EIS | Surplus Plutonium Disposition Environmental Impact Statement |
| SRS | Savannah River Site |

| | |
|---|---|
| SST | safe secure trailer |
| TA | Technical Area |
| TIGR | Thermally-Induced Gallium Removal |
| TRA | Test Reactor Area |
| TRU | transuranic |
| TTAF | Test Train Assembly Facility |
| WIPP | Waste Isolation Pilot Plant |
| WM PEIS | Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste |

## 11.0 CHEMICAL AND MEASUREMENT ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| aCi | attocurie (one-quintillionth of a curie) |
| Am | americium |
| Ci | curie |
| g | gram |
| GaO | gallium oxide |
| HYDOX | hydride-oxidation |
| kg | kilogram (one-thousandth of a gram) |
| $m^3$ | cubic meter |
| mCi | millicurie (one-thousandth of a curie) |
| mg | milligram (one-thousandth of a gram) |
| mrem | millirem (one-thousandth of a rem) |
| nCi | nanocurie (one-billionth of a curie) |
| pCi | picocurie (one-trillionth of a curie) |
| Pu | plutonium |
| $PuO_2$ | plutonium dioxide |
| U | uranium |
| $UO_2$ | uranium dioxide |

## 12.0 GLOSSARY

**Alloy:** A homogeneous mixture of two or more metals.

**Ambient Air:** The surrounding atmosphere as it exists around people, plants, and structures.

**Americium:** Americium 241 is produced by the radioactive decay of plutonium 241. In addition to being an alpha-emitter, it is an emitter of gamma rays. Americium 241 has a half-life of 433 years.

**Background Radiation:** Ionizing radiation present in the environment from cosmic rays and natural sources in the earth; background radiation varies considerably with location.

**Binder Materials:** Organic additives used in the ceramic immobilization process to produce a pourable feed that promotes adhesion of the materials when compacted.

**Ceramic:** Non-metallic materials mixed to form a porcelain-like end-product; can include surplus plutonium.

**Characterization:** The determination of waste or residue composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis.

**Cladding:** An external layer of material, in most cases metal, applied directly to nuclear fuel or other material to provide protection from a chemically reactive environment, to provide containment of radioactive products created during the irradiation of the composite, or to provide structural support.

**Crew:** The two individuals in the vehicle.

**Criteria Pollutants:** Six air pollutants for which national ambient air quality standards are established by EPA: sulfur dioxide, nitric oxides, carbon monoxide, ozone, particulate matter less than or equal to 10 microns in diameter, and lead.

**Criticality:** A state in which a self-sustaining nuclear chain reaction is achieved.

**Curie:** A unit of radioactivity equal to 37 billion disintegrations per second; also a quantity of any nuclide or mixture of nuclides having one curie of radioactivity.

**Dose Equivalent:** Dose equivalent is expressed in units of rem or sievert, where 1 rem equals 0.01 sievert. The dose equivalent to an organ, tissue, or the whole body will be that received from the direct exposure plus the 50-year committed dose equivalent received from the radionuclides taken into the body during the year.

**Dosimeter:** A small device or instrument (e.g., film badge or ionization chamber) carried by a radiation worker that measures cumulative radiation dose received during a given period of time.

**Effective Dose Equivalent:** The summation of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health effects risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides, and the effective dose equivalent due to penetrating radiation from sources external to the body.

**Environmental Justice:** The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic strength.

**Feed Materials or Feedstock:** Refined uranium or thorium metal or their pure components in a form suitable for use in nuclear reactor fuel elements or as feed to uranium enrichment facilities.

**Fissile Material:** Any isotope capable of being split by thermal (slow) neutrons; the two primary fissile isotopes are uranium 235 and plutonium 239.

**Gamma Rays:** High-energy, short-wavelength electromagnetic radiation accompanying fission and emitted from the nucleus of an atom.

**Glass:** In this instance a borosilicate material in an amorphous mixture formed by melting silica and boric oxide together with the oxides of other elements, such as sodium; can be used to immobilize surplus plutonium.

**Glovebox:** An airtight box used to work with hazardous materials; vented to a closed filtering system, it includes lead-lined gloves attached inside of the box through which the worker is able to manipulate material and equipment.

**Half-life:** The time in which half the nuclei of a radioactive substance decay; this varies for specific radioisotopes from millionths of a second to billions of years.

**High-Level Waste:** The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation.

**Highly Enriched Uranium:** Uranium enriched in the isotope uranium 235 to 20 percent or above; a level above which uranium is considered fissile.

**Homogeneous Approach:** In terms of immobilization technologies, the approach that directly mixes the plutonium with the radiation barrier (i.e., high-level waste), rather than physically separating the plutonium from the high-level waste as in the can-in-canister approach.

**Infrastructure:** The basic facilities, services, and installations needed to support a plant or site, such as transportation and communication systems.

**In-Pile Testing:** Tests conducted in one of DOE's research reactors where test elements are irradiated to determine how materials respond in a nuclear reaction.

**Isotope:** An atom of an element with a specific atomic number and atomic mass. Isotopes of the same element have the same number of protons (atomic number) but different numbers of neutrons and, therefore, different atomic masses.

**Low-Enriched Uranium:** Low-enriched uranium is enriched in the isotopic content of uranium 235, greater than 0.7 percent but less than 20 percent of the total mass, for use as light water reactor fuel.

**Maximally Exposed Individual:** A hypothetical person who could potentially receive the maximum dose of radiation as a result of normal operations or an accident at the site.

**Mixed Oxide:** A physical blend of uranium oxide and plutonium oxide which can be used to fuel light water reactors.

**Nuclide:** The atomic nucleus and therefore, the number of protons, the number of neutrons, and the energy content.

**Outfall:** The discharge point of a drain, sewer, or pipe as it empties into a body of water.

**Oxide:** A binary compound of an element (such as plutonium) with oxygen.

**Pathways:** The paths or routes by which contaminants are transferred from a source to a receptor.

**Person-rem:** The sum of the individual doses received by a population segment.

**Plutonium:** A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially in a reactor by bombarding uranium with neutrons and can be used in the production of nuclear weapons. Plutonium has 15 isotopes with mass numbers ranging from 232 to 246. Weapons-usable plutonium consists mainly of plutonium 239, which has a radioactive decay half-life of 24,110 years.

**Precursor Materials:** The initial form of the ceramic feed materials used in the ceramic immobilization process.

**Proliferation Resistance Tests:** Tests to ensure that the final glass or ceramic matrix chosen for immobilization will assist in preventing the theft or diversion of excess fissile materials and the return of these materials to a form where they can be used in nuclear weapons.

**Radionuclide:** A radioactive element characterized according to its atomic mass and atomic number which can be man-made or naturally occurring. Radionuclides can have a long life as soil or water pollutants, and potentially mutagenic or carcinogenic effects on the human body.

**Reactor-Grade Plutonium:** Plutonium which contains greater than 19 percent plutonium 240.

**Rem:** Roentgen Equivalent Man (rem) is a unit of dose equivalent. Dose equivalent in rem is numerically equal to absorbed dose in radiation multiplied by a quality factor, distribution factor, and any other necessary modifying factor.

**Risk:** A quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event.

**Risk Assessment:** The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health, the environment, or both by the presence or potential presence and/or use of specific chemical or radiological pollutants.

**Safe Secure Trailer:** A specially designed semi-trailer which is used for the safe, secure transportation of cargoes containing nuclear weapons or special nuclear material.

**Safety Analysis Report:** A facility-specific safety document providing a concise but complete description and safety evaluation of a facility, its design, normal and emergency operations, potential accidents, predicted consequences of such accidents, and the means proposed to prevent such accidents or mitigate their consequences.

**Sinter:** A process whereby ceramic pellets are formed using a combination of heat and pressure. The process does not require the material to be heated to the point of melting the plutonium which may be present.

**Spall:** To break off chips, scales or slabs.

**Stoichiometry:** The methodology and technology by which the quantities of reactants and products in chemical reactions are determined.

**Thermally-Induced Gallium Removal:** A process for removing gallium impurities from plutonium recovered from pits through thermal treatment.

**Tritium:** A radioactive isotope of the element hydrogen with two neutrons and one proton, $^{3}H$; it has a half-life of 12.5 years.

**Uranium:** A heavy, silvery-white metallic element , atomic number 92, with many radioactive isotopes. Uranium 235 is considered a fissile material. Another isotope, uranium 238, is transformed into fissionable plutonium 239 following its capture of a neutron in a nuclear reactor.

**Vitrification:** A treatment process that uses glass (e.g., borosilicate glass) to encapsulate or immobilize radioactive wastes or materials.

**Weapons-Grade Plutonium:** Plutonium which contains less than 7 percent plutonium 240.

**Weapons-Usable Fissile Material:** Plutonium and highly enriched uranium in various forms (e.g., metals and oxides) that can be readily converted for use in nuclear weapons.