Chapter 2
Alternatives for Disposition of Surplus Weapons-Usable Plutonium

2.1 ALTERNATIVES ANALYZED IN THIS SPD EIS

This *Surplus Plutonium Disposition Environmental Impact Statement* (SPD EIS) analyzes the potential environmental impacts associated with implementing the disassembly of pits (a component of nuclear weapons) and conversion of the recovered plutonium and clean plutonium metal at four candidate U.S. Department of Energy (DOE) sites; conversion and immobilization of plutonium from nonpit sources at two candidate DOE sites; and mixed oxide (MOX) fuel fabrication activities at four candidate DOE sites. This SPD EIS also evaluates immobilizing plutonium in ceramic or glass forms, and compares the can-in-canister approach with the homogenous ceramic immobilization and vitrification approaches that were evaluated in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement (Storage and Disposition PEIS)* (DOE 1996a). As part of the MOX option, this SPD EIS also evaluates the potential impacts of fabricating MOX fuel lead assemblies (for test irradiation in domestic, commercial nuclear power reactors) at five candidate DOE sites, subsequent postirradiation examination of the lead assemblies at two candidate DOE sites, and addresses the impacts of irradiating MOX fuel in domestic, commercial reactors. Figure 2–1 is a map of the United States that identifies the proposed locations of the surplus plutonium disposition facilities.

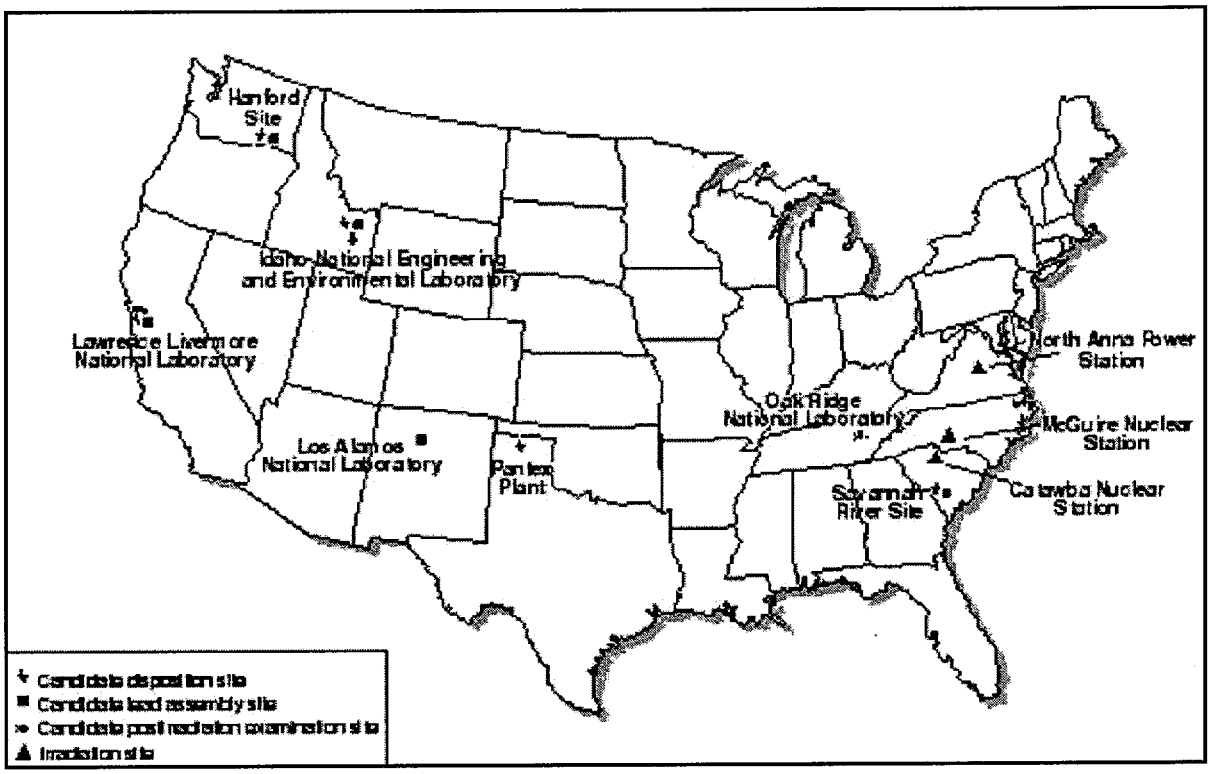


Figure 2–1. Proposed Locations of Surplus Plutonium Disposition Facilities

2.1.1 Surplus Plutonium Disposition Facility Alternatives

The alternatives analyzed in this SPD EIS are based on decisions announced in the Record of Decision (ROD) for the *Storage and Disposition PEIS*, as summarized in Chapter 1. Those decisions include:

- Combining the plutonium conversion and immobilization functions into a single facility,
- Pursuing the siting of a pit disassembly and conversion facility (pit conversion facility), a plutonium conversion and immobilization facility (immobilization facility), and a MOX fuel fabrication facility (MOX facility), and
- Reducing the number of possible disposition sites to be considered from six to four.

Fifteen surplus plutonium disposition alternatives and the No Action Alternative are shown in Table 2–1 and described in detail in Sections 2.5 through 2.16. The 15 action alternatives are organized into 11 sets of alternatives, reflecting various combinations of facilities and candidate sites, as well as the use of new or existing buildings. For example, Alternative 6, which would locate the pit conversion and MOX facilities at the Hanford Site (Hanford), and the immobilization facility at the Savannah River Site (SRS), has two variations, denoted as 6A and 6B. The variations occur because the MOX facility could be in new construction or in the Fuel and Materials Examination Facility (FMEF) at Hanford.

Each of the 15 alternatives includes a pit conversion facility, but additional facilities in each alternative vary depending on the amount of plutonium to be immobilized. Alternatives 2 through 10 involve the hybrid approach of immobilizing 17 t (19 tons) of surplus plutonium and using 33 t (36 tons) for MOX fuel, and therefore, require all three facilities. Alternatives 11 and 12 involve immobilizing all 50 t (55 tons), and therefore, only include a pit conversion facility and an immobilization facility.

Alternative 1, the No Action Alternative, does not involve disposition of surplus weapons-usable plutonium, but instead addresses continued storage of the plutonium in accordance with the *Storage and Disposition PEIS* ROD (DOE 1997a) and amended ROD (DOE 1998a).[1] Figures 2–2, 2–3, 2–4, and 2–5 are regional maps of the four candidate disposition sites: Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), the Pantex Plant (Pantex), and SRS.

2.1.2 Immobilization Technology Alternatives

The *Storage and Disposition PEIS* discusses several immobilization technologies, including the homogenous ceramic and vitrification alternatives that were evaluated in detail, as well as the variants to those alternatives, which included the ceramic and glass can-in-canister approaches and another homogenous approach using an adjunct melter (discussed further in Appendix C of this SPD EIS). The ROD for the *Storage and Disposition PEIS* states that DOE would make a determination on the specific technology on the basis of "the follow-on EIS." This SPD EIS is that follow-on EIS, and identifies the ceramic can-in-canister approach as the preferred immobilization technology.

In order to bound the estimate of potential environmental impacts associated with ceramic and glass immobilization technologies, the *Storage and Disposition PEIS* analyzes the construction and operation of

[1] Should the No Action Alternative be chosen, the ROD pursuant to this SPD EIS would also address the movement of the remaining surplus nonpit plutonium from RFETS in support of its planned closure in 2006.

vitrification and ceramic immobilization facilities that use a homogenous approach. These facilities are based on generic designs that do not involve the use of existing facilities or specific site locations. These generic

Table 2–1. Surplus Plutonium Disposition Facility Alternatives Evaluated in This SPD EIS

Alternative	Pit Disassembly and Conversion	Plutonium Conversion and Immobilization	MOX Fuel Fabrication	Disposition Amounts (Plutonium)
1	No Action			
2	Hanford (FMEF)	Hanford (FMEF and HLWVF)	Hanford (New)	17 t Immobilization/ 33 t MOX
3	SRS (New)	SRS (New and DWPF)	SRS (New)	17 t Immobilization/ 33 t MOX
4A	Pantex (New)	Hanford (FMEF and HLWVF)	Hanford (New)	17 t Immobilization/ 33 t MOX
4B	Pantex (New)	Hanford (FMEF and HLWVF)	Hanford (FMEF)	17 t Immobilization/ 33 t MOX
5	Pantex (New)	SRS (New and DWPF)	SRS (New)	17 t Immobilization/ 33 t MOX
6A	Hanford (FMEF)	SRS (New and DWPF)	Hanford (New)	17 t Immobilization/ 33 t MOX
6B	Hanford (FMEF)	SRS (New and DWPF)	Hanford (FMEF)	17 t Immobilization/ 33 t MOX
7	INEEL (FPF)	SRS (New and DWPF)	INEEL (New)	17 t Immobilization/ 33 t MOX
8	INEEL (FPF)	Hanford (FMEF and HLWVF)	INEEL (New)	17 t Immobilization/ 33 t MOX
9	Pantex (New)	SRS (New and DWPF)	Pantex (New)	17 t Immobilization/ 33 t MOX
10	Pantex (New)	Hanford (FMEF and HLWVF)	Pantex (New)	17 t Immobilization/ 33 t MOX
11A	Hanford (FMEF)	Hanford (FMEF and HLWVF)	NA	50 t Immobilization/ 0 t MOX
11B	Pantex (New)	Hanford (FMEF and HLWVF)	NA	50 t Immobilization/ 0 t MOX
12A	SRS (New)	SRS (New and DWPF)	NA	50 t Immobilization/ 0 t MOX
12B	Pantex (New)	SRS (New and DWPF)	NA	50 t Immobilization/ 0 t MOX
[Text deleted.] Alternatives 3B, 5B, 6C, 6D, 7B, 9B, 12B, and 12D in the SPD Draft EIS have been deleted. Alternative 12C has been renumbered as 12B.[a]				

[a] Section 2.3.2.2 explains the deletion of these alternatives.

Key: DWPF, Defense Waste Processing Facility; FMEF, Fuels and Materials Examination Facility; FPF, Fuel Processing Facility; HLWVF, high-level-waste vitrification facility (planned); NA, not applicable.

designs allow for surplus plutonium to be immobilized in a homogenous form, either within a ceramic matrix and formed into disks, or vitrified as borosilicate glass logs.

In order to support a decision on the immobilization technology and form, this SPD EIS evaluates the potential environmental impacts of the ceramic and glass can-in-canister technologies, and compares those impacts with the impacts of the homogenous facilities evaluated in the *Storage and Disposition PEIS*. This comparison is presented in Section 4.29.

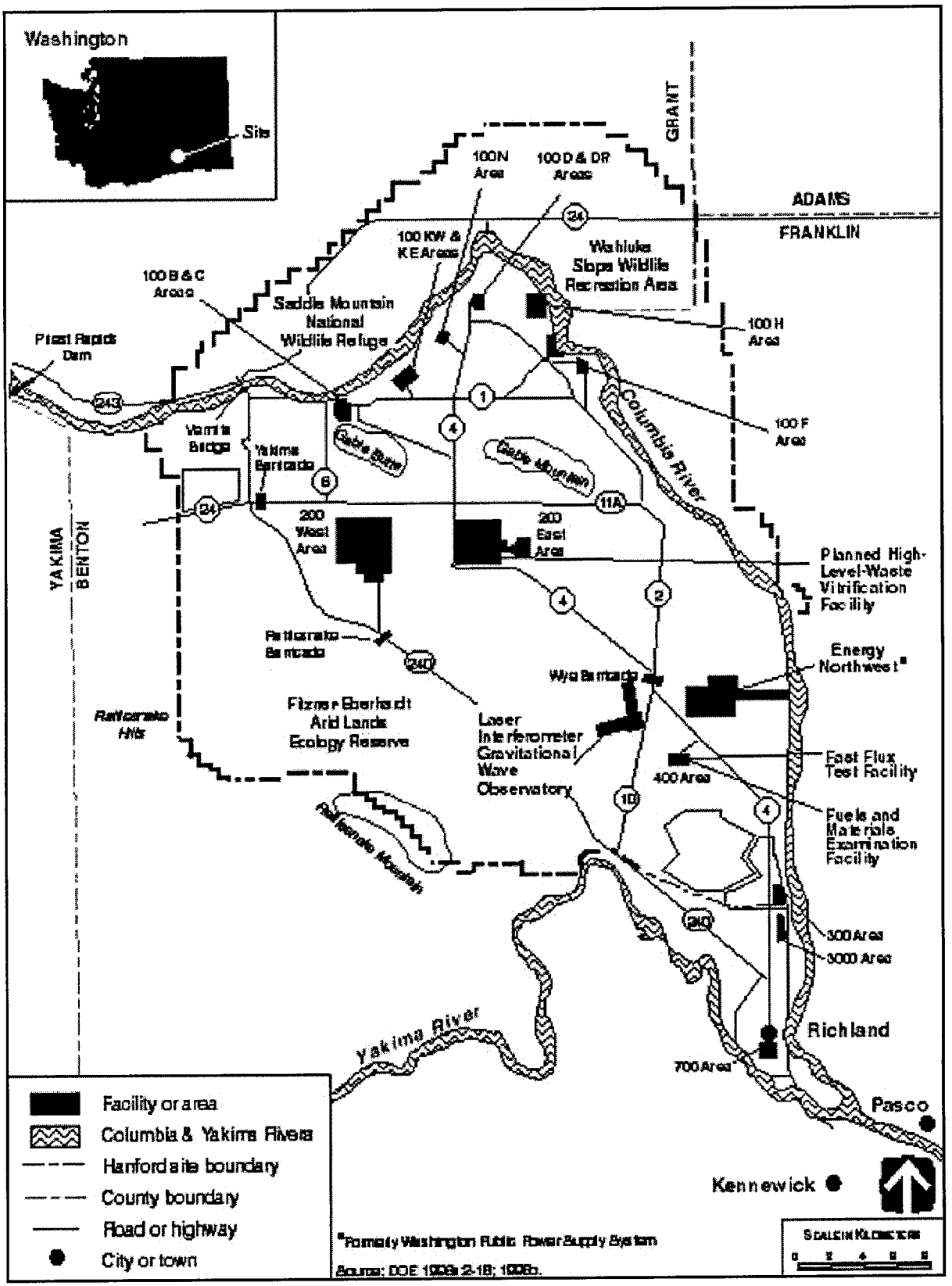


Figure 2–2. Hanford, Washington

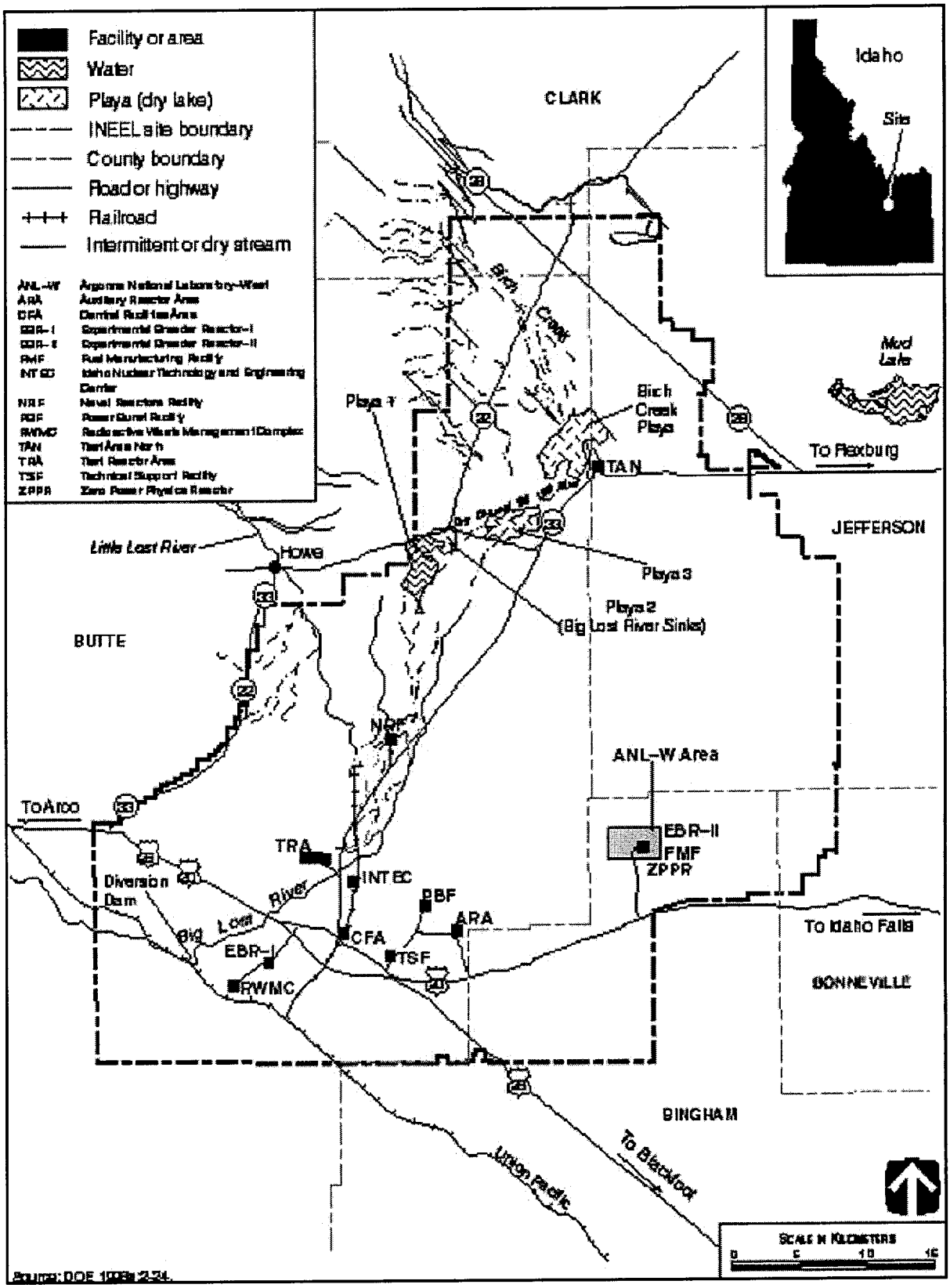


Figure 2–3. INEEL, Idaho

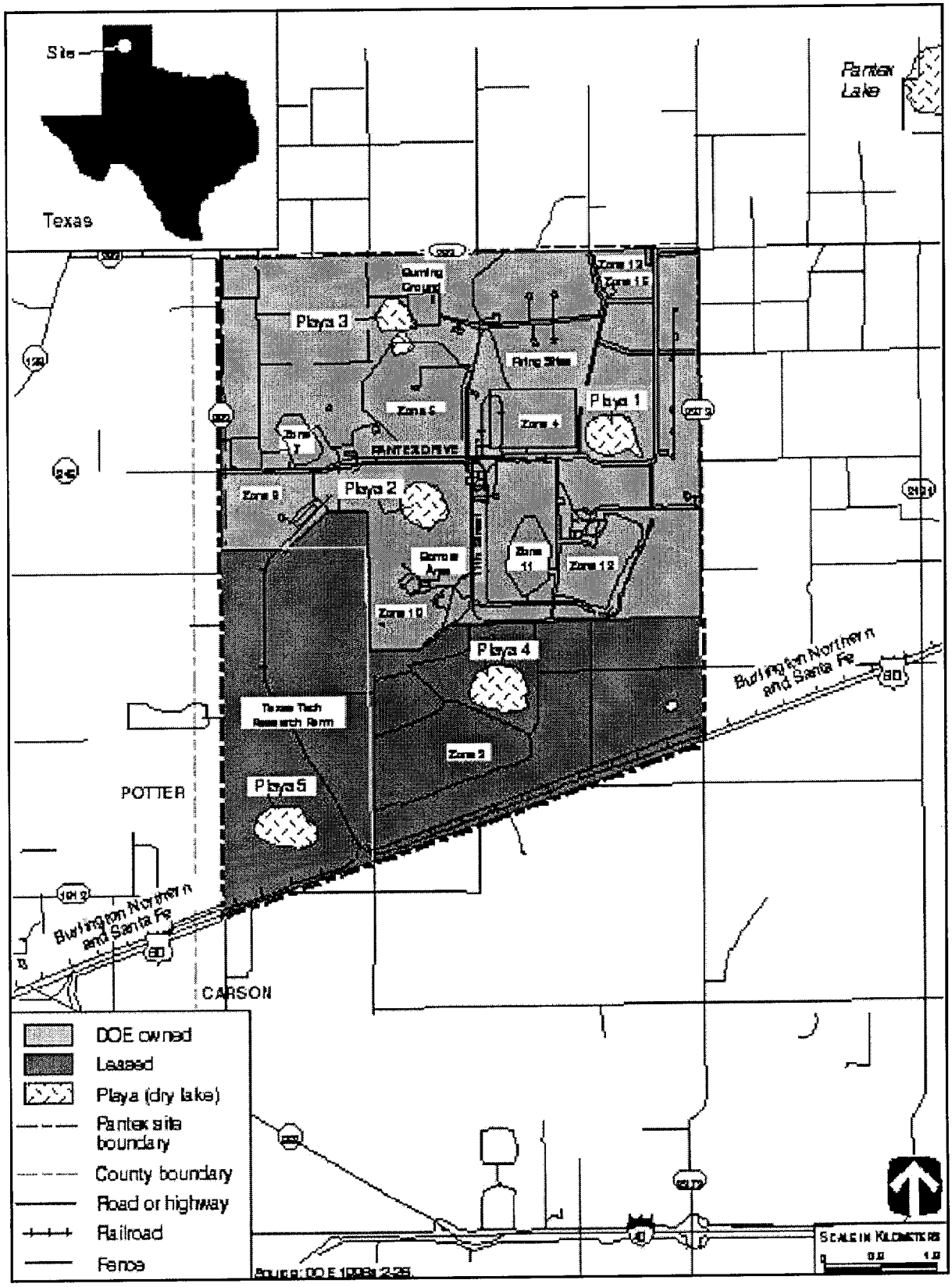


Figure 2–4. Pantex, Texas

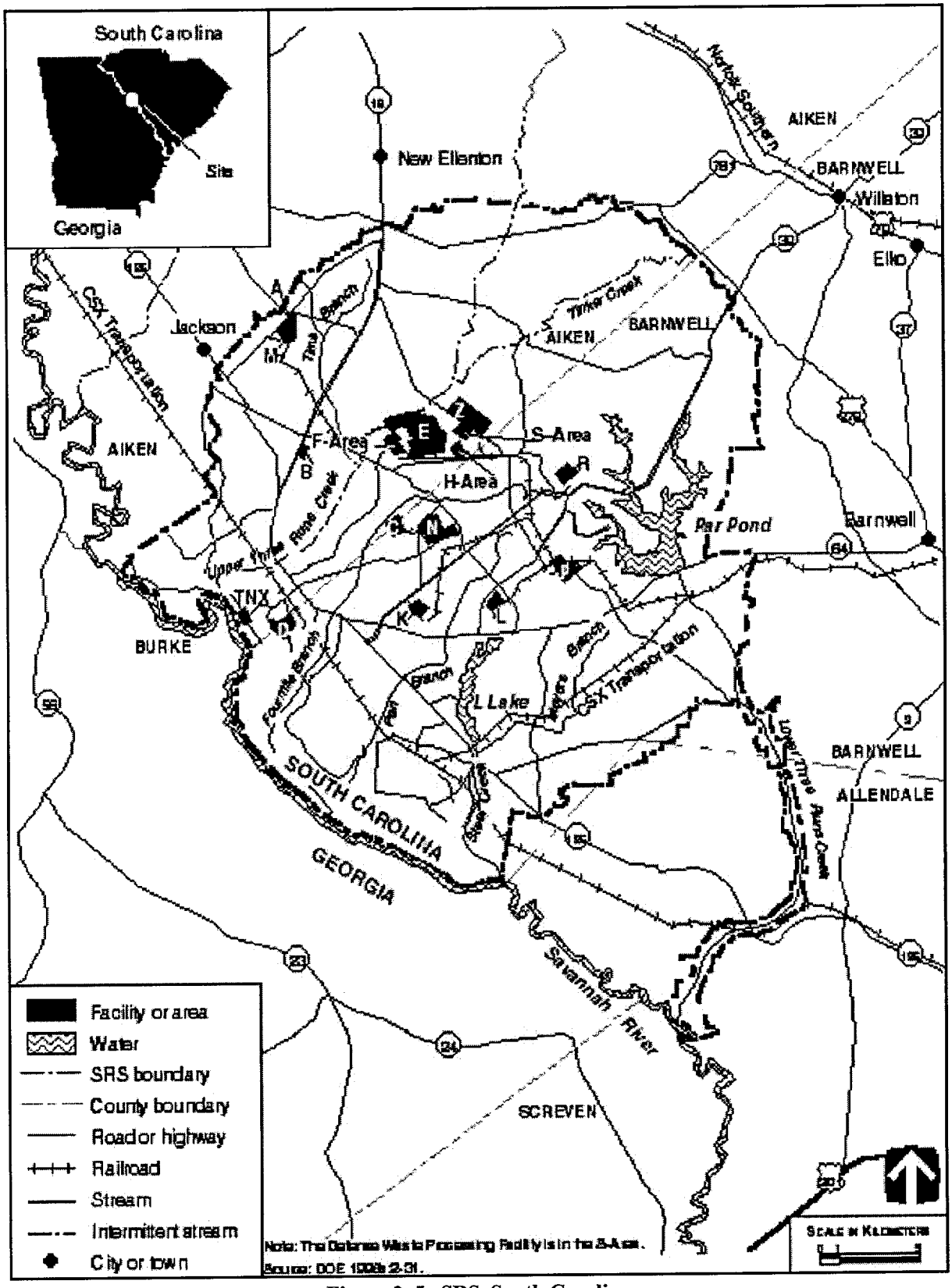


Figure 2–5. SRS, South Carolina

2.1.3 MOX Fuel Fabrication Alternatives

Alternatives that involve the manufacture of MOX fuel include the use of the fuel in existing domestic, commercial reactors. The environmental impacts of using MOX fuel in these reactors are evaluated generically in the *Storage and Disposition PEIS*. When the SPD Draft EIS was published, the specific reactors were not known; therefore, that generic analysis was incorporated by reference in the SPD Draft EIS, summarized in Section 4.28, and included in the discussion of the integrated impacts of the MOX fuel alternatives presented in Section 2.18.3. This was done with the understanding that by the time the SPD Final EIS would be published, the specific reactors would have been identified and reactor-specific analyses would replace the generic analysis.

[Text deleted.] In May 1998, DOE initiated a procurement process to obtain MOX fuel fabrication and irradiation services. The Request for Proposals (RFP) defined limited activities that may be performed prior to issuance of the SPD EIS ROD. These activities include non-site-specific work primarily associated with the development of the initial conceptual design for the fuel fabrication facility; and plans (paper studies) for outreach, long lead-time procurements, regulatory management, facility quality assurance, safeguards, security, fuel qualifications, and deactivation. In compliance with its National Environmental Policy Act (NEPA) regulations at 10 CFR 1021.216, DOE requested that each offeror provide, as part of its proposal, environmental information specific to its proposed MOX facility design and the domestic, commercial reactors proposed to be used for irradiation of the fuel. That information was analyzed by DOE to identify potential environmental impacts of the proposals and documented in an Environmental Critique prepared pursuant to 10 CFR 1021.216(g). That analysis was considered by the selection official as part of the award decision.

DOE awarded a contract to the team of Duke Engineering & Services, COGEMA Inc., and Stone & Webster (DCS) in March 1999 to provide the requested services. These services include design, licensing, construction, operation, and eventual deactivation of the MOX facility as well as irradiation of the MOX fuel in six domestic, commercial reactors at three sites. The reactors proposed by DCS are Duke Power Company's Catawba Nuclear Station, Units 1 and 2; McGuire Nuclear Station, Units 1 and 2; and Virginia Power Company's North Anna Power Station, Units 1 and 2. No facility construction or MOX fuel fabrication or irradiation of MOX fuel is to occur until the SPD EIS ROD is issued. Additionally, no MOX fuel is to be irradiated until NRC amends the operating license of each selected reactor prior to the specific reactor receiving the MOX fuel. Such site-specific activities, and DOE's exercise of contract options to allow those activities, would be contingent on decisions in the ROD.

As provided in 10 CFR 1021.216(h), an Environmental Synopsis (Synopsis), based on the Environmental Critique, was provided to

"216 Process"

DOE's NEPA Implementing Regulations (10 CFR Part 1021) include special provisions to enable a source selection official to consider, as part of the procurement decision, the environmental impacts of the offerors' proposals. As provided in 10 CFR 1021.216, DOE may require that offerors submit environmental data and analyses as a discrete part of the offeror's proposal. DOE will then:

- independently evaluate and verify the submitted information;
- prepare an environmental critique (subject to confidentiality requirements of the procurement process) for offers in the competitive range, addressing environmental issues pertinent to a decision on the proposals; and
- prepare a publicly available environmental synopsis, based on the environmental critique, to document consideration given to environmental factors in the selection process.

After a selection has been made, the environmental synopsis shall be filed with EPA, made publicly available, and incorporated in an EIS prepared for the action.

If the NEPA process is not completed before the award, the contracts shall be made contingent on completion of the NEPA process. DOE shall phase subsequent contract work to allow the NEPA review process to be completed in advance of a go/no-go decision.

the U.S. Environmental Protection Agency (EPA), made available to the public, and incorporated as Appendix P to this SPD EIS. In addition, Section 3.7 was added to describe the affected environment at the three reactor sites, Section 4.28 was revised to include the reactor-specific analyses, and the relevant sections of Chapters 2 and 4 were revised as necessary to incorporate information provided by DCS about the proposed MOX facility, where different from that presented in the SPD Draft EIS. Sections of this SPD EIS that were revised or added to include reactor-specific information, including the new Appendix P presenting the Synopsis, were also distributed as the *Supplement to the SPD Draft EIS.*[2] A Notice of Availability was published in the Federal Register on May 14, 1999 (EPA 1999), providing a 45-day public comment period on the *Supplement.* This *Supplement* was distributed to interested parties in the local communities surrounding the Catawba, McGuire, and North Anna reactor sites; stakeholders who received the SPD Draft EIS; and others as requested. Comments are addressed in Volume III, the Comment Response Document, and, where appropriate, revisions were made to this SPD EIS.

Under the hybrid alternatives, DOE could produce up to 10 MOX fuel assemblies for testing in domestic, commercial reactors before commencement of full-scale MOX fuel irradiation, although it is likely that only 2 lead assemblies would be needed.[3] These lead assemblies would be available for irradiation to support U.S. Nuclear Regulatory Commission (NRC) licensing and fuel qualification efforts. Potential impacts of MOX fuel lead assembly fabrication are analyzed for three of the candidate sites for MOX fuel fabrication (Hanford, Argonne National Laboratory–West [ANL–W] at INEEL, and SRS), and two additional sites, Los Alamos National Laboratory (LANL) in New Mexico, and Lawrence Livermore National Laboratory (LLNL) in California. Pantex was not considered for lead assembly fabrication because it does not currently have any facilities capable of MOX fuel fabrication. Postirradiation examination of the lead assemblies, if required to support NRC licensing activities, would be conducted. Two potential sites for postirradiation examination are discussed in this SPD EIS: ANL–W and Oak Ridge National Laboratory (ORNL). These two sites are currently the only sites that have the capability to conduct postirradiation examination activities without major modifications to facility and processing capabilities; only minor modifications for receipt of materials would be required. Other potential facilities, either within the DOE complex or in the commercial sector, would require significant modifications to meet expected requirements. As discussed in Section 1.6, DOE's preferred locations for lead assembly fabrication and postirradiation examination are LANL and ORNL, respectively.

2.2 MATERIALS ANALYZED IN THIS SPD EIS

As discussed in the following graphic, there are eight general categories used to describe the 50 t (55 tons) of surplus plutonium, which represent the physical and chemical nature of the plutonium. Two of the categories—clean metal (including pits) and clean oxide—could either be fabricated into MOX fuel or immobilized. The remaining six categories of material—impure metals, plutonium alloys, impure oxides, uranium/plutonium oxides, alloy reactor fuel, and oxide reactor fuel—would be immobilized.

[2] On June 15, 1999, DOE held a public hearing in Washington, D.C., to solicit comments on the *Supplement to the SPD Draft EIS.*

[3] The potential impacts of fabricating 10 lead assemblies and irradiating 8 of them were analyzed in this SPD EIS. As discussed in Sections 2.18.2 and 4.27, should fewer lead assemblies than analyzed be fabricated or irradiated, the potential impacts would be lower than those described.

DESCRIPTION OF SURPLUS PLUTONIUM BY DISPOSITION FEED CATEGORIES

PLUTONIUM FEED FOR IMMOBILIZATION OR MOX FUEL FABRICATION:

Clean Metal. Pure plutonium metal generally with less than 100 parts per million (ppm) of any given chemical impurity. The metal may have some oxidation or casting residues on the surface. The only major chemical impurities are gallium and radioactive decay products such as americium, neptunium, or uranium. Examples of pure metal items include unalloyed "buttons" of plutonium metal, billets, ingots, castings or rough machined items, finished machined weapon components such as "pits," and other miscellaneous small metal pieces and parts.

Clean Oxide. Plutonium oxides with less than 3 percent by weight of impurities.

FEED FOR IMMOBILIZATION:

Impure Metal. Items with impurities that are more than 100 ppm, but less than 50 percent by weight.

Plutonium Alloys. Plutonium-containing alloys with impurities that are less than 50 percent by weight. Examples of plutonium alloy items include alloyed plutonium "buttons," casting products, machined product items, and ingots.

Impure Oxide. Plutonium oxides with at least 3 but less than 50 percent by weight of impurities. Examples in this category include plutonium oxides containing uranium oxides and plutonium oxides containing neptunium, thorium, beryllium, or zirconium.

Uranium/Plutonium Oxide. Plutonium oxides mixed with enriched uranium oxides. Examples include powders or pellets that have been either low-fired (heated at temperatures below 700 °C) or high-fired (heated at temperatures greater than 700 °C).

Alloy Reactor Fuel and Oxide Reactor Fuel. Plutonium-containing reactor fuel that has been manufactured, but not irradiated in a reactor. The plutonium consists of 12 to 26 percent of plutonium 240 with total plutonium compositions being 13 to 27 percent of the material in the fuel. The fuel can be either alloy reactor fuel or reactor fuel containing plutonium oxide mixed with uranium oxide. The majority of alloy reactor fuel in DOE's plutonium inventory is fuel elements for the Zero Power Physics Reactor at ANL–W. Oxide fuels include experimental capsules, elements, and pins.

Source: DOE, *Feed Materials Planning Basis for Surplus Weapons-Usable Plutonium Disposition*, MD-0009, 1997.

2.3 DEVELOPMENT OF THE ALTERNATIVES

This section describes the development process for those SPD EIS alternatives and technical issues that remained to be finalized after issuance of the *Storage and Disposition PEIS* ROD.

2.3.1 Development of Facility Siting Alternatives

In the ROD for the *Storage and Disposition PEIS,* DOE identified a large number of possible options to locate three disposition facilities at four sites, and limited the immobilization options to Hanford and SRS. In addition to the four different sites for potential facility locations, the options were further increased by considering the use of either existing or new facilities at the sites, and by considering whether disposition would occur by the hybrid approach (both MOX fuel and immobilization) or only through immobilization. The following equally weighted screening criteria were used to reduce the large number of possible facility and site combinations to the range of reasonable alternatives:

- *Worker and public exposure to radiation.* This criterion was used to exclude the site combinations that involve large amounts of handling, packaging, and repackaging of the surplus plutonium for either intersite or intrasite transportation.

- *Proliferation concerns due to transportation of materials.* Application of this criterion eliminated those options that increased the transfers of the surplus plutonium, usually involving three sites.

- *Infrastructure.* This criterion was used to exclude the site combinations where a single disposition facility was located at a site with no benefit for the program or DOE. For example, collocation of two of the three hybrid case disposition facilities at a site would reduce program infrastructure costs such as

those associated with safeguards and security features, whereas locating each facility at a separate site would not allow such functions to be shared.

Over 64 options were evaluated, yielding a range of 20 reasonable alternatives that met all the criteria. Examples of options that were eliminated include all those options placing three facilities at three different sites. In its Notice of Intent (NOI), DOE proposed to collocate the pit conversion and immobilization facilities for the immobilization-only alternatives. However, during the public scoping process, the comment was made that, under all situations, Pantex should be considered as a candidate site for the pit conversion facility because most of the surplus pits are currently stored there. After confirming that they met all the screening criteria, three additional immobilization-only alternatives, which placed the pit conversion facility at Pantex, were included in the range of reasonable alternatives evaluated in the SPD Draft EIS. The number of reasonable alternatives was reduced to 15 in the *Supplement* when DOE determined, as discussed in Section 2.3.2.2 of this SPD EIS, that Building 221–F at SRS was no longer a reasonable location for the immobilization facility.

[Text and table deleted.]

2.3.2 Alternatives Considered but Eliminated From Detailed Study

Technology alternatives for surplus plutonium disposition that were evaluated in the *Storage and Disposition PEIS*, but were not selected in the ROD and, therefore, are not being considered in this SPD EIS are: (1) deep-borehole direct disposition; (2) deep-borehole immobilized disposition; (3) electrometallurgical treatment; (4) MOX fuel irradiation in a partially completed light water reactor; and (5) MOX fuel irradiation in an evolutionary advanced light water reactor. The reasons why these technologies were not selected are explained in the ROD for the *Storage and Disposition PEIS*.

Alternatives considered for inclusion in this SPD EIS but later eliminated from further analysis fall into four categories: amounts of material to be dispositioned, disposition facility siting, feed preparation methods, and immobilization technologies.

2.3.2.1 Amounts of Material to Be Dispositioned

In the *Storage and Disposition PEIS* ROD, DOE committed to immobilizing at least 8 t (9 tons) of surplus, low-purity, nonpit plutonium. Since the ROD was issued, however, DOE has determined that because of the level of impurities and additional processing that would be required to meet MOX fuel specifications, an additional 9 t (10 tons) of low-plutonium-content materials would be immobilized.

2.3.2.2 Disposition Facility Siting Alternatives

In addition to alternatives eliminated by the screening process described earlier, the following facility options were eliminated from further study. Several commentors at the public scoping meetings suggested that DOE consider locating the proposed surplus plutonium disposition facilities at three separate sites. As discussed in Section 2.3.1, DOE is striving to minimize worker and public exposure to radiation, minimize proliferation concerns associated with transportation, and reduce infrastructure cost. These goals would not be met if DOE were to build one facility at each of three candidate sites.

Locating all three proposed facilities in FMEF at Hanford was listed as Alternative 2 in Table 1 of the NOI for preparation of this SPD EIS (DOE 1997b). After further evaluation of space requirements, DOE concluded that the available space in FMEF would not be sufficient to accommodate the efficient operation and maintenance of all three facilities. Therefore, Alternative 2 was modified to collocate only the pit conversion and immobilization facilities in FMEF, with the MOX facility in new construction adjacent to FMEF.

The *Storage and Disposition PEIS* ROD stated that "to accomplish the plutonium disposition mission, DOE will use, to the extent practical, new as well as modified existing buildings and facilities for portions of the disposition mission." The subsequent NOI for the SPD EIS further stated that "construction of these facilities would be on previously disturbed land and could include the modification of existing facilities where practicable, to reduce local environmental impacts, reduce costs, and shorten schedules." As a result, DOE analyzed immobilization alternatives that included Building 221–F at SRS in the SPD Draft EIS. This building was originally built to house operations to chemically separate plutonium from irradiated targets and will be available to support other missions after these activities have been completed. The availability of Building 221–F coincides with the schedule for the proposed surplus plutonium disposition activities.

However, based on revised space requirements for the immobilization facility, the eight alternatives (3B, 5B, 6C, 6D, 7B, 9B, 12B, and 12D) in the SPD Draft EIS that proposed using a portion of Building 221–F for immobilization activities have, as discussed in the *Supplement*, been removed from consideration. These alternatives are no longer considered reasonable because the amount of new construction required for the proposed immobilization facility is now expected to be nearly the same whether the facility were located entirely in a new building or built in addition to using the available portion of Building 221–F. Deletion of the Building 221–F alternatives does not eliminate SRS from any of the immobilization alternatives under consideration. DOE is still evaluating alternatives that involve construction of a new immobilization facility at SRS.

As described in Section 2.7.2 of the SPD Draft EIS, an immobilization facility using portions of Building 221–F was estimated to require approximately 5,300 m^2 (57,000 ft^2) of space in Building 221–F and an additional 1,400 m^2 (15,000 ft^2) of process space in a new annex for a canister-loading facility, for a total of approximately 6,700 m^2 (72,000 ft^2) of space. As discussed in the *Supplement*, and as shown in Section 2.7.1 of this SPD Final EIS, the immobilization facility is now estimated to require approximately 25,000 m^2 (269,000 ft^2) of space. Because only 5,300 m^2 (57,000 ft^2) of this space could be accommodated in Building 221–F, there is no longer expected to be any advantage associated with the use of Building 221–F in terms of reducing the local environmental impacts, reducing costs, or shortening the construction schedule for this facility.

[Text deleted.]

2.3.2.3 Feed Preparation Methods for Immobilization

The homogenous ceramic immobilization facility evaluated in the *Storage and Disposition PEIS* was based on a wet-feed preparation process. Although the ceramic form of the can-in-canister approach evaluated in this SPD EIS could also use a wet-feed process, it would require larger quantities of water and generate greater amounts of waste than would a dry-feed process. For these reasons, wet-feed preparation processes for the ceramic can-in-canister approach were not considered to be reasonable and were not considered further in this SPD EIS.

2.3.2.4 Immobilization Technology Alternatives

DOE considered locating an adjunct melter adjacent to the Defense Waste Processing Facility (DWPF) at SRS. In the adjunct melter, a mixture of borosilicate glass frit and plutonium would be melted together and added directly to borosilicate glass containing high-level waste (HLW) from DWPF. Subsequent evaluations (UC 1997), however, have indicated that the adjunct melter approach would be less technically viable, would take longer to implement, and would cost twice that of the can-in-canister approach. A description of the vitrification process using the adjunct melter is presented in Appendix C, but this approach is not evaluated as a reasonable alternative.

The technology variants for the new immobilization facilities discussed in the *Storage and Disposition PEIS* considered using either radioactive cesium 137 or HLW as a radiation barrier. However, the *Storage and*

Disposition PEIS further identified that, in the can-in-canister approach, the use of HLW to produce a radiation barrier eliminates the need for introducing cesium 137 (from cesium capsules currently in storage at Hanford) into the immobilization process, which in turn reduces radiation shielding requirements and potential exposures to workers and the public. Therefore, this SPD EIS does not include the use of these cesium 137 capsules in the can-in-canister analyses as a reasonable alternative.

2.4 OVERVIEW OF PROPOSED SURPLUS PLUTONIUM DISPOSITION FACILITIES AND TRANSPORTATION

As discussed previously, three facilities are proposed for surplus plutonium disposition: pit conversion, immobilization, and MOX fuel fabrication. The three disposition facilities are proposed for locations where the plutonium would have the levels of protection and control required by applicable DOE safeguards and security directives.[4] Safeguards and security programs would be integrated programs of physical protection, information security, nuclear material control and accountability, and personnel assurance. Security for the facilities would be implemented commensurate with the usability of the material in a nuclear weapon or improvised nuclear device. Each facility would be located at an existing DOE site that has sitewide security measures in place, including access control. In addition to DOE sitewide security services, each facility would have appropriate security features. Physical barriers; access control systems; detection and alarm systems; procedures, including the two-person rule (which requires at least two people to be present when working with special nuclear materials in the facility); and personnel security measures, including security clearance investigations and access authorization levels, would be used to ensure that special nuclear materials stored and processed inside are adequately protected. Nuclear material control and accountability would be ensured through a system that monitors storage, processing, and transfers. Closed-circuit television, intrusion detection, motion detection, and other automated material monitoring methods would be employed as part of the material control and accountability program. At any time, the total amount of special nuclear material in each facility, or in any material balance area within a specific facility, would be known. Physical inventories, measurements and inspections of material both in process and in storage would be used to verify inventory records. In addition, each of the three facilities would need to provide space and, to varying degrees, access for international inspection.

Descriptions of the proposed surplus plutonium disposition facilities and process operations are provided in this section. The proposed facility layouts are renderings that show representative equipment layouts that demonstrate functional, but not final designs. These designs are subject to modification during the design and construction process, consistent with any construction project, as may be required to optimize equipment placement and process flow. Sections 2.5 through 2.16 describe, individually, each alternative being considered in this SPD EIS. Because the facilities would be implemented differently at each site and for each alternative, those differences are identified and described. Sections 2.4 through 2.16 were developed using data provided by the Regents of the University of California (UC 1998a–i, 1999a–d). MOX alternatives have also been developed using data provided in the *MOX Fuel Fabrication Facility and Nuclear Power Reactor Data Report* (DOE 1999a) and by ORNL (ORNL 1998, 1999).

Each of the three disposition facility layouts includes accommodations for international inspection. However, the implementation process for international inspection of U.S. and Russian surplus plutonium is not fully defined. Rather, that process is part of ongoing negotiations being conducted to reach a bilateral plutonium disposition agreement between the United States and Russia for their disposition programs in accordance with the *Joint Statement of Principles for Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes*. This statement was signed by Presidents Clinton and Yeltsin in September 1998

[4] The physical protection and safeguards and security for the MOX facility would be acceptable to NRC. Physical protection and safeguards and security at the domestic, commercial reactors would meet NRC regulations.

(see Appendix A). The agreement could include provisions for bilateral facility inspections or potential multilateral inspections.

Each of the disposition facilities is proposed to operate for about 10 years. However, the operating life of the facilities may vary somewhat, depending on facility startup experiences and international negotiations regarding the pace of disposition. Also, the MOX facility could operate for as long as 13 years to accommodate the fuel cycles of the reactors in which the MOX fuel would be used. Slightly more or less material could be processed in any given year, potentially extending or shortening the operating period of any of the disposition facilities. Also, for the hybrid approach, it may be necessary, based on feed material quality, to process slightly more material by immobilization than currently envisioned. An analysis of how these adjustments could incrementally affect the potential impacts evaluated in this SPD EIS is provided in Section 4.30.

Because the disposition facilities would operate for about 10 years and would meet stringent safety and natural hazard requirements, they could still be used for other programs or activities. As discussed in Section 4.31, after completion of the surplus plutonium disposition mission, equipment would be removed, decontaminated, and either reused at other DOE facilities or disposed of, and the facilities would be stabilized to a condition suitable for reuse. It is expected that this facility deactivation would take 3 years or less to complete. During this time, DOE would perform engineering evaluations, environmental studies, and further NEPA review to assess the consequences of different courses of action with respect to these facilities.

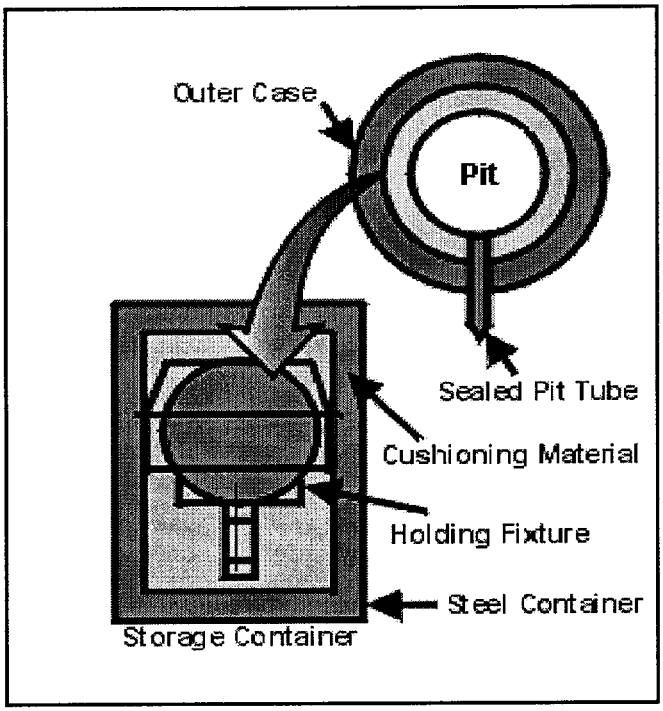


Figure 2–6. Depiction of a Pit

2.4.1 Pit Disassembly and Conversion

Each surplus plutonium disposition action alternative requires a pit conversion facility to produce appropriate plutonium dioxide feed material. That facility would recover plutonium from pits (see Figure 2–6) and process clean plutonium metal (as described in Section 2.2); convert the plutonium to an unclassified (i.e., no longer exhibiting any characteristics that are protected for reasons of national security) oxide; and then transfer the oxide to either the immobilization facility or the MOX facility. This process would include the removal of gallium, beryllium, or other materials that may be considered impurities in plutonium dioxide feed for MOX fuel fabrication. Potential impurities include any of the elements listed in Table 2–2. Given the national security sensitivity of information on pit materials and assembly, pit conversion facility operations

Table 2–2. Potential Impurities in Weapons-Grade Plutonium

Aluminum	Magnesium
Americium	Manganese
Boron	Nickel
Beryllium	Neptunium
Carbon	Silicon
Calcium	Tantalum
Cadmium	Tin
Chromium	Thorium
Copper	Titanium
Gallium	Tungsten
Iron	Uranium
Lead	Zinc

would be classified (i.e., access restricted) through the material-processing steps, and possibly through the final canning stage.

2.4.1.1 Pit Conversion Facility Description

The pit conversion facility would be designed to process up to 3.5 t (3.8 tons) of plutonium metal into plutonium dioxide annually. Facility operations would require a staff of about 400 personnel. The general layout of the pit conversion facility, which approximates how the pit conversion process would be implemented, is presented in Figures 2–7 and 2–8. The specific layout and design of the facility would vary from site to site depending on a number of factors, as discussed in Sections 2.6 through 2.16.

The pit conversion facility would be built in a hardened space of thick-walled concrete that meets all applicable standards for processing special nuclear material. One or possibly both levels of the two-story building would be below grade. Areas of the facility in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with fissile and radioactive materials. Ancillary buildings would be required for support activities.

Activities involving radioactive materials or externally contaminated containers of radioactive materials would be conducted in gloveboxes. The gloveboxes would be interconnected by a contained conveyor system to move materials from one process step to the next. Gloveboxes would remain completely sealed and operate independently, except during material transfer operations. Built-in safety features would limit the temperature and pressure inside the gloveboxes and ensure that operations remained within criticality safety limits. When dictated by process needs or safety concerns, an inert atmosphere would be maintained in gloveboxes. The exhaust from the gloveboxes would be monitored continuously for radioactive contamination. The atmosphere in the gloveboxes would be kept at a lower pressure than that of the surrounding areas so that any leaks of gaseous or suspended particulate matter would be contained and filtered appropriately. The building ventilation system would include high-efficiency particulate air (HEPA) filters and would be designed to maintain confinement, thus precluding the spread of airborne radioactive particulates or hazardous chemicals within the facility or to the outside environment. Both intake and exhaust air would be filtered, and exhaust gases would be monitored for radioactivity.

Beryllium may be a constituent of some of the pits that would be disassembled in the pit conversion facility. Because inhalation of beryllium dust and particles has been proven to cause a chronic and sometimes fatal lung disease, beryllium is of special interest from a health effects perspective. The process operations in the pit

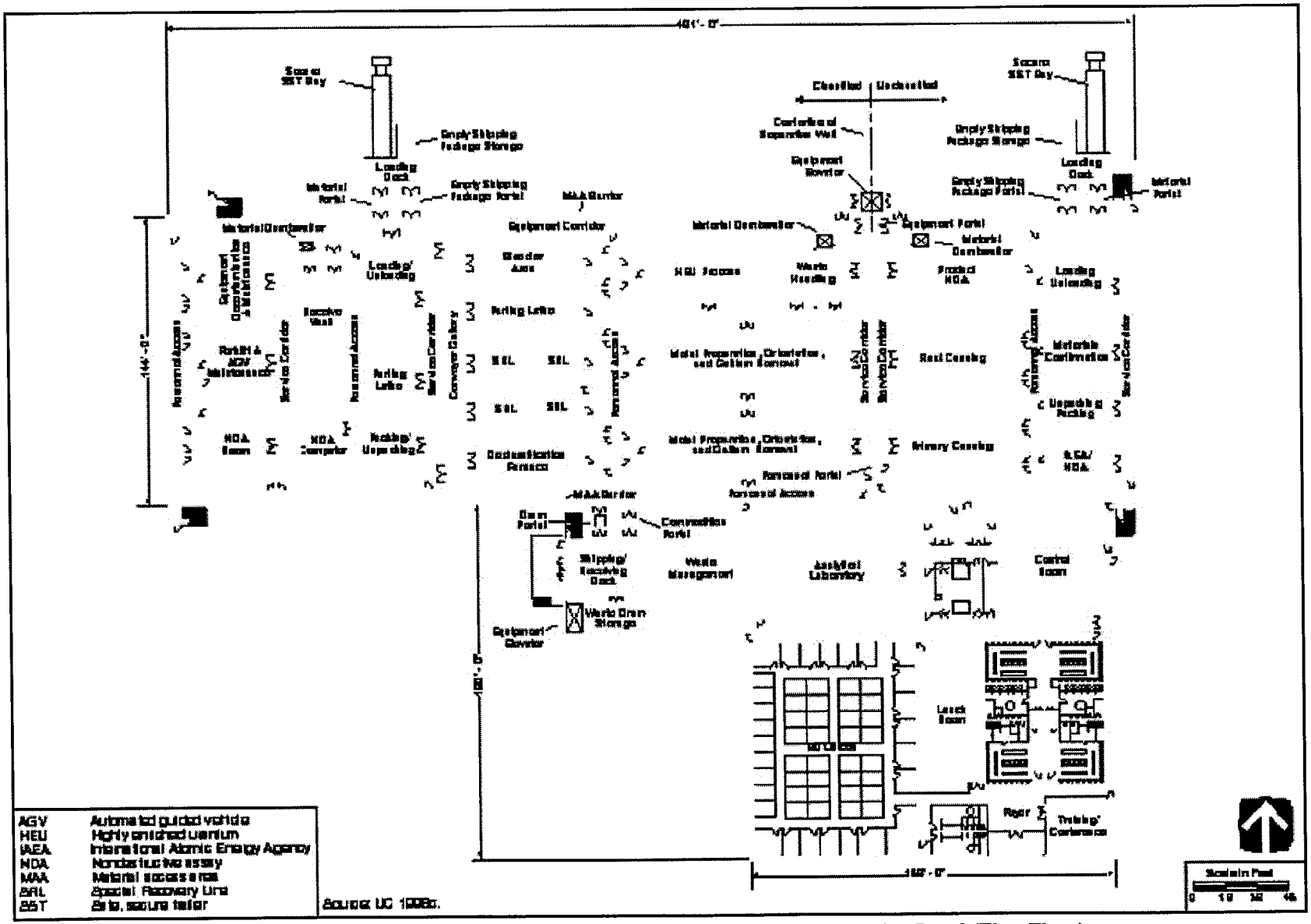
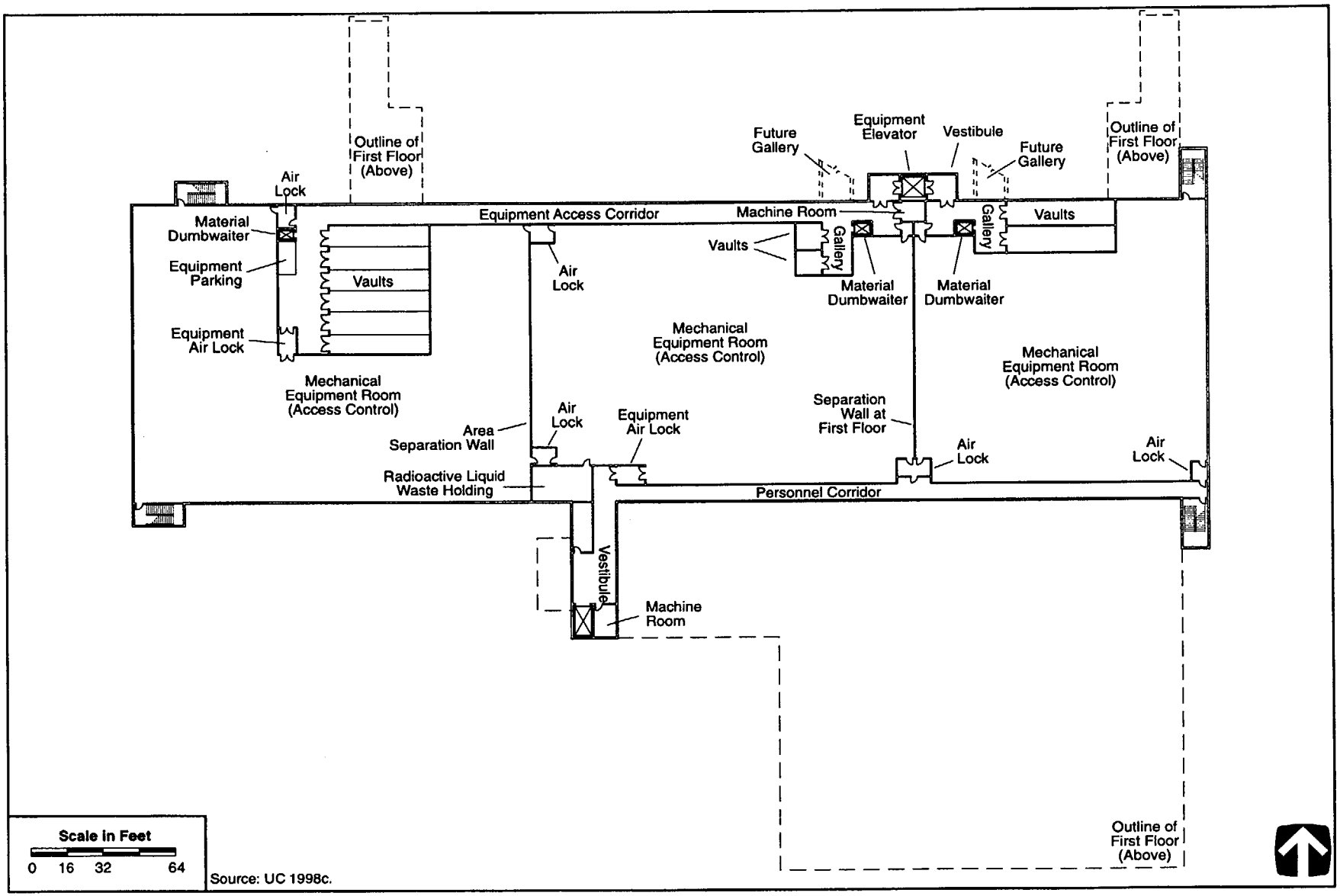


Figure 2–7. General Design of Pit Conversion Facility—Main Processing Level (First Floor)



Source: UC 1998c.

Figure 2–8. General Design of Pit Conversion Facility—Lower (Basement) Level

conversion facility are expected to generate only larger, nonrespirable turnings and pieces of metal, and all work would be performed in gloveboxes. No grinding would be done that could cause small pieces of beryllium to become airborne. The beryllium in solid form would be disposed of as low-level waste (LLW) or transuranic (TRU) waste and has been included in the waste estimates presented in Chapter 4. Therefore, exposure to airborne beryllium is not considered a concern for pit disassembly and conversion operations.

The pit conversion facility would accommodate the following surplus plutonium-processing activities: pit receipt, storage, and preparation; pit disassembly;

[5] Tritium can be used as a boosting fuel in high-energy atomic weapons. Although the operators of the pit conversion facility would know which pits contain tritium, the pit types and the number of surplus pits that contain tritium are classified.

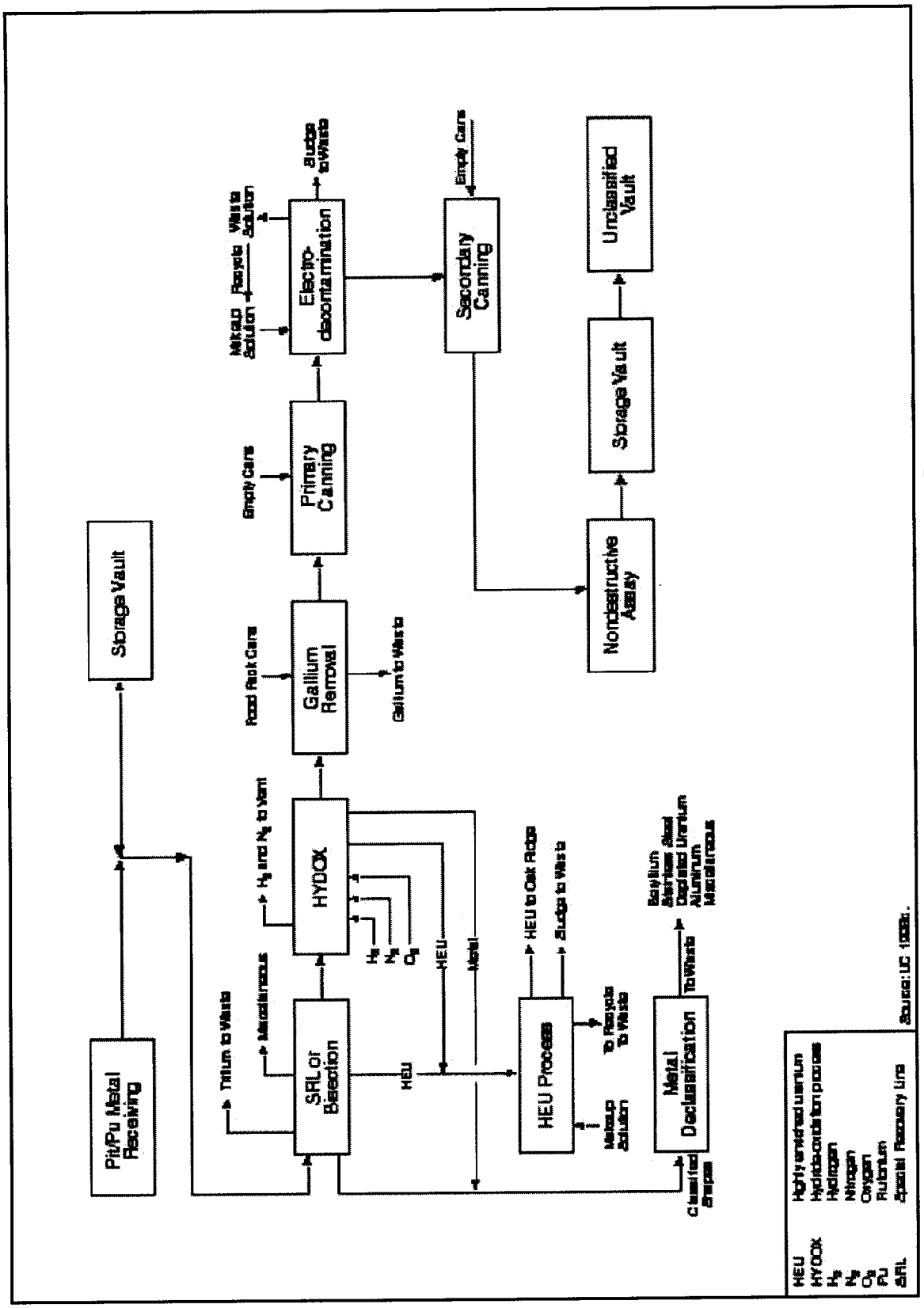


Figure 2–9. Pit Disassembly and Conversion Process

tritium removal process in the Special Recovery Line. It is expected that in a small number of pits, the tritium will have absorbed into the plutonium. For these pits, an additional step would occur in the Special Recovery Line glovebox: the plutonium would be heated in a vacuum furnace to drive off the tritium as a gas. The tritium would then be captured on a catalyst bed and packaged as LLW for treatment and disposal. For purposes of analysis in this SPD EIS, it has been conservatively estimated that 1,100 Ci of tritium would escape to the atmosphere annually through the process building stack. HEU and classified metal shapes would be decontaminated and sent to the HEU-processing station and declassification furnaces, respectively; classified nuclear material parts would be placed in storage at the pit conversion facility. After confirmation that the plutonium metal was free of tritium, the plutonium would be assayed as part of the special nuclear material accountability program and transferred to the HYDOX station. Recovered HEU would be stored in a vault at the pit conversion facility until shipped to the ORR for declassification, storage, and eventual disposition. The HEU would meet the Y–12 acceptance criteria prior to shipment to ORR.

In the HYDOX module, plutonium metal would react with hydrogen, nitrogen, and oxygen at controlled temperatures and pressures in a pressure vessel to produce plutonium dioxide. The plutonium metal would first be reacted with hydrogen gas to form a hydride. Then the vessel would be purged of the hydrogen and the hydride reacted with nitrogen gas to form a nitride. The nitrogen would then be purged and replaced with oxygen for the final reaction forming plutonium dioxide. The plutonium dioxide product would be collected and assayed for the material accountability program to confirm that all the plutonium metal entering the HYDOX process left as an oxide.

Next in this process would be gallium removal. Gallium, a metallic element with a low melting point that is alloyed with plutonium in pits, is considered an impurity in plutonium dioxide feed for MOX fuel fabrication.[6] As currently proposed and analyzed in this SPD EIS, the pit conversion process includes a gallium removal step in which heat would be used in a controlled manner to separate and collect (for disposal as LLW or TRU waste) gallium oxide from plutonium dioxide. Following gallium removal, the plutonium dioxide would be subjected to a series of tests to verify that it met specifications, sealed in a metal can, and sent to the primary canning module.

This gallium removal process was evaluated in the SPD Draft EIS as meeting the needs of the surplus plutonium disposition program. However, as explained in the *Supplement*, based on public comments, and the responses to the procurement discussed in Section 2.1.3 of this SPD Final EIS, the plutonium-polishing process for gallium removal that was evaluated as a contingency in Appendix N of the SPD Draft EIS has been included in the MOX facility evaluated in this SPD Final EIS. Plutonium polishing consists of a small-scale aqueous process to remove gallium (and the other impurities that can affect the use of the plutonium as reactor fuel) to a greater extent than the dry, thermal process proposed for the pit conversion facility. Because the MOX facility would include the plutonium-polishing component, it may not be necessary to subject the plutonium dioxide to the thermal gallium removal step at the pit conversion facility. Both the pit conversion and MOX facilities, however, are being analyzed with their respective gallium (and other impurity) removal processes. Should it be determined that the thermal process is not needed, the impacts of operating the pit conversion facility, in particular, electrical use and waste generation, would be lower than those estimated in this SPD Final EIS.

In the primary canning module, the cans of plutonium dioxide would be placed into a primary storage can made of stainless steel. This can would then be welded shut and leak tested to ensure that the weld was sound. If the can were to fail the leak test, it would be reopened and rewelded. After passing the leak test, the primary can would be sent to the electrolytic decontamination module. After decontamination, each can would be rinsed, dried, and surveyed to verify decontamination, then sent to the secondary canning module.

[6] Gallium removal would not be necessary for material that would be immobilized.

In the secondary canning module, primary cans would be placed into secondary stainless steel storage cans meeting DOE's long-term storage requirements. Also in this module, secondary storage cans would be welded shut and leak tested. After leak testing, each can would be marked with a laser to identify the can and its contents, and passed to the nondestructive assay module. For alternatives where the pit conversion facility would be collocated with the MOX facility (or the immobilization facility for immobilization-only alternatives), and the plutonium dioxide would not need to be transported between sites, use of only a primary can, or another less rigorous primary and secondary can arrangement, may be used.

In the nondestructive assay module, each can would be assayed to confirm its contents. Following assay, the cans would be moved into the main storage vault and would be available for international inspection. After inspection, the cans would be transferred to another vault that would also be subject to international inspection. For the disposition alternatives being studied in this SPD EIS, the storage containers would be transferred to either the immobilization facility or the MOX facility. All offsite shipments would be in DOE SST/SGTs.

2.4.2 Plutonium Conversion and Immobilization

The immobilization facility would perform two operations on the surplus nonpit plutonium materials described in Section 2.2: (1) conversion of miscellaneous surplus plutonium that is not in pit form into plutonium dioxide for immobilization; and (2) immobilization of this plutonium dioxide, and possibly the plutonium dioxide from pits (if it were decided to also immobilize plutonium from pits), in a ceramic or glass form. This material would then be sealed in cans, and these cans would be placed inside canisters that would subsequently be filled with vitrified HLW from either the HLW vitrification facility at Hanford or DWPF at SRS (i.e., the can-in-canister approach). Filled and sealed waste canisters would be placed into storage for ultimate disposition in a potential geologic repository pursuant to the Nuclear Waste Policy Act (NWPA). The immobilization facility would be open to international inspection.

2.4.2.1 Immobilization Facility Description

The immobilization facility would consist of two primary components: a main process building and an HLW vitrification facility. It would be designed to immobilize up to 5 t/yr (5.5 tons/yr) of plutonium metal. This annual throughput would consist of up to 1.7 t (1.9 tons) of surplus nonpit plutonium and up to 3.3 t (3.6 tons) of surplus plutonium derived from pits. Operation of the facility would involve three shifts 7 days per week, and would require a workforce ranging from about 335 to 412 personnel.[7] For 11 of the alternatives considered in this SPD EIS, a total plutonium immobilization throughput of 17 t (19 tons) was assumed. These alternatives involve the hybrid approach of disposition through both immobilization and MOX fuel fabrication. Four alternatives involve disposition only by immobilization, and the facility design for the two candidate sites would accommodate the assumed 50-t (55-ton) throughput of plutonium metal. The lower throughput for the hybrid approach would be reflected in differences in operational employment and resource requirements, but would not affect construction requirements.

The immobilization facility would be at either Hanford or SRS. At Hanford, the immobilization facility would occupy parts of both FMEF and the HLW vitrification facility planned to be constructed to support Hanford's tank waste remediation system. At SRS, immobilization would occur in a new building near the planned Actinide Packaging and Storage Facility (APSF), and at DWPF.

[7] Personnel needed to operate the planned HLW vitrification facility at Hanford, or DWPF at SRS, are not included because these facilities are required regardless of the immobilization alternatives presented in this SPD EIS.

DOE is preparing a supplemental environmental impact statement (SEIS) (DOE/EIS-0082-S2) on the proposed replacement of the In-Tank Precipitation (ITP) process at SRS (64 FR 8558, February 22, 1999). The ITP process was intended to separate soluble high-activity radionuclides (mainly cesium, with trace amounts of strontium, uranium, and plutonium) from liquid HLW before vitrifying this high-activity fraction of the waste in DWPF[8] and disposing of the remaining low-activity fraction as saltstone in vaults at SRS. Initial ITP testing and operation, and subsequent studies, have demonstrated that the ITP process as presently configured cannot meet production goals and safety requirements for processing HLW.

As part of the surplus plutonium disposition program, DOE is proposing to take advantage of its HLW vitrification capabilities by using the high-activity fraction of the HLW as the source of radiation to meet the "Spent Fuel Standard" for immobilized surplus plutonium. As noted in Chapter 1, the "Spent Fuel Standard," as modified by DOE, specifies that surplus plutonium must be roughly as inaccessible and unattractive for weapons use as the much larger and growing stock of plutonium in civilian spent nuclear fuel. Since the early 1980s, a great deal of research and engineering effort has been devoted to the development of technologies to separate the high-activity radionuclides from the other constituents in HLW.

Due to problems experienced with ITP operation, DWPF is currently operating with sludge feed only. A thorough search for alternatives using a disciplined systems engineering approach identified two viable processes (ion exchange and small tank precipitation) for separating the high-activity fraction from HLW and sending this fraction to DWPF. Extensive laboratory and bench-scale testing has been conducted on both of these processes using both simulated and actual HLW. Test results indicate that either process is capable of separating the high-activity radionuclides from HLW at SRS and feeding these high-activity radionuclides to DWPF, although further research and development is necessary. An independent team chartered by DOE's Assistant Secretary for Environmental Management has conducted a review of the alternatives evaluation process and supported the selection of these two processes (DOE 1998c).[9] Designation of a preferred process and construction of a pilot plant for scale-up of the selected process are the next steps planned to resolve this issue. This would mark a transition from proof-of-concept testing to engineering and process scale-up operations. As such, DOE would expect the remaining uncertainties could be resolved through engineering of the process and components rather than development of a new technology.

In addition to small tank precipitation and ion exchange alternatives, the SEIS will also analyze a third action alternative, direct grout, in light of technical and cost considerations. Under the direct grout alternative, the cesium component of the high-activity radionuclides would be entombed in grout (for surface disposal) rather than remaining in the high-activity fraction provided to DWPF for vitrification and eventual disposal in a potential geologic repository. Therefore, the direct grout alternative would not provide the radiation barrier needed to meet the spent fuel standard for surplus plutonium disposition.

A DOE waste management requirement (DOE Manual 435.1, *Radioactive Waste Management*, Section II.B.2) provides that, for direct grout material to be disposed of as now being analyzed, "key radionuclides would have to be removed to the maximum extent that is technically and economically practical." This criterion would not be met in the event that either of the other alternatives is determined to be viable after further evaluation.

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[8] The HLW in the SRS storage tanks is composed of liquid and sludge (high-activity insoluble waste that has settled to the bottom of the tanks) fractions that are treated separately before being vitrified together in DWPF. During the vitrification process, this high-activity sludge is intended for blending in specific ratios with the concentrated high-activity liquid from ITP to form a slurry feed for DWPF.

[9] The National Research Council (the Council) is also evaluating alternatives to the ITP process. The Council's study committee issued an interim report in October 1999 (NC 1999). This committee recommends further research and development for the ion exchange and small tank precipitation alternatives, and for caustic side solvent extraction, a third process that would separate high-activity radionuclides that could be sent to DWPF.

Therefore, DOE regards the direct grout alternative as reasonable only if both the ion exchange and small tank precipitation alternatives analyzed in the SEIS prove not to be viable.

In summary, although the method for providing the HLW needed for the can-in-canister immobilization alternatives for surplus plutonium disposition has not been determined, DOE is confident that the technical solution will be available at SRS by using radioactive cesium either from the ion exchange or small tank precipitation process.

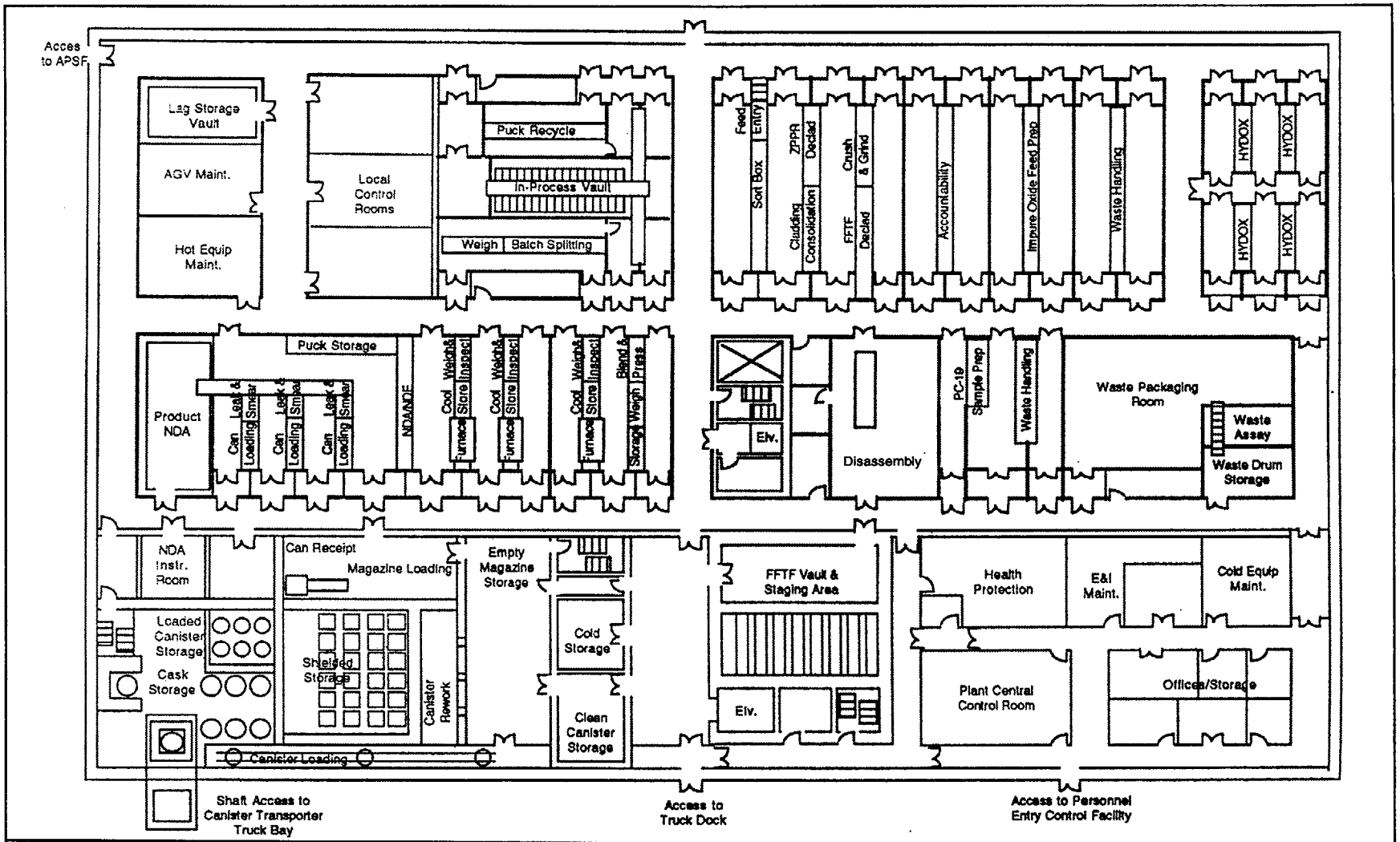
Since the issuance of the SPD Draft EIS, DOE has developed a more detailed conceptual design for the can-in-canister immobilization facility. Some of the design changes include lengthening the process gloveboxes by about 35 percent; doubling the material conveyor length; changing to a vertical ceramification stack that affected the configuration of the second level of the facility; increasing the heating, ventilation, and air-conditioning systems and electrical support to correspond to the increased process space; enlarging the space required for maintenance activities; and increasing the size of the canister-loading area. To accommodate these design modifications, the proposed immobilization facility has approximately doubled in size in terms of floor space.

A general layout for the immobilization facility main process building is depicted in Figures 2–10 and 2–11. This layout approximates how the immobilization process would be implemented. However, the layout and design of the facility would vary depending on whether the facility were proposed as a new building, located in an existing building, or collocated in an existing building with either the pit conversion or MOX facility; and which immobilization process were selected. In addition to the main process building, the planned HLW vitrification facility at Hanford, or the existing DWPF at SRS, would be used in part of the immobilization process. Activities at these facilities would include canister receipt and unloading, canister filling with HLW, decontamination, and closure. The design of the Hanford HLW vitrification facility would be modified as needed before the facility would be constructed. DWPF would have to be modified slightly to accommodate the proposed immobilization activities. Modifications to DWPF would be needed to enable the receipt and storage of canisters containing immobilized plutonium. This would include modifications to security features as well as material handling systems. Minor changes within DWPF material processing or handling areas would be completed remotely. Construction worker exposures resulting from these modifications are expected to be negligible.

The main process building would house the following functions: material receiving, feed material storage, unpacking and sorting operations, fuel decladding, metal-to-oxide conversion, calcination, halide removal, sample preparation and product assay, in-process storage, feed blending and preparation, immobilization of the plutonium using either a ceramic or glass process, can loading, and canister loading. Separate truck bays would be designed to accommodate the DOE SST/SGTs that would be used to transport plutonium feed materials.

The main process building would be a reinforced concrete structure meeting all applicable standards for the processing of special nuclear material. Areas of the building in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with the fissile and radioactive materials. Ancillary buildings would be required for support activities.

Confinement barriers would separate the immobilization facility into zones so as to control the spread of any airborne contamination. The exhaust from process operations would be properly confined, filtered, and monitored prior to release. The facility would have heating, ventilation, and air-conditioning systems and HEPA filters, with provisions for redundant trains of HEPA filters and equipment to facilitate maintenance activities such as filter cleaning while maintaining zone-regulated air flow. An uninterruptible power supply



AGV	Automated Guided Vehicle	HYDOX	Hydride-oxidation process
APSF	Actinide Packaging and Storage Facility	NDA	Nondestructive assay
E&I	Equipment and instrumentation	NDE	Nondestructive examination
FFTF	Fast Flux Test Facility	ZPPR	Zero Power Physics Reactor

Source: UC 1999c.

Figure 2–10. General Design of Immobilization Facility Main Processing Building—Main Level

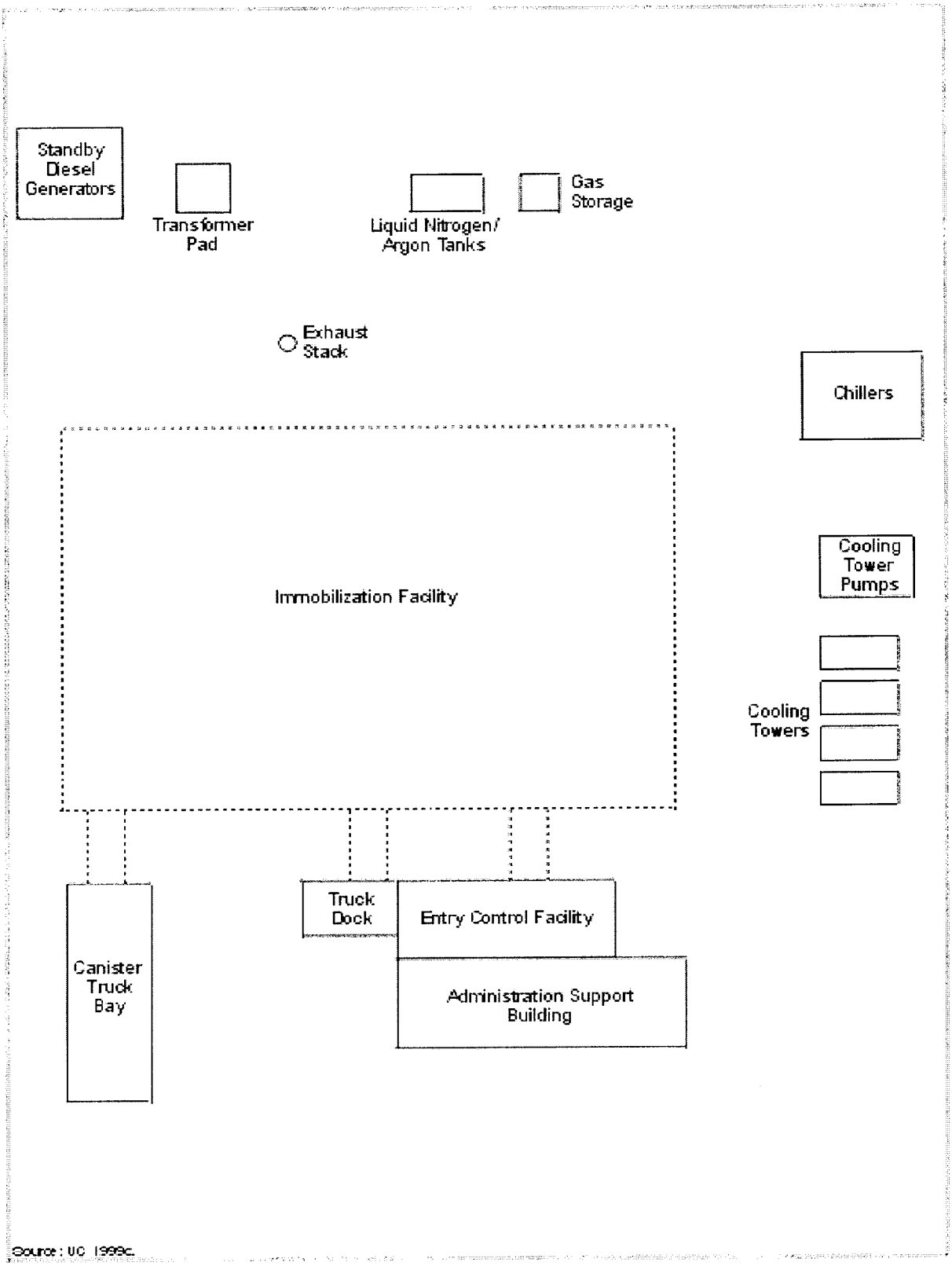


Figure 2–11. General Design of Immobilization Facility Main Processing Building—Above-Grade Structures

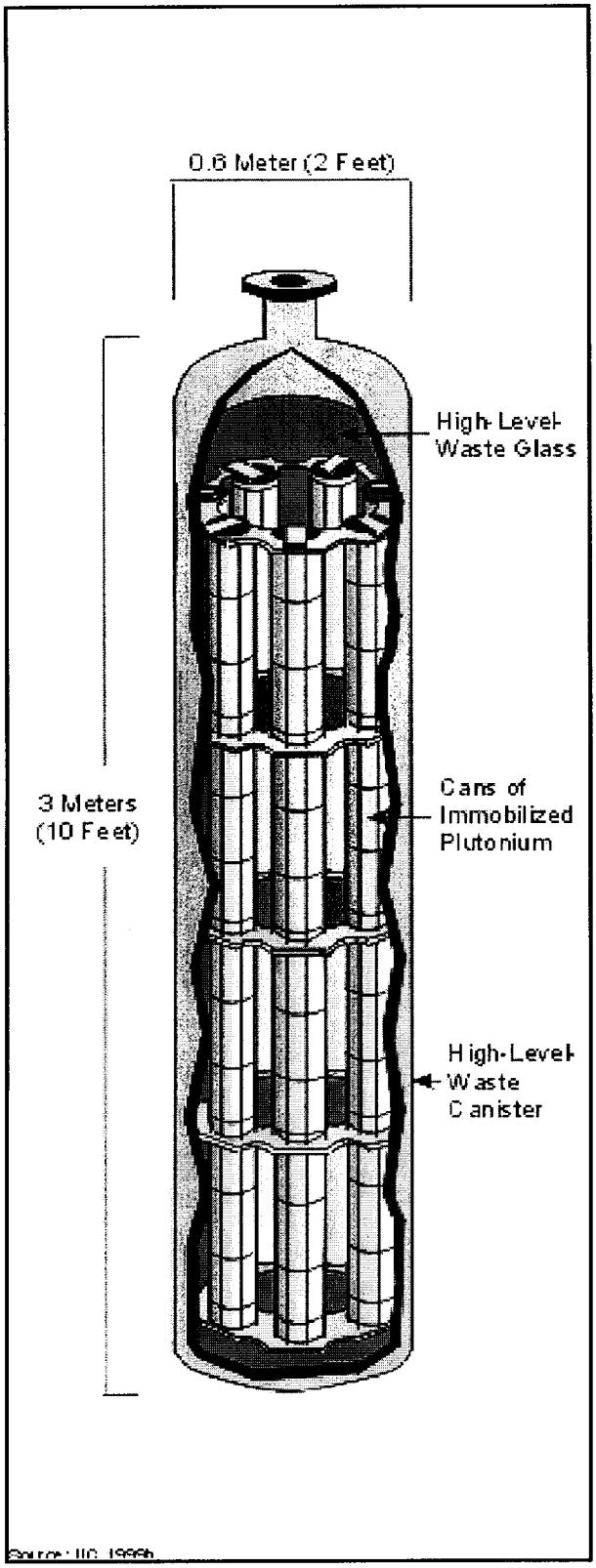


Figure 2–12. Cutaway View of Can-in-Canister Approach

and standby generators would provide backup power for critical systems. This arrangement would ensure that critical systems remain operational during any interruption of offsite power.

2.4.2.2 Plutonium Conversion and Immobilization Process

The plutonium conversion and immobilization process would have the capability to immobilize surplus plutonium material from both pit and nonpit sources. Surplus plutonium derived from pits and already processed by the pit conversion facility would be directly suitable for immobilization, whereas most surplus nonpit plutonium would first have to be converted to a suitable oxide. These oxides would then be incorporated into either a titanate-based ceramic material or a lanthanide borosilicate glass.

The plutonium immobilized in ceramic or glass would be placed inside stainless steel cans, which would be welded shut. The cans would be loaded into an HLW canister (similar to the type currently in use at DWPF at SRS), and filled with HLW to provide a radiation barrier that contributes to the proliferation resistance of the final product. The filled canister, as depicted in Figure 2–12, would then be sealed and stored on the site pending final disposition in a potential geologic repository pursuant to the NWPA. Figure 2–13 provides an overview of the ceramic and glass can-in-canister immobilization processes.

2.4.2.2.1 Plutonium Conversion Process

Plutonium feed materials would be transported in DOE SST/SGTs from the pit conversion facility (if not collocated with the immobilization facility) and the DOE sites storing surplus nonpit plutonium. The shipping containers would be unpacked and the nuclear material assayed at the immobilization facility. Several forms of surplus plutonium materials, all unclassified, would be received by the facility: unirradiated metal reactor fuel in the form of pins and plates clad in stainless steel (from the Zero Power Physics Reactor [ZPPR] at INEEL), unirradiated oxide reactor fuel consisting of fuel pins and bundles (from the Fast Flux Test Facility [FFTF] at Hanford), plutonium alloys, metals, and

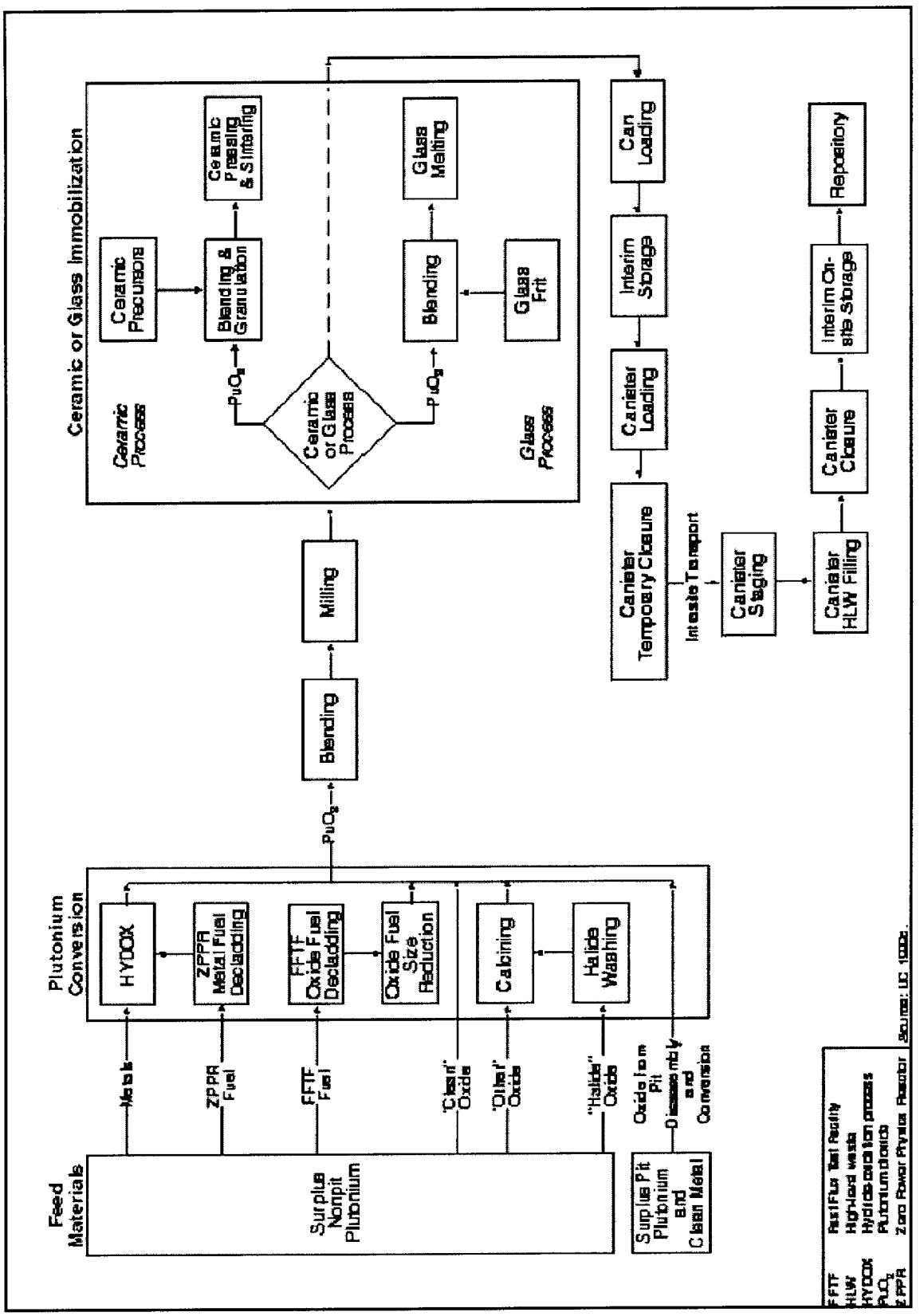


Figure 2–13. Can-in-Canister Process

oxides. Some of these feed materials would also have a uranium component. A feed material storage vault would be available to store up to 6 months of incoming plutonium feed materials. Individual containers would be transferred from the feed material storage vault to a glovebox, unpacked, and inspected to determine the conversion process necessary to render the feed material suitable for immobilization. Metals and alloys would be converted to oxide using the HYDOX process. Metal reactor fuel may require decladding before HYDOX conversion. Oxide reactor fuel would also be decladded, and the individual fuel pellets removed and sorted according to fissile material content. Pellets containing plutonium or enriched uranium would then be ground to an acceptable particle size. Oxides containing moisture or impurities would undergo a calcining process; oxides containing significant concentrations of halide impurities would be "washed" with water to remove the halides before calcining could take place.

Following these conversion processes, the plutonium materials would be stored in the in-process storage vault. Clean oxides—in particular, oxides received from the pit conversion facility, if the decision were made to immobilize all the surplus plutonium—would not require conversion and would be transferred directly to the vault.

2.4.2.2.2 Immobilization Process

Ceramic Process. The ceramic immobilization process would be conducted in a series of glovebox operations that would incorporate the plutonium oxide into ceramic disks, stack the disks inside stainless steel cans, and load the cans into an HLW canister.

In the feed-blending step, plutonium dioxide feed materials would be selected from in-process storage for blending with depleted uranium dioxide. Uranium dioxide would be added to generate a consistent product and reduce criticality concerns, and neutron absorbers (for example, the elements gadolinium or hafnium) would be added to provide criticality safety in the ceramic product. As explained in Section 1.5, uranium dioxide made from depleted uranium hexafluoride in storage at the gaseous diffusion plants previously operated by DOE, such as the Portsmouth Gaseous Diffusion Plant, would be used for this purpose.

After blending, each batch of feed material would be milled to reduce the size of the oxide powder, then blended with ceramic precursors. This mixture would then be granulated with an organic binder to produce a pourable feed that would hold together adequately when compacted into disks. In the press and sinter step, the mixture would be fed into a hydraulic press to form disks, which in turn would be baked in a furnace for reactive sintering to produce the desired mineral phases in the ceramic form. The final product would consist of homogeneous disks about 6.3 cm (2.5 in) in diameter by 2.5 cm (1 in) in height, containing about 10 weight-percent plutonium and 20 weight-percent uranium. These disks would then be stacked and sealed inside stainless steel cans. The cans would be leak tested, assayed, loaded into magazines, and stored in the product vault until removed for canister-filling operations.

As needed, magazines of canned ceramic disks would be removed from storage and inserted and locked into a framework inside an HLW canister. A temporary closure plug would be installed, and following leak testing, the canister would be loaded into a shielded transportation box for intrasite shipment from the main process building to the HLW vitrification facility in a specialized canister transport vehicle.

Glass Process. The glass immobilization process would be conducted in a series of glovebox operations that would incorporate the plutonium oxide into molten lanthanide borosilicate glass, pour it into stainless steel cans, and load the cans into an HLW canister.

In the feed-blending step, plutonium oxide feed materials would be selected from in-process storage for blending to produce individual batches with the desired isotopic composition. Each batch would be milled

to reduce the size of the oxide powder to achieve faster dissolution during the melting process. The milled oxide would then be blended with glass frit (small glass pebbles) containing neutron absorbers (e.g., gadolinium and hafnium) to form a mixture of about 8 weight-percent plutonium and 3 to 8 weight-percent uranium.

This mixture would be fed at a controlled rate into electrically heated melters operating at about 1,500 °C (2,732 °F) to melt the frit and dissolve the plutonium oxide. The homogenous glass melt would be drained into stainless steel cans, which in turn would be sealed, leak tested, assayed, loaded into magazines, and stored in the product vault. As needed, these magazines would be removed from storage and inserted and locked into a framework inside an HLW canister. A temporary closure plug would be installed, and following leak testing, the canister would be loaded into a shielded transportation box for intrasite shipment from the main process building to the HLW vitrification facility in a specialized canister transport vehicle.

Canister Filling. Canister filling, the last major step of the immobilization process, would occur at the HLW vitrification facility. The canisters received from the main process building would be moved individually through an inspection area to the HLW melt cell. In the melt cell, molten, vitrified HLW would be poured into the canister around the stainless steel cans of immobilized plutonium. After removal of any contamination from its outside surface, the canister would be plugged and welded closed. Following inspection and verification that the exterior of the canister was free of contamination, the canister would be transported to an onsite storage vault for interim storage pending final disposition at a potential geologic repository pursuant to the NWPA.

The HLW canisters would measure 0.6 m (2 ft) in diameter by 3 m (10 ft) in height, and, when filled, would weigh up to 2,500 kg (5,500 lb).[10] As each canister of plutonium immobilized in ceramic would contain about 28 kg (61 lb) of plutonium,[11] about 1,820 of these canisters would be required to process all 50 t (55 tons) of surplus plutonium. In the ceramic process, the cans, magazines, and internal framework within each canister would displace approximately 15 percent (by volume) of HLW glass. This would result in 272 canisters more than otherwise planned for the DOE HLW vitrification program. Each canister of plutonium immobilized in glass would contain about 26 kg (58 lb) of plutonium.[11] As such, about 1,900 canisters would be required to vitrify the 50 t (55 tons) of surplus plutonium. Because the cans, magazines, and internal framework used in the glass process would displace approximately 21 percent (by volume) of HLW glass, this would result in 395 canisters more than otherwise planned for the DOE HLW vitrification program. For the hybrid alternatives, about 670 canisters of plutonium immobilized as a ceramic or 690 canisters of vitrified plutonium would be produced. This would result in 101 or 145 additional canisters, depending on whether the immobilized form were ceramic or glass, respectively, than otherwise planned for the DOE HLW vitrification program.

2.4.3 MOX Fuel Fabrication

The MOX facility would produce completed MOX fuel assemblies for use in domestic, commercial reactors. Feed materials would be the plutonium dioxide from the pit conversion facility and uranium dioxide made from either the DOE stockpile of depleted uranium hexafluoride at a representative DOE site (i.e., the Portsmouth Gaseous Diffusion Plant) or another source selected by the fuel fabricator (DCS) and approved

[10] Consistent with the *Storage and Disposition PEIS* and the WM PEIS, the DWPF HLW canister has been used as the reference canister design for the surplus plutonium immobilization program. Although DOE is considering the possibility of using a larger canister for the Hanford HLW vitrification program, the analyses in this SPD EIS also assume that a DWPF-type canister would be used at Hanford.

[11] Plutonium loading in the final design specification and between individual canisters may vary slightly.

by DOE. MOX fuel fabrication involves blending the plutonium dioxide with uranium dioxide; forming the mixed oxide into pellets; loading the pellets into fuel rods; and assembling the fuel rods into fuel assemblies. Once assembled, each of the fuel assemblies would be transported in SST/SGTs to one of the domestic, commercial reactors for use as fuel. Following irradiation, the MOX fuel would be removed from the reactor and managed at the reactor site as spent fuel. Final disposition would be at a potential geologic repository pursuant to the NWPA.

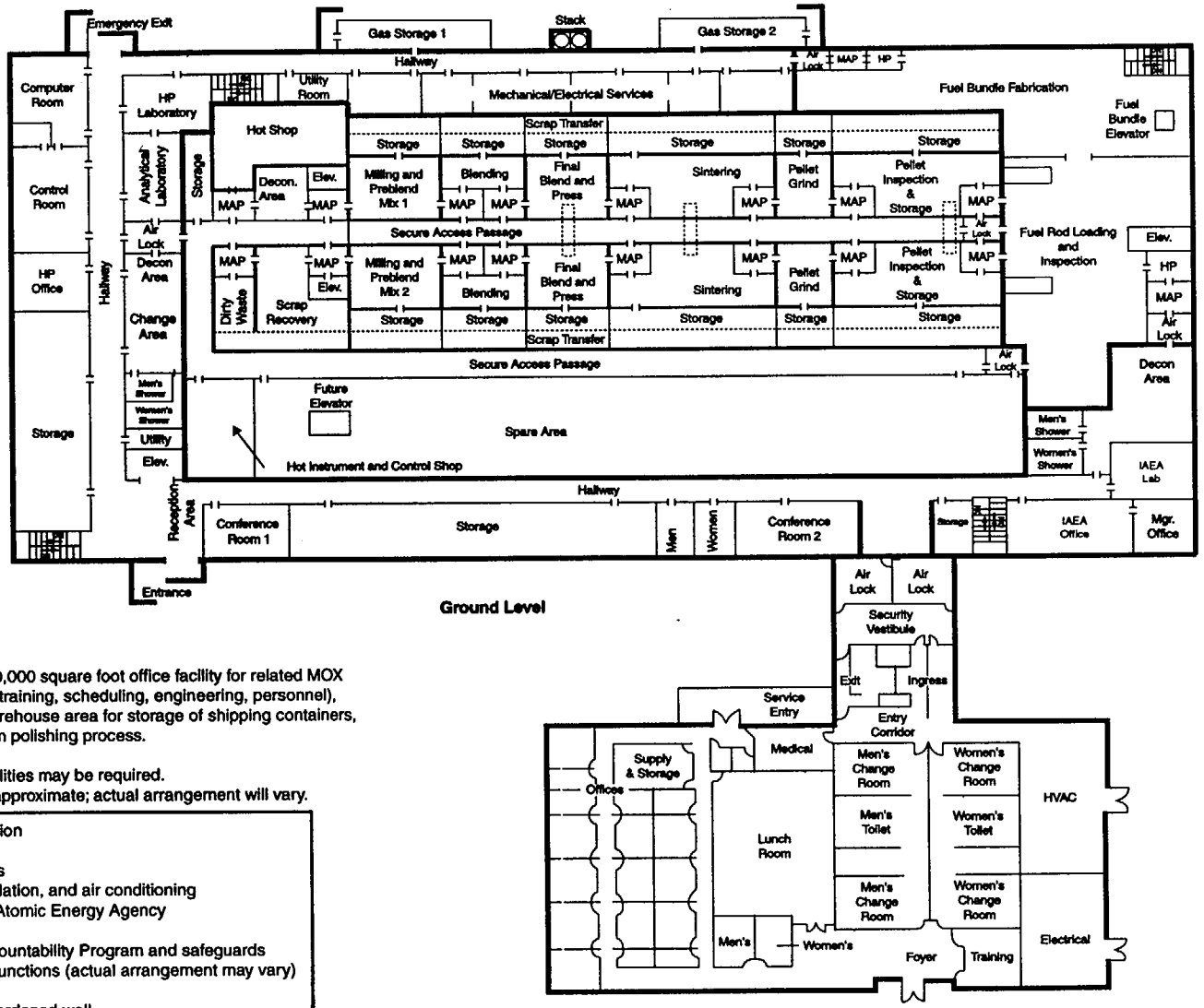
The proposed MOX facility would also include plutonium polishing (a small-scale aqueous process) to remove impurities,[12] in particular gallium, from the plutonium dioxide feed prior to MOX fuel fabrication. This initial plutonium-polishing process would be essentially that described in Appendix N of the SPD Draft EIS, and would add approximately 2,500 m^2 (27,000 ft^2) of process space and about 315 m^2 (3,400 ft^2) of nonhardened space for support functions to the MOX facility. However, the MOX facility layout depicted in Figures 2–14 and 2–15 has not been revised to show this process. This layout approximates how the MOX fuel fabrication process would be implemented. It is a conceptual design that would be updated in subsequent design phases should DOE choose the hybrid approach for surplus plutonium disposition in the ROD. If so, during the design process, the plutonium-polishing component would be integrated into the MOX facility design. The potential impacts of the MOX facility, including plutonium polishing, are evaluated in Chapter 4 and would be the same regardless of where the plutonium-polishing equipment would be located within the MOX facility.

2.4.3.1 MOX Facility Description

The MOX facility would be designed to process up to 3.5 t (3.8 tons) of surplus plutonium (as plutonium dioxide from the pit conversion facility) annually. Facility operations would require a staff of about 385 personnel. The MOX facility has been increased in size from about 11,000 m^2 (120,000 ft^2) in the SPD Draft EIS to about 20,000 m^2 (215,000 ft^2) to include the plutonium-polishing component and additional space proposed by DCS (DOE 1999a). However, about 2,000 m^2 (21,000 ft^2) of administrative space have been relocated from support facilities to the MOX facility, so the net increase in space needed to implement the MOX option is about 7,000 m^2 (75,000 ft^2). As depicted in Figures 2–14 and 2–15, the MOX facility would be a two-story, hardened, reinforced-concrete structure with a below-grade basement and an at-grade first floor. The facility would meet all applicable standards for processing special nuclear material. The walls, floors, and roof of the building would be constructed of about 46 cm (18 in) thick reinforced concrete. Areas of the facility in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with processing fissile and radioactive materials. Ancillary buildings would be required for support activities.

The fuel fabrication areas, two parallel process lines, would be at ground level. To accommodate the potential for fabricating a different type of fuel, the MOX facility would have sufficient unused space for the installation of another production-scale MOX fuel line. An inert atmosphere would be maintained in gloveboxes where dictated by process needs or safety concerns. The exhaust from the gloveboxes would be monitored continuously for radioactive contamination. The atmosphere in the gloveboxes would be kept at a lower pressure than that of the surrounding areas so that any leaks of gaseous or suspended particulate matter would be contained and filtered appropriately. The building ventilation system would include HEPA filters, and would be designed to maintain confinement, thus precluding the spread of airborne radioactive particulates or hazardous chemicals within the facility and to the outside environment. Both intake and exhaust air would be filtered, and exhaust gases would be monitored for radioactivity. Power would be supplied to the MOX facility by two independent offsite power supplies. An uninterruptible power supply and standby generators

[12] Table 2–2 lists the potential impurities.

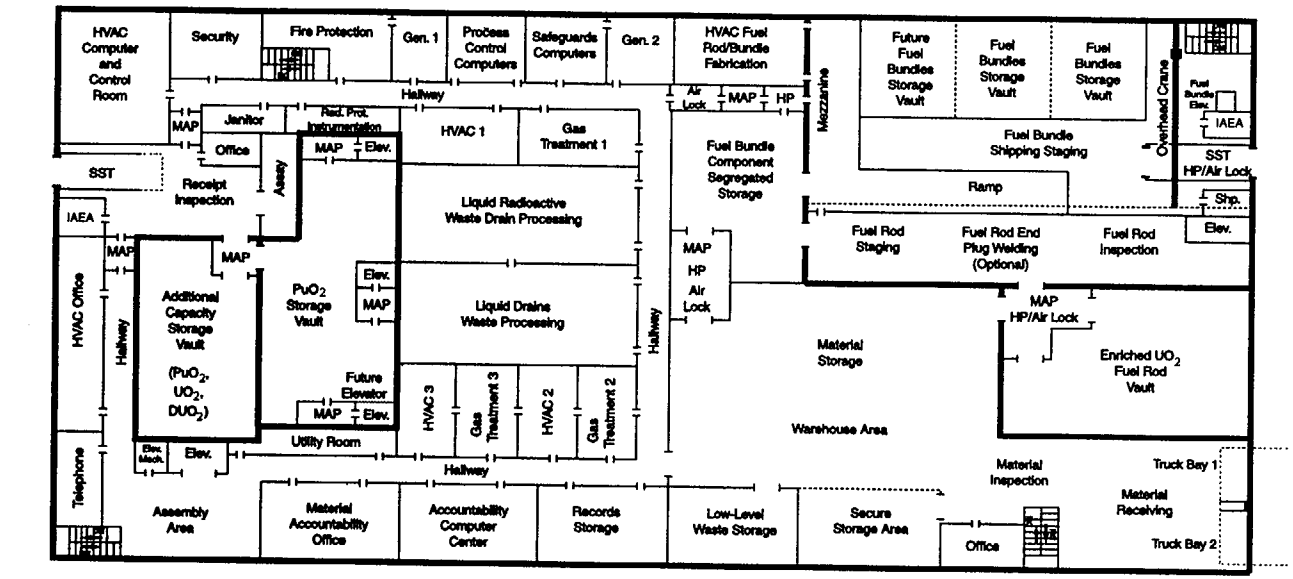


Notes:
1. Not Shown, 10,000–20,000 square foot office facility for related MOX mission support (e.g., training, scheduling, engineering, personnel), 20,000 square foot warehouse area for storage of shipping containers, and layout of plutonium polishing process.
2. Category 1 building.
3. Additional security facilities may be required.
4. Room/area sizes are approximate; actual arrangement will vary.

Decon	Decontamination
Elev	Elevator
HP	Health physics
HVAC	Heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
Lab	Laboratory
MAP	Materials Accountability Program and safeguards and security functions (actual arrangement may vary)
Mgr	Manager's
▬	Structurally hardened wall
—	Shield wall

Source: UC 1998g.

Figure 2–14. General Design of MOX Facility—Ground Level



DUO_2	Depleted uranium dioxide	Mech	Mechanical
Elec	Electrical	Prot	Protection
Elev	Elevator	PuO_2	Plutonium dioxide
Gen	Generator	Rad	Radiation
HP	Health physics	Shp	Shipping
HVAC	Heating, ventilation, and air conditioning	SST	Safe, secure trailer
IAEA	International Atomic Energy Agency	UO_2	Uranium dioxide
MAP	Materials Accountability Program and safeguards and security functions (actual arrangement may vary)	▬	Structurally hardened wall
		—	Shield wall

Source: UC 1998g.

Notes:
1. Not Shown, 10,000–20,000 square foot office facility for related MOX mission support (e.g., training, scheduling, engineering, personnel), 20,000 square foot warehouse area for storage of shipping containers, and layout of plutonium polishing process.
2. Category 1 building.
3. Additional security facilities may be required.
4. Room/area sizes are approximate; actual arrangement will vary.

Figure 2–15. General Design of MOX Facility—Basement Level and Frontal Elevation

would provide backup power for critical systems. This arrangement would ensure continued operation of critical systems during any interruption of offsite power.

The basement level of the MOX facility would contain areas for support activities, including special nuclear material vault areas; general shipping and receiving docks; a general warehouse area; radioactive waste storage; assay facilities; emergency generators; heating, ventilation, and air-conditioning equipment; process gas and waste processing and treatment areas; the fuel rod fabrication area; and the fuel bundle assembly, storage, and shipping areas. Separate truck bays would be designed to accommodate the DOE SST/SGTs that would be used to transport the plutonium dioxide powder and the unirradiated fuel assemblies. Access control, office space, and warehouse facilities have been proposed for areas outside the secure MOX facility building. Facilities to support international or bilateral inspection and oversight activities would also be provided. Existing DOE site security and emergency services and environmental monitoring would support the MOX fuel fabrication mission.

MOX fuel is made from a mixture of plutonium dioxide and uranium dioxide. The uranium dioxide would be received from a commercial, NRC-licensed conversion facility. Conversion services for low-enriched uranium hexafluoride are commercially available in the United States at five facilities. As explained in Sections 2.4.4.2 and 2.4.4.3, for purposes of the analyses in this SPD EIS, the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, was analyzed as the representative facility for the source of depleted uranium hexafluoride to be converted into uranium dioxide.[13] An NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, was used as a representative conversion facility.

2.4.3.2 MOX Fuel Fabrication Process

Figure 2–16 provides an overview of the MOX fuel fabrication process. The vast majority of the MOX fuel matrix, about 95 percent, is uranium dioxide. MOX fuel fabrication is essentially the same process that is used to produce low-enriched uranium fuel for commercial nuclear power reactors, once the plutonium and uranium dioxide powders are blended together into a mixed oxide. Processing of feed materials would begin with the plutonium-polishing process to remove gallium, but the process would also remove other impurities, including americium, aluminum, and fluorides. This process would include three elements: dissolution of the plutonium in nitric acid, removal of impurities by chemical separation (solvent extraction), and conversion of the plutonium back to an oxide powder by precipitation. Acid recovery steps, by which nearly all the nitric acid would be recovered and reused in the process, would also be included.

To begin the process, plutonium dioxide feedstock would be dissolved in near-boiling nitric acid with a silver nitrate catalyst. This solution would then be transferred to the solvent extraction process. Following solvent extraction, the plutonium would be converted from a nitrate solution back to an oxide powder through an oxalate precipitation, filtration, and calcination process. The resulting plutonium dioxide, verified to meet fabrication requirements, would then be transferred into containers for storage until needed, or transferred directly to the MOX fuel fabrication steps.

MOX fuel fabrication would begin with blending and milling the plutonium dioxide powder to ensure general consistency in enrichment and isotopic concentration. The uranium and plutonium powders would be blended and milled together to ensure uniform distribution of the plutonium in the MOX, and to adjust the particle size of the MOX powder. The MOX powder would then be made into pellets by pressing the powder into shape, sintering (baking at high temperature) the formed pellets, and grinding the sintered pellets to the proper

[13] In July 1999, DOE submitted its *Final Plan for the Conversion of Depleted Uranium Hexafluoride* to Congress and is finalizing a request for proposals for, among other depleted uranium hexafluoride management activities, construction and operation of a depleted uranium hexafluoride conversion facility at one or more gaseous diffusion plants.

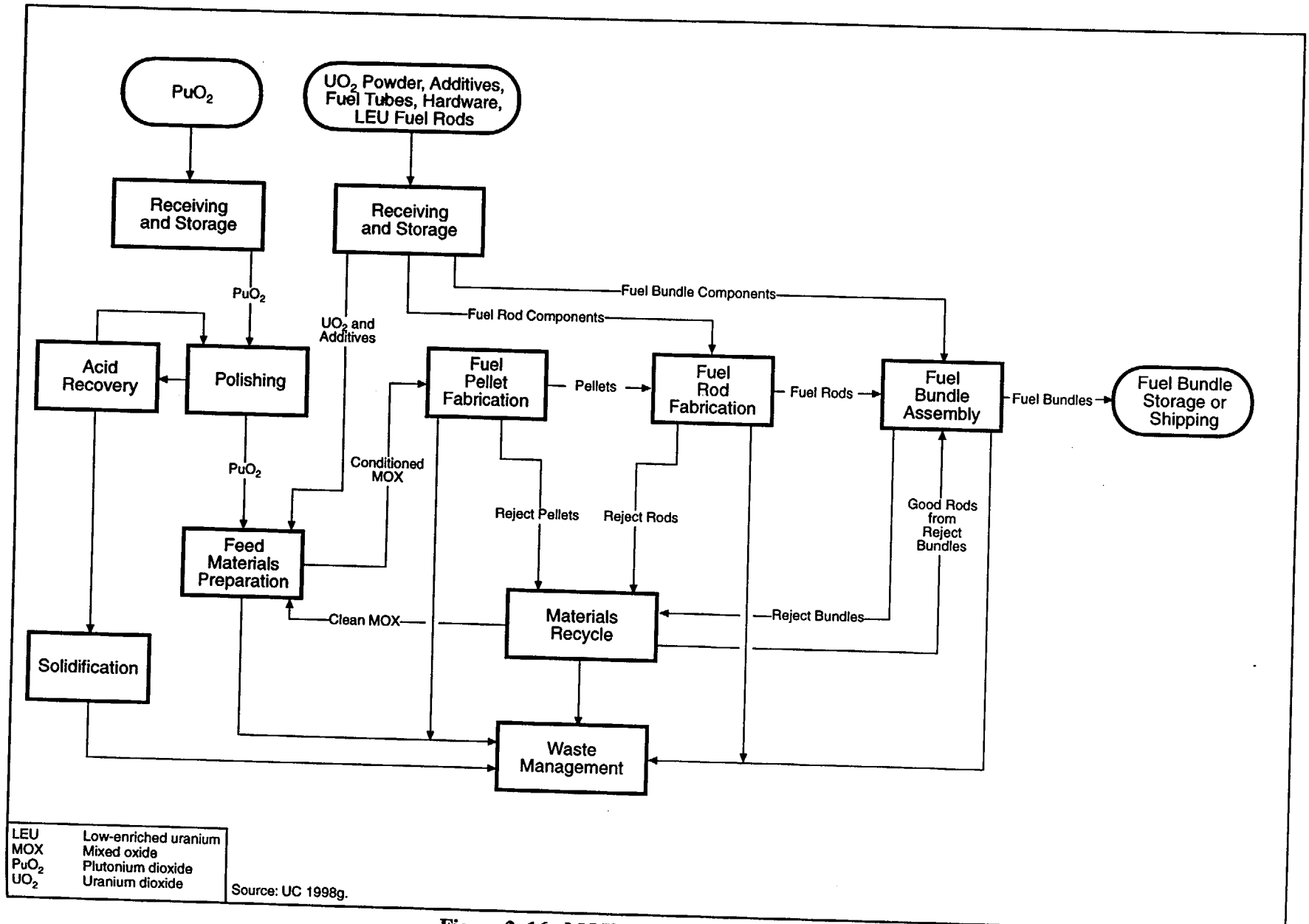


Figure 2–16. MOX Fuel Fabrication Process

dimensions. Materials and pellets would be inspected at each stage, and any rejected materials would be returned to the process for reuse. Most operations would be performed in sealed gloveboxes with inert atmospheres. Sintering furnaces would also be sealed, and offgases would be filtered and monitored prior to release to the atmosphere.

The finished pellets would be moved to the fuel rod fabrication area, where they would be loaded into empty rods. The rods would be sealed, inspected, and decontaminated, then bundled together to form fuel assemblies. Fuel assemblies would consist of only MOX rods or a mixture of MOX and low-enriched uranium rods. Low-enriched uranium rods used in fuel assembly fabrication would be fabricated at another of the fuel fabricator's facilities and brought to the MOX facility for final assembly with the MOX rods. Any rejected fuel bundles would be disassembled, and the materials recycled. Usable rods would be reassembled into new fuel assemblies. Pellets from rods not meeting final product specifications would be crushed and returned to the fabrication process, and decontaminated tubes and hardware would be recycled offsite as scrap metal. Storage for 2 years' production of fuel assemblies would be provided at the MOX facility. Individual fuel assemblies could be stored for that long prior to shipment to the designated domestic, commercial reactor, although production is anticipated to closely follow product need.

The plutonium-polishing process would produce aqueous waste containing the separated impurities (e.g., gallium, americium, aluminum, and fluorides). The liquid wastes from the various impurity removal processes would be transferred to a waste feed tank for evaporation and chemical treatment as required. The evaporator condensate would be treated to produce concentrated acid and acidified water for reuse. The evaporator concentrate would be chemically denitrated, and the offgas from the denitrator scrubbed to produce concentrated nitric acid for reuse. The impurities removed during these processes would be concentrated and solidified for disposal as TRU waste.

Solid wastes generated from process operations would include glovebox gloves, equipment, tools, wipes, and glovebox and HEPA filters. These materials would be removed from the process glovebox lines and transferred to a waste packaging glovebox. Nonprocess materials would be decontaminated to remove residual plutonium. The plutonium would be returned to the dissolution step, and the waste materials would be packaged, assayed, and disposed of as either TRU or LLW, as appropriate.

2.4.4 Transportation Activities

The plutonium disposition alternatives examined in this SPD EIS would require DOE to ship surplus plutonium-bearing materials from their current storage locations, shown in Figure 1–1, to the proposed disposition facility locations for processing. Table 2–3 is an overview of the different types of shipments that would be required for each proposed disposition facility and the vehicles in which the shipments would be made.

The overland transportation of any commodity involves a risk to both the transportation crew and members of the public. The risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of hazardous or radioactive materials poses an additional risk due to the unique nature of the material being transported. Chapter 4 and Appendix L discuss the risks associated with the transportation of these materials and the steps that would be taken to mitigate these risks as they relate to this SPD EIS.

Table 2–3. Facility Transportation Requirements

Required Shipment	Vehicle[a, b]
Pit Conversion Facility	
Intersite shipment of surplus pits and clean metal to the pit conversion facility	SST/SGT
Recovered HEU from the pit conversion facility to ORR	SST/SGT
[Text deleted.]	
Plutonium dioxide to the immobilization or MOX facility	SST/SGT
Immobilization Facility	
Under Alternatives 11B and 12B, plutonium dioxide from the pit conversion facility[c]	SST/SGT
Surplus nonpit plutonium to the immobilization facility[d]	SST/SGT
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a conversion facility (ceramic immobilization option only)[e]	Commercial truck
Uranium dioxide from the conversion facility to the immobilization facility (ceramic immobilization option only)	Commercial truck
Immobilized plutonium from immobilization facility to the HLW vitrification facility (intrasite transport)	Special transport vehicle
Vitrified HLW with immobilized plutonium to a potential geologic repository	Commercial truck
MOX Facility[f]	
Under Alternatives 4 and 5, plutonium dioxide from the pit conversion facility[g]	SST/SGT
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a commercial conversion facility[e]	Commercial truck
Uranium dioxide from the conversion facility to the MOX facility	Commercial truck
Uranium fuel rods from a commercial fuel fabrication facility to the MOX facility[h]	Commercial truck
MOX fuel bundles to selected domestic, commercial reactors	SST/SGT
MOX spent fuel from domestic, commerical reactors to a potential geologic repository[i]	Commercial truck
Lead Assembly Fabrication Facility	
Plutonium dioxide from LANL to a lead assembly facility at a location other than LANL	SST/SGT
For lead assembly fabrication at LANL, intrasite movement of plutonium materials	Special transport vehicle
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a commercial conversion facility[e]	Commercial truck
Uranium dioxide from the conversion facility to the lead assembly facility	Commercial truck
Uranium fuel rods from a commercial fuel fabrication facility to the lead assembly facility	Commercial truck
MOX fuel bundles to the selected domestic, commercial reactor	SST/SGT
Irradiated lead assemblies or rods from the reactor to an examination site	Commerical truck
Spent fuel from an examination site to INEEL for storage[j]	Commercial truck
Spent fuel from INEEL to a potential geologic repository[i]	Commercial truck

[a] All containers and vehicles will meet Department of Transportation requirements.
[b] Commercial trucks will be driven by drivers certified to meet all radioactive materials transportation requirements.
[c] Under Alternatives 11A and 12A, the two facilities would be collocated; therefore, the transfer of the plutonium dioxide would not require any over-the-road transportation.
[d] For cases where the surplus nonpit plutonium requires offsite transportation.
[e] DOE is considering building one or more facilities at the gaseous diffusion plant(s) to convert depleted uranium hexafluoride to an oxide form.
[f] Some equipment for the MOX facility may be manufactured in Europe and shipped to the United States. No nuclear or radiologically contaminated materials would be transported. Any such shipments would be made by commercial vessel, and no impacts other than those occurring from routine commercial shipping would be expected.
[g] Under Alternatives 2, 3, 6A, 6B, 7, 8, 9, and 10, the two facilities would be collocated; therefore, the transfer of the plutonium dioxide would not require any over-the-road transportation.
[h] For cases where the fuel assemblies are a combination of MOX and low-enriched uranium fuel rods.
[i] Shipments of spent fuel are analyzed in the *Draft EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.*
[j] Shipments of spent fuel within the DOE complex are analyzed in the *DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final EIS.*

Key: HEU, highly enriched uranium; HLW, high-level waste; LANL, Los Alamos National Laboratory; ORR, Oak Ridge Reservation; SST/SGT, safe, secure trailer/SafeGuards Transport.

2.4.4.1 Pit Conversion Transportation Requirements

To implement any of the disposition alternatives being considered in this SPD EIS, clean plutonium metal and surplus pits would need to be shipped from current storage locations around the DOE complex to the proposed location of the pit conversion facility. Due to the attractiveness of these materials for use in constructing nuclear weapons, all intersite shipments would be made in DOE SST/SGTs.[14] In the alternatives that include locating the pit conversion facility at Pantex, where surplus pits are stored, the transfer of the surplus pits from onsite storage to the pit conversion facility would be made in specially designed transport vehicles that are routinely used to transport pits around the site. This would reduce the number of intersite trips and the distance that would have to be traveled to transport pits to the pit conversion facility. Also, as discussed in Appendix L, the dose associated with transferring the pits from storage to the pit conversion facility at Pantex could be reduced because the pits would be transferred from current storage locations to the pit conversion facility without being repackaged into the shipping containers that would be required for intersite transport.

After conversion, the plutonium from the pit conversion facility would be in the form of plutonium dioxide. For most of the alternatives, this material would be transferred from the pit conversion facility to either the immobilization or MOX facility through a secure underground tunnel. In Alternatives 6B and 11A, where the pit conversion facility is collocated in the same building with another disposition facility, the plutonium dioxide would be transferred within the building. However, several alternatives (4A, 4B, 5, 11B, and 12B) locate the pit conversion facility at Pantex and immobilization and/or MOX facilities at another site. The reason for including these alternatives is that the vast majority of the surplus pits are stored at Pantex. Less intersite transportation would be required to move these pits to the pit conversion facility, and the doses associated with repackaging pits into shipping containers at Pantex would be avoided. Under these alternatives, the plutonium dioxide from the pit conversion facility would be shipped in SST/SGTs to the other proposed disposition facilities.

HEU recovered during the pit disassembly process would be shipped via SST/SGT to ORR for declassification, storage, and eventual disposition.[15] The HEU would be decontaminated at the pit conversion facility, and would meet Y–12 acceptance criteria prior to shipment.

2.4.4.2 Immobilization Transportation Requirements

Figure 2–17 shows the transportation requirements for the proposed immobilization disposition activities. Surplus nonpit plutonium in various forms would be moved from current storage locations (i.e., Hanford, INEEL, LLNL, LANL, the Rocky Flats Environmental Technology Site [RFETS], and SRS) to the proposed immobilization facility location, either Hanford or SRS. The quantity of plutonium contained in these materials dictates that they be subjected to the same safeguards and security requirements as materials that could be used in nuclear weapons. Therefore, intersite shipments would be made in SST/SGTs.

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[14] The SST/SGT is a specially designed component of an 18-wheel tractor-trailer vehicle. Although the details of the vehicle enhancements are classified, key characteristics are not, and include: enhanced structural supports and a highly reliable tie-down system to protect cargo from impact; heightened thermal resistance to protect the cargo in case of fire; deterrents to protect the unauthorized removal of cargo; couriers who are armed federal officers and receive rigorous training and are closely monitored through DOE's Personnel Assurance Program; an armored tractor to protect the crew from attack and advanced communications equipment; specially designed escort vehicles containing advance communications and additional couriers; 24-hr-a-day real-time monitoring of the location and status of the vehicle; and significantly more stringent maintenance standards.

[15] Shipments would be in accordance with 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). Storage would be in accordance with the ROD for the *Storage and Disposition PEIS*; disposition would be in accordance with the ROD for the *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (61 FR 40619, August 5, 1996).

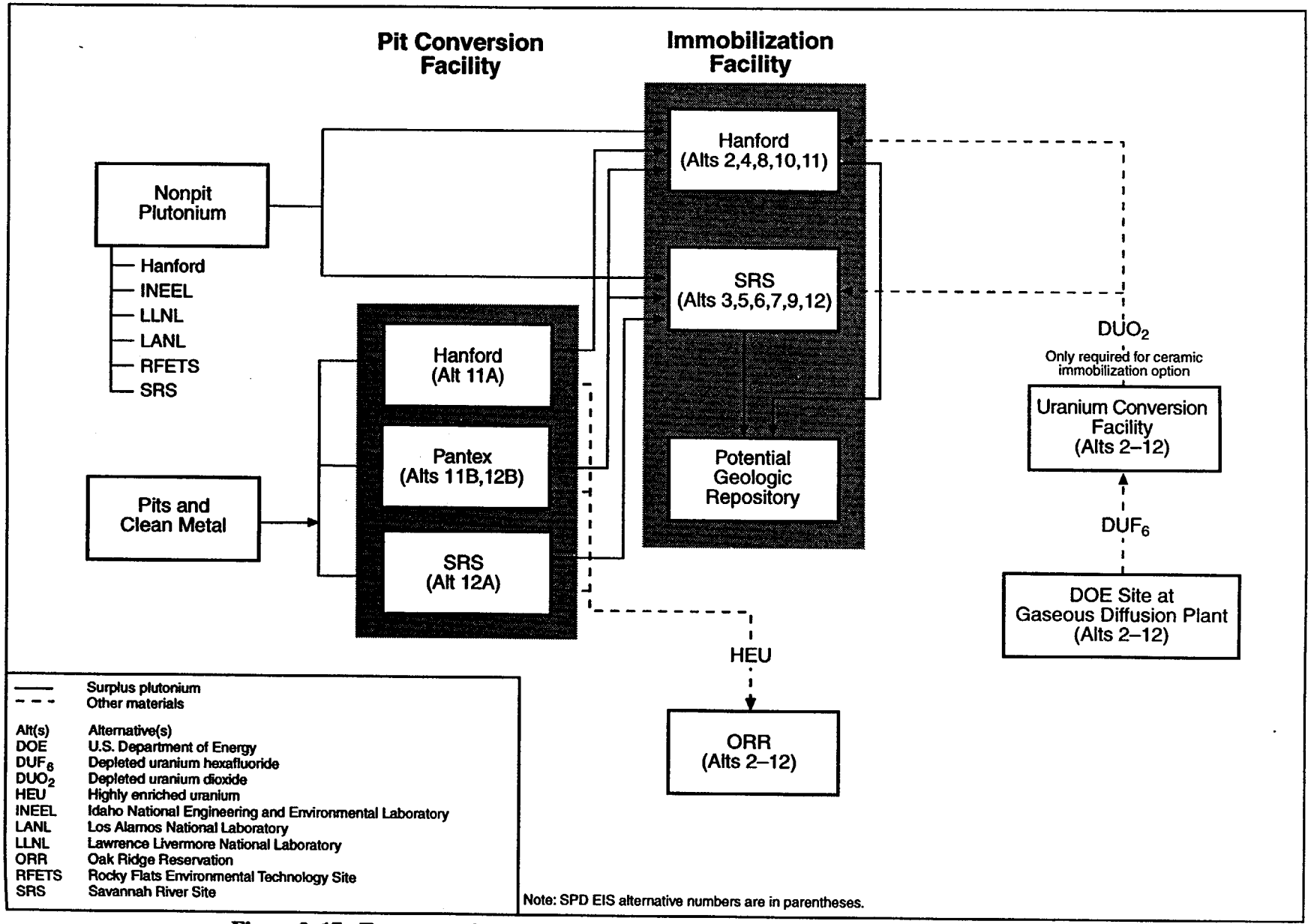

Figure 2–17. Transportation Requirements for Plutonium Conversion and Immobilization

For Alternatives 11 and 12, where all the surplus plutonium would be immobilized, the plutonium dioxide from the pit conversion facility would also be transferred to the immobilization facility. For Alternative 11A, both facilities would be collocated in FMEF and the transfer would take place within the same building. For Alternative 12A, the transfer would be made between the two facilities at SRS through a secure underground tunnel and would not require any vehicular transportation. [Text deleted.] However, as discussed in Section 2.4.4.1, for Alternatives 11B and 12B, the plutonium dioxide would be shipped from the pit conversion facility at Pantex to the immobilization facility at either Hanford or SRS in SST/SGTs.

Surplus plutonium destined for immobilization would be immobilized in either a ceramic or glass form, placed in small stainless steel cans and then into HLW canisters at the immobilization facility. The canisters would then be transported in specially designed intrasite transport vehicles to an HLW vitrification facility (either DWPF at SRS, or the planned HLW vitrification facility at Hanford). In keeping with the current practice at these sites for this type of shipment, this intrasite transportation could require roads at Hanford or SRS to be closed temporarily while the material would be transported from one area of the site to another. This practice would provide all needed security measures and mitigate potential risk to the public, without requiring the use of SST/SGTs for intrasite transfers.

Immobilization alternatives at Hanford could involve the transfer of plutonium between FMEF and the immobilization annex. This transfer would occur either through an underground tunnel or by surface vehicle within the protected security zone.

Immobilization of the plutonium as a ceramic material also requires a small amount of depleted uranium dioxide (i.e., less than 10 t/yr [11 tons/yr]) as discussed in Section 2.4.2.2.2. This depleted uranium dioxide could be produced by shipping depleted uranium hexafluoride from one of DOE's storage areas at a gaseous diffusion plant in Kentucky, Ohio, or Tennessee via commercial truck to a commercial site for conversion to depleted uranium dioxide. Possible sites for this conversion include nuclear fuel fabrication facilities in Missouri, North Carolina, South Carolina, or Washington, or a uranium conversion facility in Illinois. After conversion at one of these sites, the uranium dioxide would be shipped on a commercial truck to either Hanford or SRS for use in the immobilization facility. Because the risks associated with transporting either depleted uranium hexafluoride or depleted uranium dioxide are extremely low, the shipments could be made to or from any of the locations discussed above and not significantly affect the overall risks associated with the transportation required in this SPD EIS. For the purposes of quantifying the transportation analysis in this SPD EIS, it was assumed that the depleted uranium hexafluoride would be shipped from the DOE facility at the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, to an NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, for conversion.

After the immobilized plutonium would be encased by HLW at the HLW vitrification facility, it would eventually be shipped to a potential geologic repository for ultimate disposal. Because the cans of immobilized plutonium would displace some of the HLW that would otherwise fill the canister, additional canisters would have to be filled over the life of the immobilization program to address this displaced HLW. It is estimated that up to 395 additional canisters of HLW would result from the decision to immobilize all 50 t (55 tons) of surplus plutonium. The *Draft Environmental Impact Statement for* a *Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (*Yucca Mountain Draft EIS*), (DOE 1999b) analyzed a number of different options for the shipment of these canisters using either trucks or trains. The analysis in the *Yucca Mountain Draft EIS* indicated that the risks would be lower if the canisters were shipped by train. However, no ROD has been issued regarding these shipments. To bound the risks, this SPD EIS has taken the most conservative analytical approach (i.e., the approach that results in the highest risk to the public) and assumed that all of these shipments would be made by truck to the potential geologic repository, with one canister being loaded on each truck.

2.4.4.3 MOX Transportation Requirements

To implement the MOX disposition alternatives being considered in this SPD EIS, plutonium dioxide from the pit conversion facility would have to be transferred to the MOX facility. Under all the MOX alternatives except Alternatives 4A, 4B, and 5, the pit conversion and MOX facilities would be located at the same site. Figure 2–18 shows the transportation requirements for the proposed MOX disposition activities. ForAlternative 6B, the transfer would take place within the same building (FMEF). Under Alternatives 2, 3, 6A, 7 , 8, 9, and 10, current designs assume that facility materials would be transferred between the two facilities through a secure, underground tunnel. No vehicular transportation over public roads would be required for any of these alternatives. However, as discussed in Section 2.4.4.1, for Alternatives 4A, 4B, and 5, the plutonium dioxide would be shipped in SST/SGTs from the pit conversion facility at Pantex to the MOX facility at either Hanford or SRS.

MOX fuel fabrication also requires uranium dioxide. Depleted uranium dioxide could be produced by shipping depleted uranium hexafluoride from one of DOE's storage areas at a gaseous diffusion plant in Kentucky, Ohio, or Tennessee via commercial truck to a commercial site for conversion to depleted uranium dioxide. Possible sites for this conversion include nuclear fuel fabrication facilities in Missouri, North Carolina, South Carolina, or Washington, or a uranium conversion facility in Illinois. After conversion at one of these sites, the uranium dioxide would be shipped on a commercial truck to Hanford, INEEL, Pantex, or SRS for use in the MOX facility. Because the radiological risks associated with transporting either depleted uranium hexafluoride or depleted uranium dioxide are extremely low, the shipments could be made from or to any of the locations discussed above and not significantly change the overall risks associated with the transportation required in this SPD EIS. For the purposes of quantifying the transportation analysis in this SPD EIS, representative sites for obtaining the depleted uranium dioxide were chosen. The Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, represents the source of the depleted uranium hexafluoride and an NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, represents the conversion facility.

After conversion, the depleted uranium dioxide would be shipped on a commercial truck from the conversion facility to the MOX facility. After fabrication, the MOX fuel would be shipped to Catawba, McGuire, or North Anna where it would be inserted into the reactor and irradiated. These shipments would be made in SST/SGTs because unirradiated MOX fuel in large enough quantities is subject to security concerns similar to those associated with weapons-grade plutonium. [Text deleted.]

It is also possible that some equipment for the MOX facility may be manufactured in Europe and shipped to the United States. No nuclear or radiologically contaminated materials would be transported. Any such shipments would be made by commercial vessel, and no impacts other than those occurring from routine commercial shipping would be expected.

2.4.4.4 Lead Assembly and Postirradiation Examination Transportation Requirements

To implement the MOX disposition alternatives being considered in this SPD EIS, MOX fuel assemblies would be fabricated, irradiated, and tested before the actual production of MOX fuel. Figure 2–19 shows the transportation requirements for the proposed lead assembly activities. As described in Section 2.17, plutonium dioxide from the Pit Disassembly and Conversion Demonstration Project at LANL would be shipped in SST/SGTs to one of four candidate DOE facilities (Hanford, ANL–W, LLNL, or SRS), or remain at LANL, for fabrication into lead assemblies. If the lead assemblies were to be fabricated at LANL, the plutonium dioxide would be transferred from the pit conversion demonstration to the lead assembly fabrication area within the same plutonium processing building (PF–4), in Technical Area 55 (TA–55), for MOX pellet production. Any intrasite transfers of plutonium outside of TA–55 would be in special vehicles in accordance

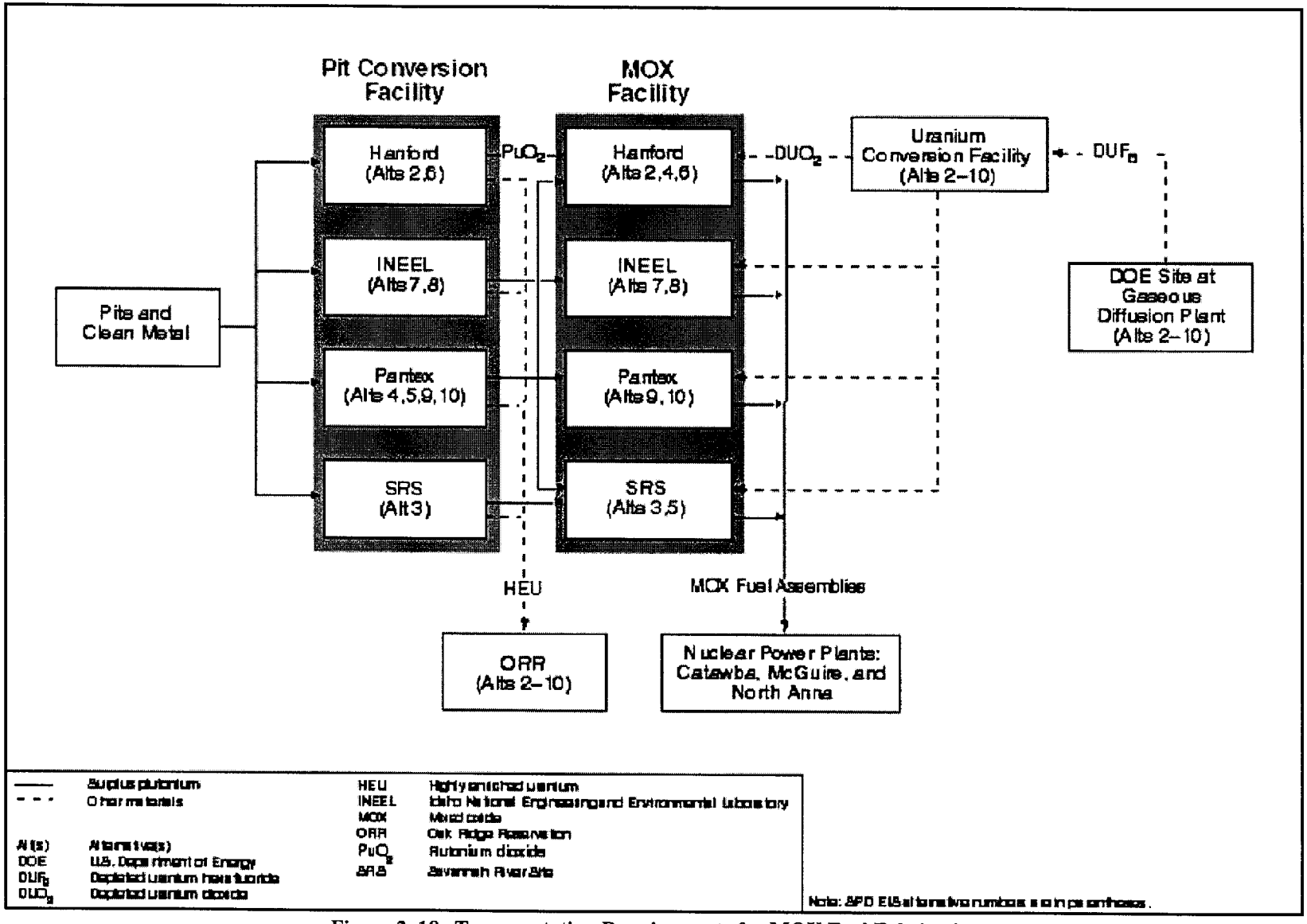

Figure 2–18. Transportation Requirements for MOX Fuel Fabrication

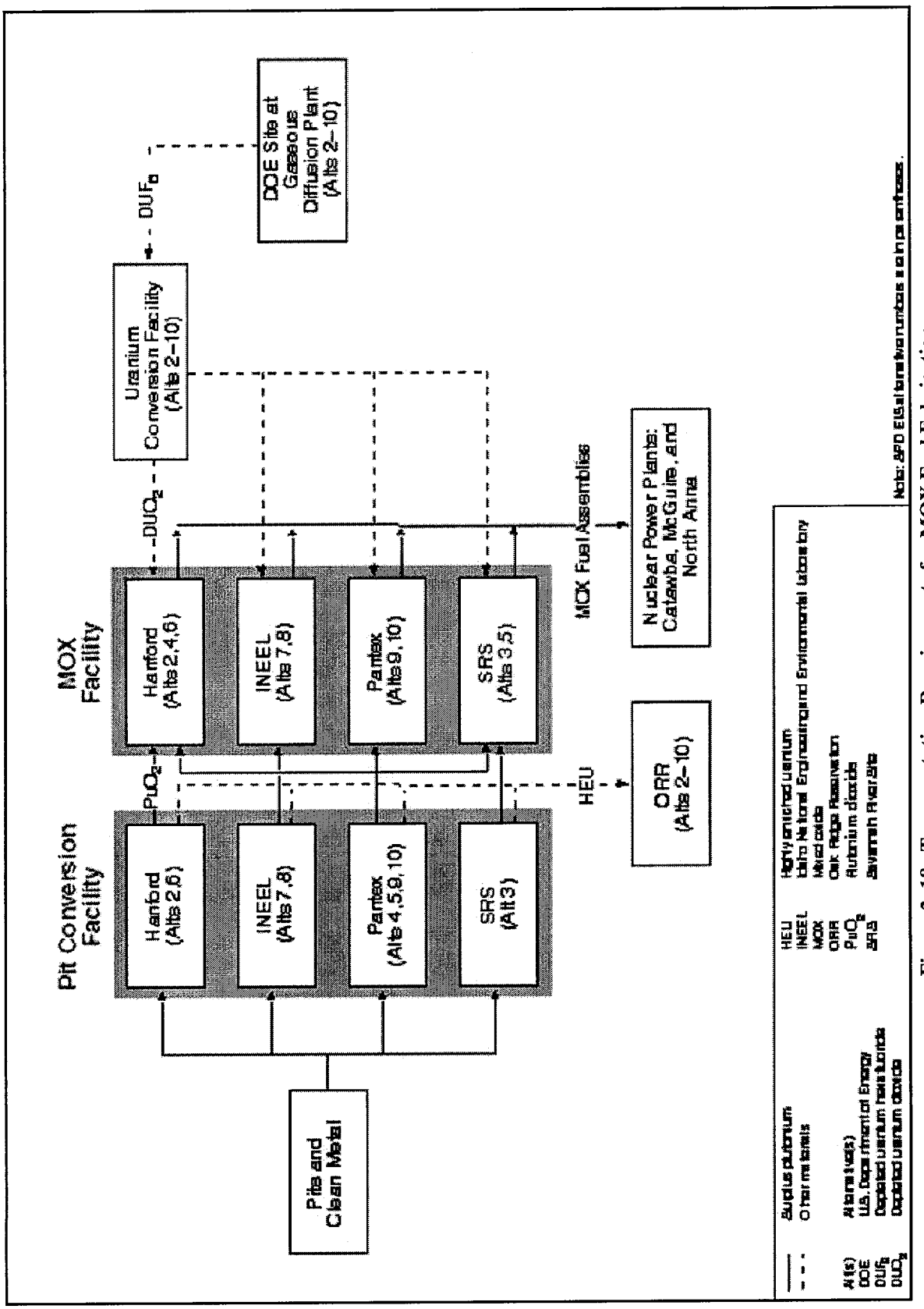

Figure 2–18. Transportation Requirements for MOX Fuel Fabrication

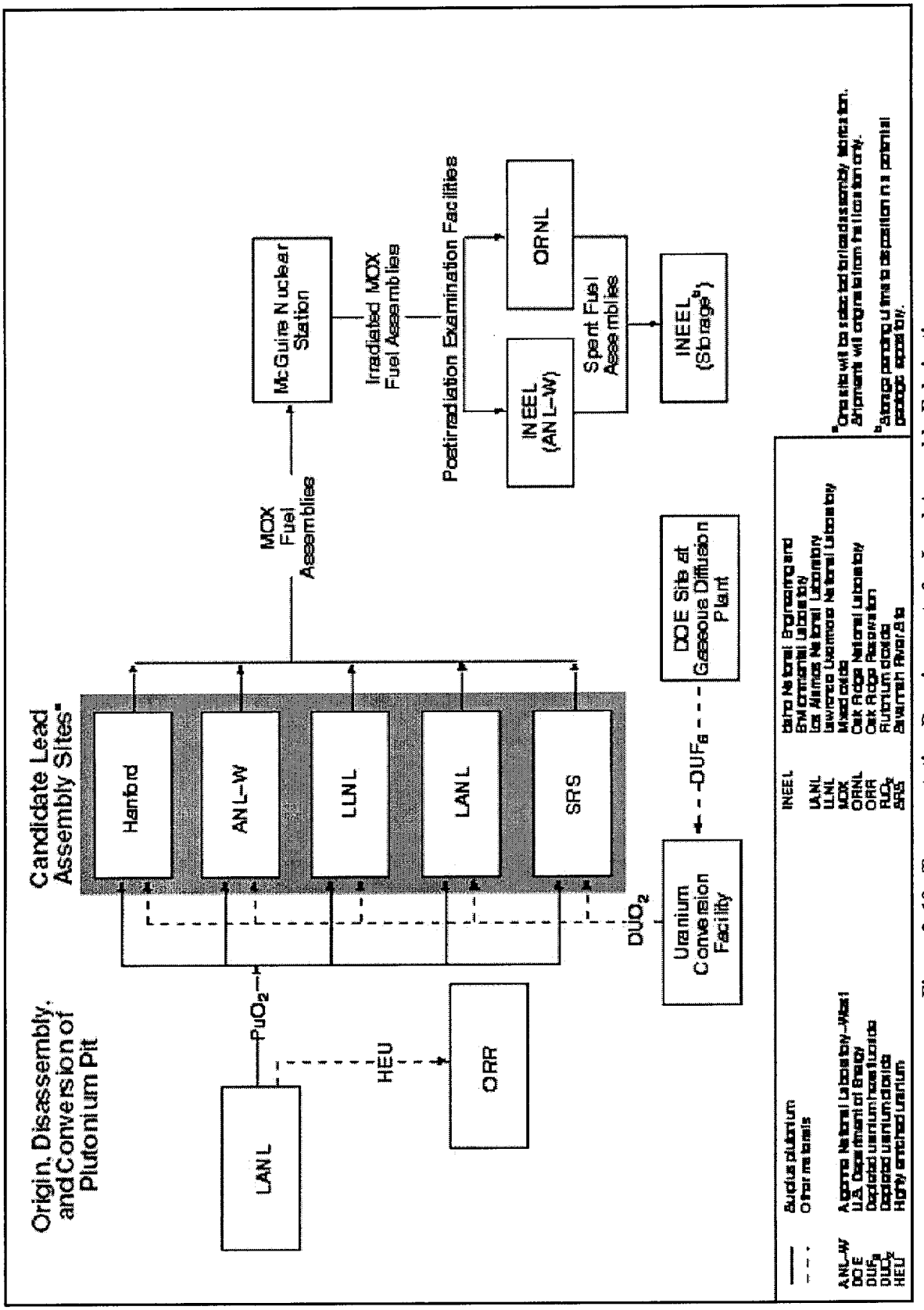

Figure 2–19. Transportation Requirements for Lead Assembly Fabrication

with site practices for this type of shipment. This intrasite transportation could require temporary road closures while the material would be moved from one area of the site to another. This practice would provide all needed security and mitigate potential risk to the public, without requiring the use of SST/SGTs for intrasite transfers.

The depleted uranium needed to support this effort is assumed to be shipped from one of DOE's storage areas at the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, to the nuclear fuel fabrication facility in Wilmington, North Carolina, for conversion, and then to the lead assembly fabrication site. All the transportation associated with depleted uranium would be via commercial truck.

After fabrication, the lead assemblies would be shipped to McGuire Nuclear Station[16] near Huntersville, North Carolina, for irradiation. These shipments would be made in SST/SGTs because unirradiated MOX fuel in large enough quantities is subject to security concerns similar to those associated with weapons-grade plutonium. Although the Preferred Alternative would fabricate lead assemblies at LANL, the lead assemblies could be fabricated as far away from McGuire as Hanford. Because transportation impacts are proportional to distance, the transportation analysis assumes, in order to evaluate the maximum potential impact, that the reactor will be 5,000 km (3,100 mi) from the lead assembly fabrication facility, the approximate distance between Hanford and McGuire. Transportation impacts would be proportionally less for other sites closer to McGuire.

After irradiation, the lead assemblies may be shipped from the reactor site to a postirradiation examination facility for analysis. Postirradiation examination, if required, would occur at one of two DOE sites, ANL–W or ORNL. As discussed in Section 2.1.3, these are the only two sites that have the capability to conduct postirradiation examination without major modifications to facility and processing capabilities. These shipments would be via commercial truck because the MOX fuel would be irradiated, thereby removing the proliferation concerns associated with plutonium. Because the actual postirradiation facility that would be used has not been selected (ORNL has been identified as the preferred location), the transportation analysis assumes that it will be 4,000 km (2,500 mi) from the reactor site where the lead assemblies were irradiated. This is the approximate distance between McGuire and ANL–W, the maximum distance that the irradiated lead assemblies would be transported. Any postirradiation examination activities and shipments of spent fuel remaining after postirradiation examination would comply with the Consent Order and Settlement Agreement in Public Service Company of Colorado v. Batt and all other applicable agreements and orders, including provisions concerning removal of the material from the applicable examination site and limits on the number of truck shipments to the site.

2.4.4.5 Other Transportation Requirements

All the alternatives being considered in this SPD EIS require some overland transportation of wastes from the proposed disposition facilities to treatment, storage, or disposal facilities. The proposed action does not result in a large increase in waste generation at any of the candidate sites, and transportation would be handled in the same manner as other site waste shipments. In addition, the shipments would not represent any new, different, or additional risks beyond those associated with existing waste shipments at these sites, as analyzed in the WM PEIS. The possible exceptions are the alternatives that consider siting disposition facilities at Pantex and the alternative that considers placing the lead assembly fabrication facility at LLNL. Because Pantex does not currently generate any TRU waste and does not have any TRU waste in storage, the WM PEIS did not consider TRU waste being shipped from Pantex to the Waste Isolation Pilot Plant (WIPP). Therefore, a small number of shipments of TRU waste to WIPP via commercial truck have been included in the transportation analysis in this SPD EIS. In addition, the projected amount of LLW generated by the proposed action would represent a large percentage of this waste type at both Pantex and LLNL, as analyzed in the WM PEIS. Because these sites ship

[16] Based on information provided by DCS, DOE has identified McGuire as its preference for irradiating lead assemblies.

LLW to the Nevada Test Site (NTS) for disposal, the transportation analysis in this SPD EIS includes a small number of shipments of LLW from Pantex and LLNL to NTS via commercial carrier.

2.5 ALTERNATIVE 1: NO ACTION

In the No Action Alternative, surplus weapons-usable plutonium materials in storage at various DOE sites shown in Figure 1–1 would remain at those locations. The vast majority of pits would continue to be stored at Pantex, and the remaining plutonium in various forms would continue to be stored at Hanford, INEEL, LLNL, LANL, RFETS, and SRS. The No Action Alternative would not satisfy the purpose and need for the proposed action because DOE's disposition decisions in the *Storage and Disposition PEIS* ROD would not be implemented. The ROD announced that, consistent with the Preferred Alternative in the *Storage and Disposition PEIS*, DOE had decided to reduce, over time, the number of locations where the various forms of plutonium are stored, through a combination of storage and disposition alternatives. Implementation of much of this decision requires the movement of surplus materials to disposition facility locations. Pits that have been moved from RFETS to Pantex would be relocated in accordance with the *Storage and Disposition PEIS* ROD, as amended.[17] Other surplus materials would continue to be stored indefinitely at their current locations, with the exception that DOE is considering leaving the repackaged surplus pits in Zone 4 at Pantex for long-term storage.[18] An appropriate environmental review will be conducted when the specific proposal for this change has been determined (e.g., whether additional magazines need to be air-conditioned). The analysis in this SPD EIS assumes that the surplus pits are stored in Zone 12 in accordance with the ROD for the *Storage and Disposition PEIS*.

2.6 ALTERNATIVE 2: ALL FACILITIES AT HANFORD

Pit Conversion in FMEF; Immobilization in FMEF and the HLW Vitrification Facility; MOX Fuel Fabrication in New Construction

This alternative would involve locating the three proposed surplus plutonium disposition facilities in the 400 Area at Hanford, combining the use of an existing building, FMEF, with new construction (see Figure 2–20). Canister filling would be accomplished at the planned HLW vitrification facility in the 200 East Area[19] (see Figure 2–21), about 24 km (15 mi) northwest of the 400 Area. FMEF, completed in 1984, is a reinforced concrete process building with an attached mechanical equipment wing on the west side, and an entry wing with administrative space across the south side. The building has six levels, two of which are below grade. FMEF was designed and constructed to fabricate fast breeder reactor fuel, but it has not been used for any major projects to date. The building has been modified since 1984, and the utility systems and support systems, including the ventilation system, have been completed. Designed to handle highly radioactive materials, FMEF includes a number of thick-walled cells surrounded by corridors. Space for offices,

[17] Recent studies have indicated that cost savings could be realized from the transfer of nonpit materials from RFETS and Hanford to SRS earlier than specified in the *Storage and Disposition PEIS* ROD. A Supplement Analysis was prepared, and based on this analysis, DOE determined that a supplemental PEIS would not be needed; an amended ROD was issued in August 1998 (63 FR 43386) and included decisions to accelerate shipment of all nonpit surplus plutonium from RFETS to SRS and to relocate all Hanford surplus plutonium to SRS, should SRS be selected as the immobilization disposition site.

[18] Should the No Action Alternative be chosen, the ROD pursuant to this SPD EIS would also address movement of the remaining surplus nonpit plutonium from RFETS in support of its planned closure in 2006.

[19] The planned HLW vitrification facility is described in the *Tank Waste Remediation System Final Environmental Impact Statement* and is currently scheduled to be available in a timeframe that would meet the needs of the surplus plutonium disposition program.

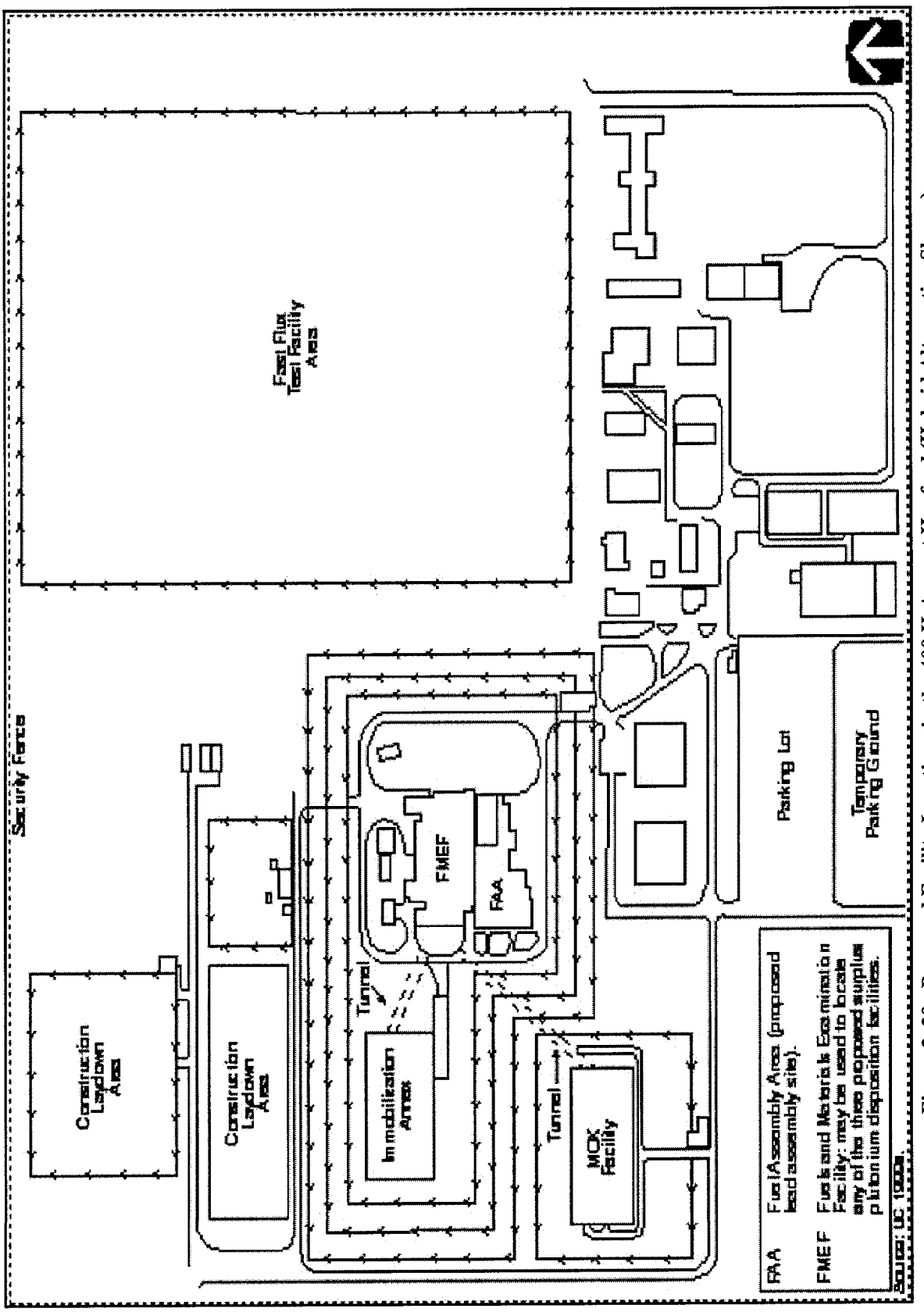

Figure 2–20. Proposed Facility Locations in the 400 H-Area at Hanford (Hybrid Alternative Shown)

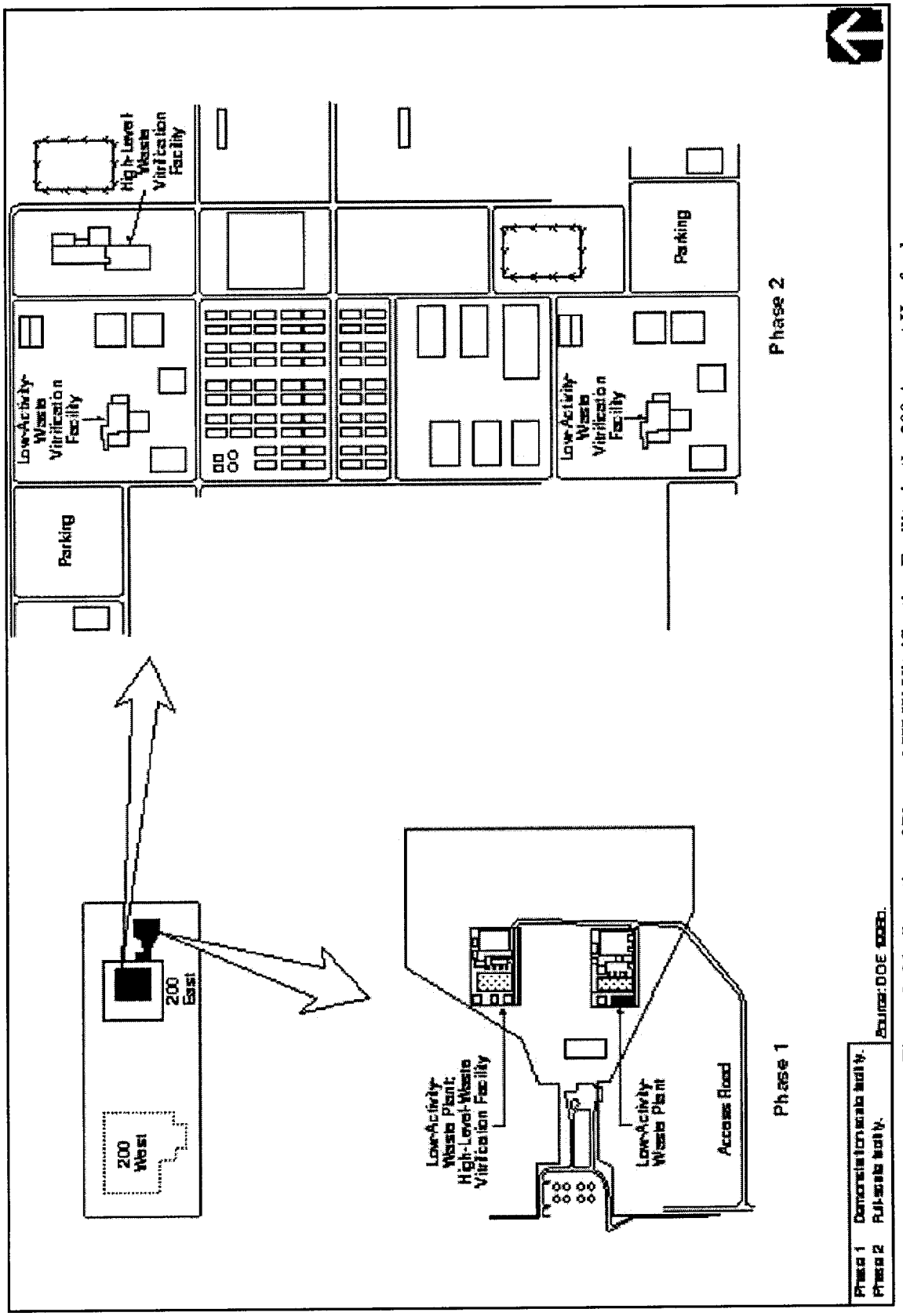

Figure 2–21. Location of Planned HLW Vitrification Facility in the 200 Area at Hanford (Proposed Location of Canister-Filling Operations)

laboratories, control rooms, utilities, and other activities is available around the interior perimeter of the building. Modification to the interior spaces would be required to use the building for surplus plutonium disposition activities. No radioactive materials have been introduced into the building, so the modification would neither generate radioactive waste nor contribute radiological dose to the construction workforce. The building is large enough to house facilities for only two of the three proposed disposition activities. Therefore, this alternative calls for collocation of the pit conversion and immobilization facilities in FMEF, and the construction of a new building close to FMEF to house the MOX facility.

In this alternative, the pit conversion facility would occupy the lower floors of FMEF, and the immobilization facility, the upper two floors. About 13,000 m^2 (140,000 ft^2) of space on the -35-ft, -17-ft, ground, and +21-ft levels would be modified to support pit disassembly and conversion activities. Not all the space on every floor would be required for pit disassembly and conversion activities, but the floors would be predominately associated with that process.

Plutonium conversion and immobilization activities would primarily occupy the +42- and +70-ft levels. While a portion of the +42-ft level would be shared by the two facilities, most of the floor would be dedicated to the immobilization facility, which would occupy about 17,000 m^2 (183,000 ft^2). Both facilities would share utilities, loading docks, and security assets. The large shipping and receiving area of FMEF would allow for housing a number of SST/SGTs.

The immobilization facility would also require the construction of a two-story annex northwest of FMEF. This building would provide approximately 4,600 m^2 (49,000 ft^2) of space for canister-loading activities and some analytical laboratory operations. The security fence surrounding FMEF would be extended to include this additional area. Material movement between FMEF and the annex would occur either by surface vehicle or through an underground tunnel between the two facilities within the protected security zone.

For the MOX facility, a new two-story building of about 20,000 m^2 (215,000 ft^2) would be constructed west of FMEF. A secure underground tunnel would connect the two buildings for special nuclear material transfers. This tunnel would be locked and alarmed under normal operating conditions and subject to the same security measures on both sides as the building perimeters, both to ensure the protection of the special nuclear materials and to maintain the independence of the MOX facility. The tunnel would be opened in accordance with safeguards and security procedures for the transfer of plutonium dioxide from the pit conversion facility to the MOX facility, and would be closed immediately upon completion of transfer activities. Other than being joined to it by this tunnel, the MOX facility would be independent of FMEF, and would be inside its own fenced security area. Various nonhardened support buildings totaling about 2,300 m^2 (25,000 ft^2) would be needed to support the MOX mission. The proposed facilities would use such existing Hanford services as sitewide security (although there would be additional security assigned to each of the three disposition facilities), emergency services, environmental monitoring, and waste management.

Construction would begin in about 2001, with modifications to FMEF for the pit conversion facility, and would continue through completion of the MOX facility in about 2006. Operations would commence in about 2004 with pit disassembly and conversion, and would continue until about 2019 when the MOX and immobilization facilities have completed their missions. Operation of the MOX facility would not begin until the pit conversion facility had been operating for a year, so that feed material would be available for MOX fuel fabrication.

2.7 ALTERNATIVE 3: ALL FACILITIES AT SRS

Pit Conversion and MOX Fuel Fabrication in New Construction; Immobilization in New Construction and DWPF

2.7.1 [Section heading deleted.]

This alternative would involve locating the three proposed surplus plutonium disposition facilities in newly constructed buildings near the area currently designated for APSF in F-Area at SRS (see Figure 2–22). In addition, the canister receipt area at DWPF in S-Area, about 6 km (3.7 mi) east of F-Area (see Figures 2–5 and 2–23), would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. [Text deleted.]

In the SPD Draft EIS, alternatives that considered locating the disposition facilities in new construction at SRS used the proposed APSF as a receiving facility for SST/SGT shipments; storage vaults for plutonium dioxide and metal; and for the pit conversion and immobilization facilities, nondestructive assay facilities. Therefore, the SPD Draft EIS analyzed somewhat smaller disposition facilities at SRS than at the other candidate sites. DOE has recently decided to delay the construction of APSF. Because the schedule for APSF is uncertain, this SPD Final EIS has been modified to disregard any benefit to the proposed facilities as a result of APSF being present at SRS. This SPD EIS now presents the environmental impacts that would be associated with construction and operation of disposition facilities at SRS that are stand-alone and include no reliance on APSF for storage space or other functions. Throughout this SPD EIS, references to APSF have been qualified by the phrase "if built" or a similar phrase, and no credit has been taken in the environmental analyses for the use of APSF.

The pit conversion facility now analyzed at SRS is identical to that proposed in the Pantex alternatives, where it has always been considered a stand-alone facility. In the current immobilization facility design, some space would be available to partially offset the use of APSF for functions such as storage or accountability measurements. However, without APSF, construction of truck bays and other minor modifications (up to approximately 980 m^2 [10,500 ft^2]) would be necessary. The MOX facility proposed for SRS has also been replaced with the larger stand-alone facility that has been proposed for the other candidate sites. Should DOE decide to collocate all three disposition facilities at SRS, as indicated in the Preferred Alternative (see Section 1.6), the final design of these facilities would coordinate potential common functions among the facilities to the extent practical as a means to reduce space requirements and the associated environmental impacts.

As shown in Figure 2–22, the immobilization facility would be east of the area currently designated for APSF, the pit conversion facility due south of the immobilization facility, and the MOX facility due south of the pit conversion facility.[20] To accommodate all three disposition facilities at this location, it would be necessary to move the F-Area fence line to incorporate more area. These facilities would be connected to each other by material transfer tunnels. These tunnels would be locked and alarmed under normal operating conditions and subject to the same security measures on both sides as the building perimeters, both to ensure the protection of the special nuclear materials and to maintain the independence of the MOX facility. The tunnels would be opened in accordance with safeguards and security procedures for the transfer of special nuclear materials and would be closed immediately upon completion of transfer activities. Other than being joined by the tunnel, the MOX

[20] As discussed in Section 4.26.4.4.1, facility construction would avoid any cultural resource areas eligible or potentially eligible for nomination to the National Register of Historic Places.

facility would be independent of the other plutonium disposition facilities and would be inside its own fenced security area.

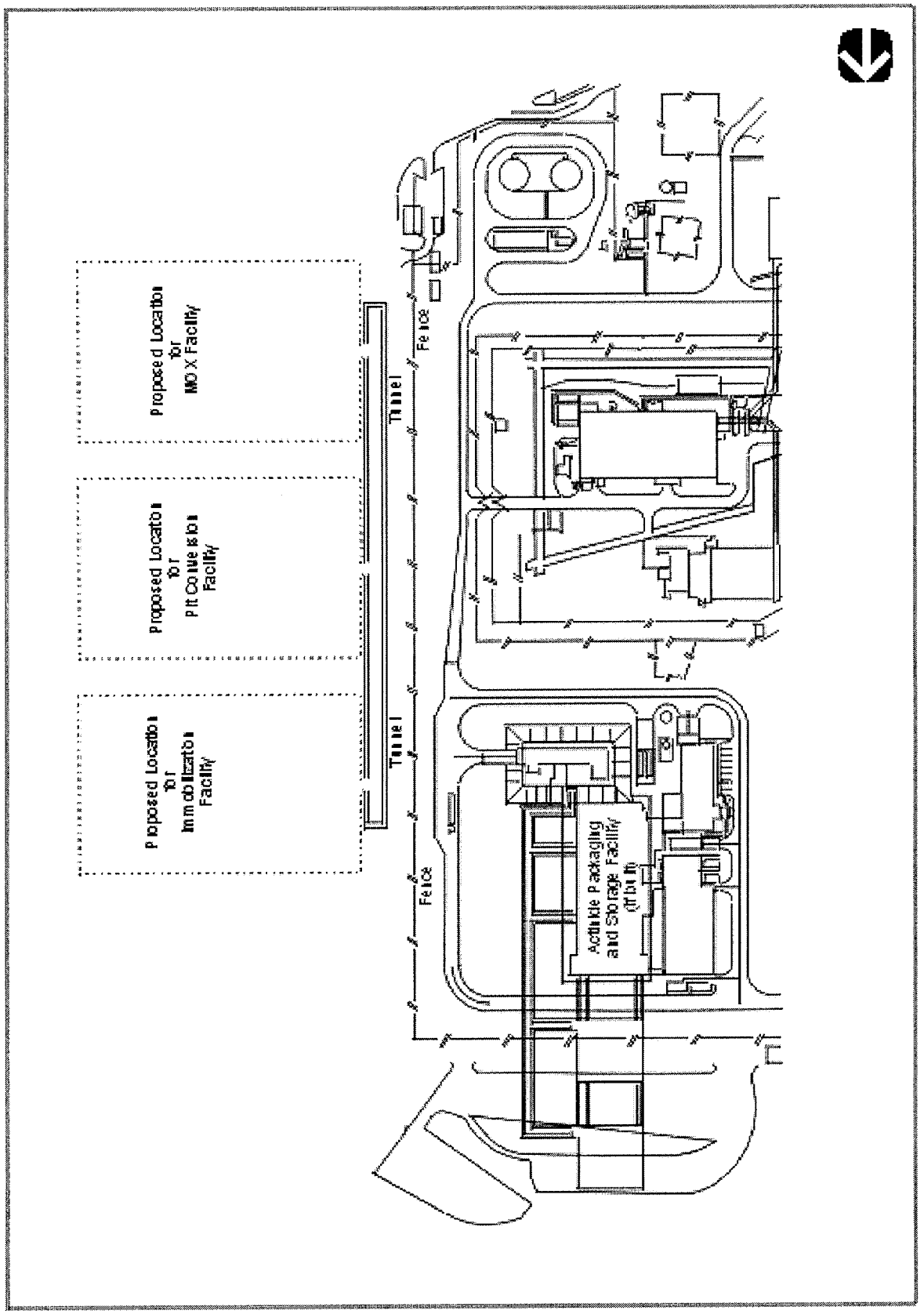

Figure 2–22. Proposed Facility Locations in F-Area at SRS

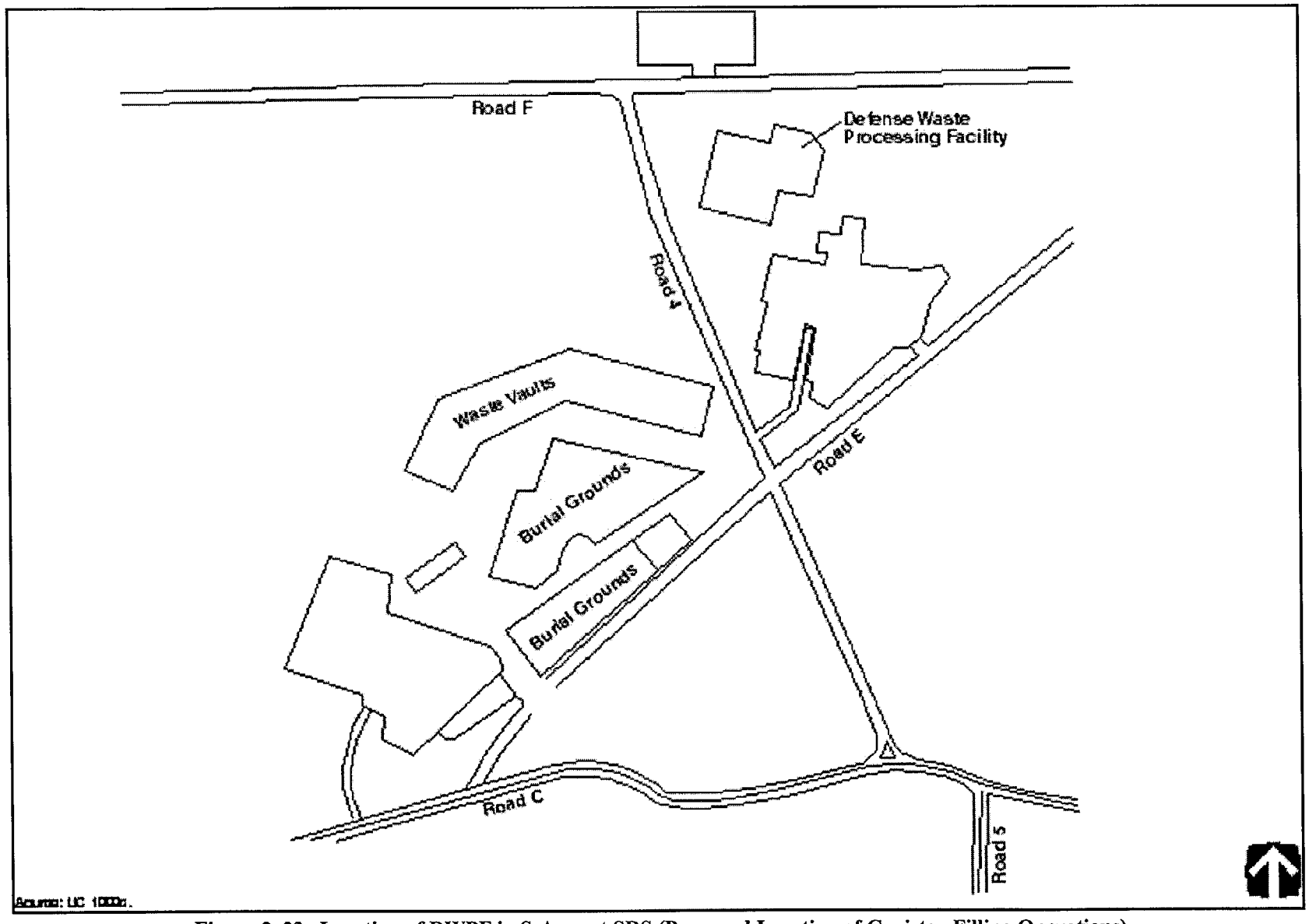

Figure 2–23. Location of DWPF in S-Area at SRS (Proposed Location of Canister-Filling Operations)

The pit conversion facility would occupy about 18,600 m^2 (200,000 ft^2) on two levels, one or both of which may be below grade. Another 2,400 m^2 (26,000 ft^2) would be required for a utility building, standby generator, and an electrical substation in F-Area. The total space required for the immobilization facility would be about 25,000 m^2 (269,000 ft^2). Of that, 23,000 m^2 (248,000 ft^2) would be in new facilities in F-Area; the remainder would be space in existing facilities that would not require further modification. The immobilization facility would have four levels, three of which would be above grade. The main process area would be at grade level, below which a small basement level would contain transfer corridors and a fire-water collection facility. The third level would house support equipment such as heating, ventilation, and air-conditioning systems, and electrical and mechanical utilities. In the center of the facility, a core "stack" or shaft would extend from the main processing level up to the small fourth level for vertical processing of materials. Two smaller, two-level structures immediately adjacent and connected to the main processing building would serve as entry control and provide administrative space. The MOX facility would occupy about 20,000 m^2 (215,000 ft^2) on two levels, one below grade. Another 2,300 m^2 (25,000 ft^2) would be required for new support buildings in F-Area. The proposed facilities would use such existing SRS services as sitewide security (although there would be additional security assigned to each of the three disposition facilities), emergency services, environmental monitoring, and waste management.

Construction would commence in about 2001 with the pit conversion facility, and would continue through completion of the MOX facility in about 2006. Operations would commence in about 2004 with pit conversion, and would continue until about 2019, when the MOX and immobilization facilities have completed their missions. Operation of the MOX facility would not begin until the pit conversion facility had been operating for a year, so that feed material would be available for MOX fuel fabrication.

2.7.2 [Section deleted because alternative deleted.]

2.8 ALTERNATIVE 4: PIT CONVERSION AT PANTEX; MOX FUEL FABRICATION AND IMMOBILIZATION AT HANFORD

2.8.1 Alternative 4A

Pantex: Pit Conversion in New Construction
Hanford: MOX Fuel Fabrication in New Construction; Immobilization in FMEF and HLW Vitrification Facility

This alternative would involve locating the pit conversion facility at Pantex and the immobilization and MOX facilities at Hanford. The pit conversion and MOX facilities would be in new construction, and FMEF would be modified to house the immobilization facility. Canister filling would be accomplished at the planned HLW vitrification facility scheduled for construction in the 200 East Area, about 24 km (15 mi) northwest of the 400 Area (see Figures 2–20 and 2–21).

At Pantex, the pit conversion facility would be in a new building in Zone 4 West, with some support facilities to the west of, and adjacent to, Zone 4 West (see Figure 2–24). Utilities and storage vaults would be on the ground floor of the pit conversion facility; and the main processing and loading areas, offices, and support areas, in a below-grade basement. The building would occupy about 18,600 m^2 (200,000 ft^2). New buildings totaling 5,300 m^2 (57,000 ft^2) would have to be constructed to support the pit conversion facility. Additional space in existing buildings in Zone 4 West would be used for administration, access control, warehousing, and other services. New or upgraded electrical, water, and gas supply lines would be constructed from existing trunk lines. The proposed pit conversion facility would use such existing Pantex services as sitewide security (although there would be an additional security assigned to the facility), emergency services, environmental monitoring, and waste management. TRU waste storage would be provided in the main pit conversion facility

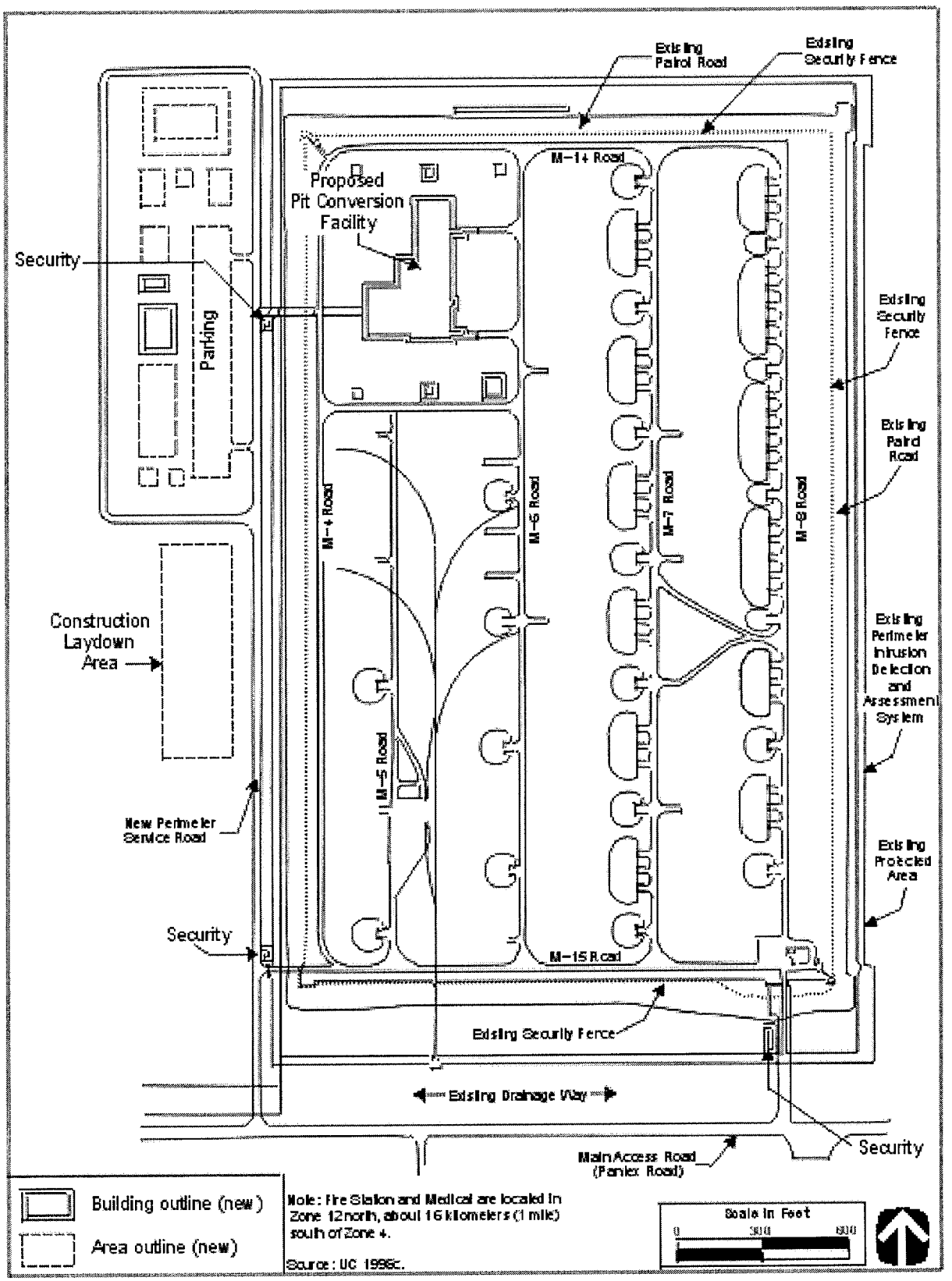

Figure 2–24. Proposed Pit Conversion Facility Location in Zone 4 West at Pantex

or in ancillary facilities. Construction would commence in about 2001 and continue through about 2003. Operations would commence in about 2004 and continue until about 2014.

Facilities at Hanford would be in the 400 Area, the immobilization facility in the FMEF and the MOX facility in new construction near FMEF. Immobilization would be concentrated on the +42- and +70-ft levels of FMEF, although process support functions would be conducted on all six floors of the building. The total space required for the immobilization facility would be about 20,000 m^2 (215,000 ft^2); the remainder of FMEF would be available for other missions.

For the MOX facility, a new two-story building of about 20,000 m^2 (215,000 ft^2) would be constructed west of FMEF. This facility would be independent of FMEF and inside its own fenced security area. In addition to the main process building, the MOX facility would require 2,300 m^2 (25,000 ft^2) of new support buildings throughout the 400 Area. The proposed disposition facilities would use such existing Hanford services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Modification and new construction at Hanford would commence in about 2002 and continue through about 2006. The immobilization facility would commence operations in about 2005; the MOX facility, in about 2006. The MOX facility would operate until about 2019; the immobilization facility until 2016. Operation of the MOX facility would not begin until the pit conversion facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.8.2 Alternative 4B

Pantex: Pit Conversion in New Construction
Hanford: Plutonium Conversion and Immobilization in FMEF and HLW Vitrification Facility; and MOX Fuel Fabrication in FMEF

This alternative would involve locating the pit conversion facility in new construction at Pantex and the immobilization and MOX facilities in FMEF at Hanford. Canister filling would be accomplished at the planned HLW vitrification facility scheduled for construction in the 200 East Area, about 24 km (15 mi) northwest of the 400 Area. At Pantex, the pit conversion facility would be the same as the one described for Alternative 4A in Section 2.8.1. This alternative differs from Alternative 4A in that the MOX facility would be located in FMEF rather than in new construction.

At Hanford, FMEF would be modified to contain both the MOX and immobilization facilities. While these facilities would share the building, they would be totally separate from each other to accommodate NRC regulation of the MOX facility. The immobilization facility would occupy about 14,000 m^2 (150,000 ft^2), primarily on the ground and +21-ft levels. Only the receiving area would be shared by the two facilities, but the area would be modified to physically separate the two sides and provide independent access to the two facilities.

The immobilization facility would also require the construction of a two-story annex northwest of FMEF. This building would provide approximately 6,700 m^2 (72,000 ft^2) of space for canister-loading activities and most analytical laboratory operations. The security fence surrounding FMEF would be extended to include this additional area. Material movement between FMEF and the annex would occur either by surface vehicle or through an underground tunnel between the two facilities within the protected security zone.

To implement the MOX mission at FMEF, the building would be remodeled and annexes added to accommodate the functions and processes required for MOX fuel fabrication. The MOX facility would occupy about 8,200 m^2 (88,000 ft^2) on the ground, +42-ft, and +70-ft levels of FMEF. New annex areas on the north and east sides of

the building for utilities and an entrance area with office space would add another 1,900 m^2 (20,000 ft^2) to the FMEF structure. Partition walls and other isolation mechanisms would be used to completely segregate the MOX portion of the building from the other portions. In addition to the main process building, the MOX facility would require 4,200 m^2 (45,000 ft^2) of new support buildings throughout 400 Area. The proposed disposition facilities would use such existing Hanford services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Modification of FMEF would commence in about 2002 and continue through about 2006. The immobilization facility would commence operations in about 2005; the MOX facility, in about 2006. The MOX facility would operate until about 2019; the immobilization facility until 2016. Operation of the MOX facility would not begin until the pit facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.9 ALTERNATIVE 5: PIT CONVERSION AT PANTEX; MOX FUEL FABRICATION AND IMMOBILIZATION AT SRS

Pantex: **Pit Conversion in New Construction**
SRS: **MOX Fuel Fabrication in New Construction; and Immobilization in New Construction and DWPF**

2.9.1 [Section heading deleted.]

This alternative would involve locating the pit conversion facility at Pantex and the immobilization and MOX facilities in new construction near the area currently designated for APSF at SRS. In addition, the canister receipt area at DWPF in S-Area would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. At Pantex, the pit conversion facility would be the same as the one described for Alternative 4A in Section 2.8.1.

As shown in Figure 2–22, the immobilization facility would be east of the area currently designated for APSF, and the MOX facility south of the immobilization facility. (The pit conversion facility, shown on this map, would not be located at SRS.) To accommodate both the immobilization and MOX facilities, it would be necessary to move the F-Area fence line to incorporate more area. These facilities would be constructed as described for Alternative 3 in Section 2.7.

Construction at SRS would commence in about 2002 and continue through about 2006. The immobilization facility would commence operations in about 2005; the MOX facility, in about 2006. The MOX facility would operate until about 2019; the immobilization facility until 2016. Operation of the MOX facility would not begin until the pit facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.9.2 [Section deleted because alternative deleted.]

2.10 ALTERNATIVE 6: PIT CONVERSION AND MOX FUEL FABRICATION AT HANFORD; IMMOBILIZATION AT SRS

2.10.1 Alternative 6A

Hanford: Pit Conversion in FMEF; MOX Fuel Fabrication in New Construction
SRS: Immobilization in New Construction and DWPF

This alternative would involve locating the pit conversion and MOX facilities at Hanford, in FMEF and new construction, respectively; and the immobilization facility in new construction near the area currently designated for APSF at SRS. In addition, the canister receipt area at DWPF in S-Area would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. In this alternative, the pit conversion facility would occupy about 13,000 m^2 (140,000 ft^2) of space on the -35-ft, -17-ft, ground, and +21-ft levels of FMEF, as described in Section 2.6; the remainder of FMEF would be available for other missions. A new two-story building would be constructed for the MOX facility, as described in Section 2.6. The proposed disposition facilities would use such existing Hanford services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Construction would commence in about 2001, with modifications to FMEF for the pit conversion facility, and would continue through completion of the MOX facility in about 2006. The pit conversion facility would commence operations in about 2004; the MOX facility, in about 2006. Operations would continue until about 2019, when the MOX facility has completed its mission. Operation of the MOX facility would not begin until the pit conversion facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

The new immobilization facility at SRS would be east of the area currently designated for APSF, as described in Section 2.7. The total space required for that facility would be about 25,000 m^2 (269,000 ft^2). Of that, 23,000 m^2 (248,000 ft^2) would be in new facilities; the remainder would be space in existing facilities that would not require further modification. To accommodate the immobilization facility, it would be necessary to move the F-Area fence line out to incorporate more area. The immobilization facility would use such existing SRS services as sitewide security (although there would be an additional security assigned to the facility), emergency services, environmental monitoring, and waste management. Construction would commence in about 2002 and continue through about 2005. Operations would commence in about 2005 and continue until about 2016.

2.10.2 Alternative 6B

Hanford: Pit Conversion and MOX Fuel Fabrication Collocated in FMEF
SRS: Immobilization in New Construction and DWPF

This alternative would involve locating both the pit conversion and MOX facilities in FMEF at Hanford, and the immobilization facility in new construction near the area currently designated for APSF at SRS. In addition, the canister receipt area at DWPF in S-Area would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. In this alternative, the immobilization facility would be constructed and operated at SRS as described for Alternative 6A in Section 2.10.1.

FMEF would be modified to contain both the pit conversion and MOX facilities. While these facilities would share the building, they would be totally separate from each other to accommodate NRC regulation of the MOX facility. The pit conversion facility would occupy about 13,000 m^2 (140,000 ft^2) of space on the -35-ft, -17-ft,

ground, and +21-ft levels of FMEF, as described in Section 2.6. Plutonium dioxide would be moved from the pit conversion facility to the MOX facility in a secure elevator.

To implement the MOX mission at FMEF, the building would be remodeled and annexes added to accommodate all the functions and processes required for MOX fuel fabrication. The MOX facility would occupy about 8,200 m^2 (88,000 ft^2) on the ground, +42-ft, and +70-ft levels of FMEF. The new annex areas on the north and east sides of the building for utilities and an entrance area with office space would add another 1,900 m^2 (20,000 ft^2) to the FMEF structure. Partition walls and other isolation mechanisms would be used to completely segregate the MOX portion of the building from the other portions. In addition to the main process building, the MOX facility would require 4,200 m^2 (45,000 ft^2) of new support buildings throughout 400 Area. The proposed disposition facilities would use such existing Hanford services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Modification of FMEF would commence in about 2001 and would continue through about 2006. The pit conversion facility would commence operations in about 2004; the MOX facility, in about 2006. Operations would cease when the MOX facility has shut down in about 2019. Operation of the MOX facility would not begin until the pit facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.10.3 [Section deleted because alternative deleted.]

2.10.4 [Section deleted because alternative deleted.]

2.11 ALTERNATIVE 7: PIT CONVERSION AND MOX FUEL FABRICATION AT INEEL; IMMOBILIZATION AT SRS

INEEL: Pit Conversion in the Fuel Processing Facility; MOX Fuel Fabrication in New Construction
SRS: Immobilization in New Construction and DWPF

2.11.1 [Section heading deleted.]

This alternative would involve locating the pit conversion facility in the Fuel Processing Facility (FPF) and the MOX facility in new construction in the Idaho Nuclear Technology and Energy Center (INTEC) area at INEEL, and the immobilization facility in new construction near the area currently designated for APSF at SRS. In addition, the canister receipt area at DWPF in S-Area would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. The immobilization facility would be implemented at SRS as described for Alternative 6A in Section 2.10.1.

FPF has six levels, three below grade. It is structurally complete, but has never been used. Construction was started in 1986, but discontinued in 1993, leaving essentially a concrete shell with temporary lighting and ventilation. As the building was designed to handle highly radioactive materials, it includes a number of interior thick-walled cells surrounded by corridors and access ways. Building utility areas and office space surround the corridors of the above-grade stories. Modification to the interior spaces would be required to accommodate surplus plutonium disposition activities. No radioactive materials have been introduced into the building, so the modification would neither generate radioactive waste nor contribute a radiological dose to the construction workforce. In this alternative, the pit conversion facility would occupy about 14,000 m^2 (150,000 ft^2) on four levels of FPF. No new support buildings would have to be built, as the facility's needs would be met by existing facilities at INTEC.

A new two-story building of about 20,000 m^2 (215,000 ft^2) would be constructed for the MOX facility. As shown in Figure 2–25, this building would be south of FPF. A secure underground tunnel would connect the two buildings for special nuclear material transfers. This tunnel would be locked and alarmed under normal operating conditions, and subject to the same security measures on both sides as the building perimeters, both to ensure protection of the special nuclear materials and to maintain the independence of the MOX facility. The tunnel would be opened in accordance with safeguards and security procedures for the transfer of plutonium dioxide from the pit conversion facility to the MOX facility, and would be closed immediately upon completion of transfer activities. Other than being joined to it by this tunnel, the MOX facility would be independent of FPF, and would be inside its own fenced security area. In addition to the main process building, the MOX facility would require 2,300 m^2 (25,000 ft^2) of new support buildings throughout the INTEC Area. The proposed disposition facilities would use such existing INEEL services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Construction would commence in about 2001, with modifications to FPF for the pit conversion facility, and would continue through completion of the MOX facility in about 2006. Operations would commence in about 2004, with pit conversion, and would continue until about 2019, when the MOX facility has completed its mission. Operation of the MOX facility would not begin until the pit conversion facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.11.2 [Section deleted because alternative deleted.]

2.12 ALTERNATIVE 8: PIT CONVERSION AND MOX FUEL FABRICATION AT INEEL; IMMOBILIZATION AT HANFORD

INEEL: Pit Conversion in FPF; MOX Fuel Fabrication in New Construction
Hanford: Immobilization in FMEF and HLW Vitrification Facility

This alternative would involve locating the pit conversion facility in FPF and the MOX facility in new construction in the INTEC area at INEEL; and the immobilization facility in FMEF at Hanford. The pit conversion and MOX facilities would be implemented at INEEL as described for Alternative 7 in Section 2.11.

At Hanford, FMEF would be modified to house the immobilization facility as described for Alternative 4A in Section 2.8.1. Canister filling would be accomplished at the planned HLW vitrification facility scheduled for construction in the 200 East Area, about 24 km (15 mi) northwest of the 400 Area. Modification of FMEF would commence in about 2002 and continue through about 2004. Operation of the immobilization facility would commence in about 2005 and continue until about 2016.

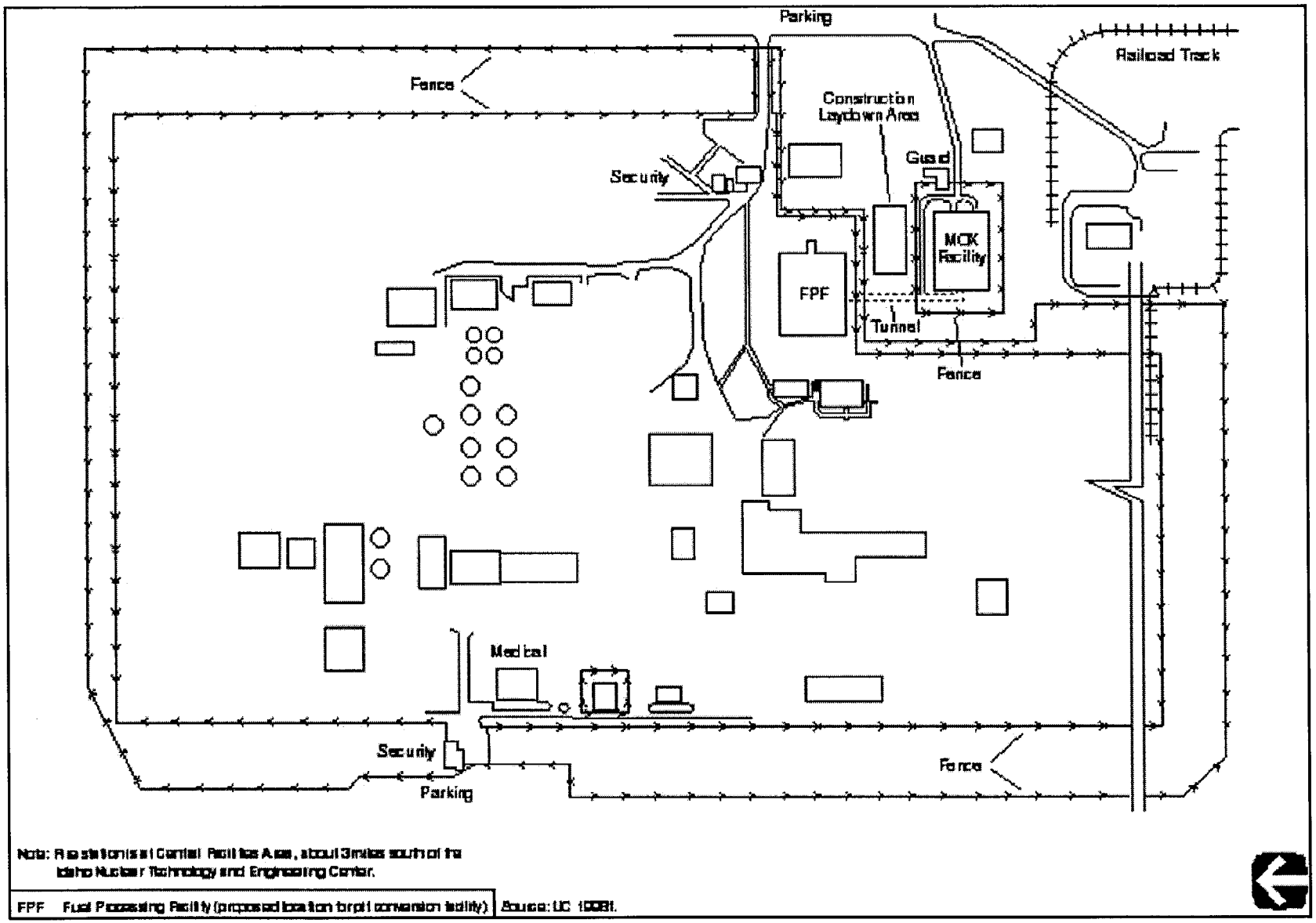

Figure 2–25. Proposed Pit Conversion and MOX Facility Locations in INTEC at INEEL

2.13 ALTERNATIVE 9: PIT CONVERSION AND MOX FUEL FABRICATION AT PANTEX; IMMOBILIZATION AT SRS

Pantex: Pit Conversion and MOX Fuel Fabrication in New Construction
SRS: Immobilization in New Construction and DWPF

2.13.1 [Section heading deleted.]

This alternative would involve locating both the pit conversion and the MOX facilities at Pantex, and the immobilization facility in new construction near the area currently designated for APSF at SRS. In addition, the canister receipt area at DWPF in S-Area would be modified as described in Section 2.4.2.1 to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. The immobilization facility would be as described in Section 2.10.1.

At Pantex, the pit conversion and MOX facilities would be in new construction in Zone 4 West (see Figure 2–26). The pit conversion facility in this alternative would be the same as that described in Section 2.8.1. For the MOX facility, a new two-story building of about 20,000 m^2 (215,000 ft^2) would be constructed south of the pit conversion facility. A secure underground tunnel would connect the two buildings for special nuclear material transfers.[21] This tunnel would be locked and alarmed under normal operating conditions, and subject to the same security measures on both sides as the building perimeters, both to ensure protection of the special nuclear materials and to maintain the independence of the MOX facility. The tunnel would be opened in accordance with safeguards and security procedures for the transfer of plutonium oxide from the pit conversion facility to the MOX facility, and would be closed immediately upon completion of transfer activities. Other than being joined by this tunnel, the MOX facility would be independent of the pit conversion facility, and would be inside its own fenced security area. In addition to the main process building, the MOX facility would require 2,300 m^2 (25,000 ft^2) of new support buildings throughout Zone 4 West. TRU waste storage would be provided in the main pit conversion and MOX facilities or in ancillary facilities. The proposed disposition facilities would use such existing Pantex services as sitewide security (although there would be additional security assigned to each of the disposition facilities), emergency services, environmental monitoring, and waste management.

Construction at Pantex would commence in about 2001 with the pit conversion facility, and continue through completion of the MOX facility in about 2006. Operations would commence in about 2004 with pit conversion, and continue until about 2019, when the MOX facility has completed its mission. Operation of the MOX facility would not begin until the pit conversion facility had been operating for at least a year, so that feed material would be available for MOX fuel fabrication.

2.13.2 [Section deleted because alternative deleted.]

[21] Current facility design includes a tunnel for material transfers. Intrasite transfers of special nuclear materials in accordance with current site practices may be considered in lieu of a tunnel in the facility design.

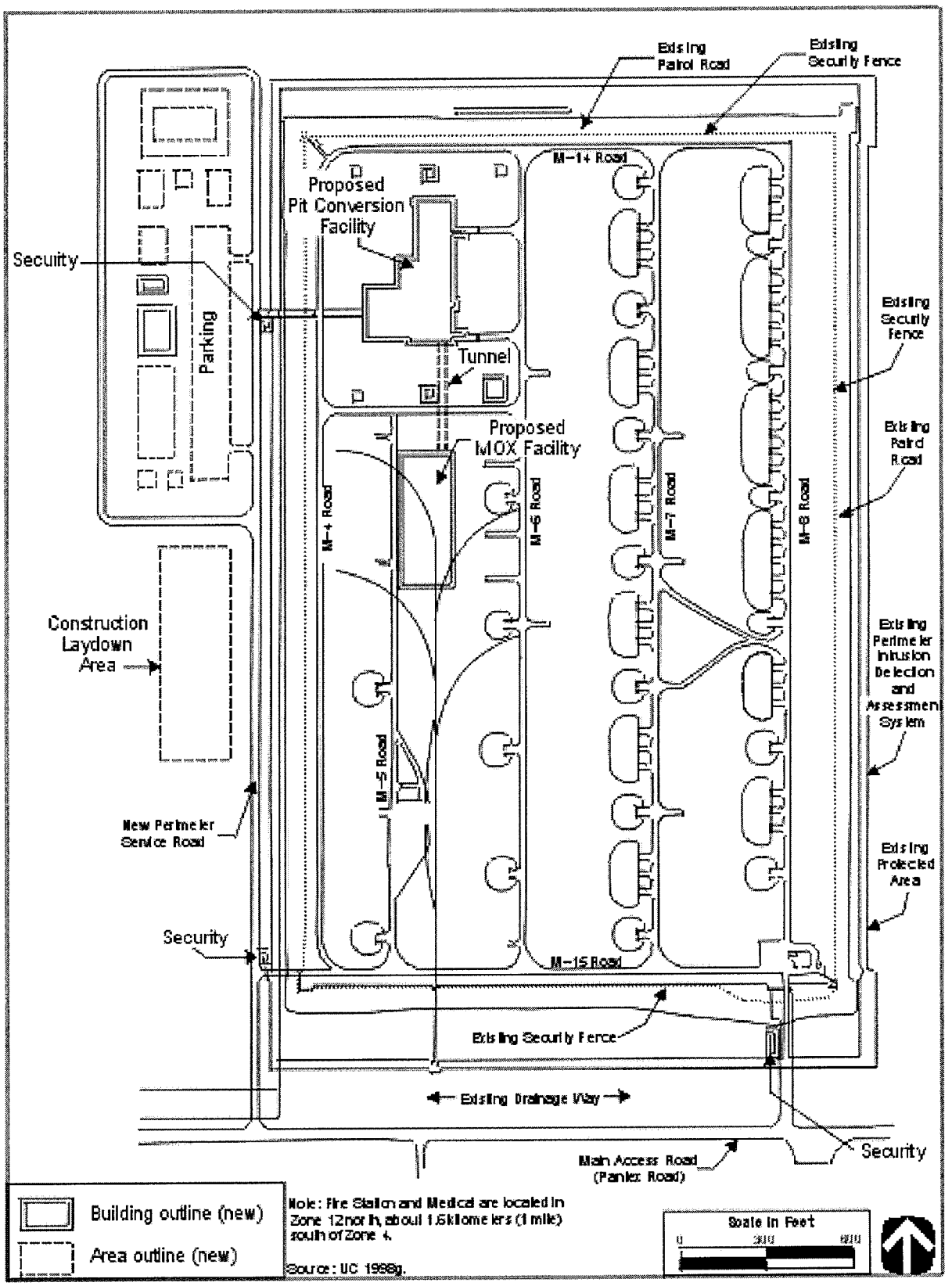

Figure 2–26. Proposed Pit Conversion and MOX Facility Locations in Zone 4 West at Pantex

2.14 ALTERNATIVE 10: PIT CONVERSION AND MOX FUEL FABRICATION AT PANTEX; IMMOBILIZATION AT HANFORD

Pantex: Pit Conversion and MOX Fuel Fabrication in New Construction
Hanford: Immobilization in FMEF and HLW Vitrification Facility

This alternative would involve locating both the pit conversion and MOX facilities in new construction at Pantex, as described for Alternative 9 in Section 2.13. The immobilization facility would be in FMEF at Hanford, and canister filling would be accomplished at the planned HLW vitrification facility scheduled for construction in the 200 East Area, about 24 km (15 mi) northwest of the 400 Area. Immobilization would be implemented as described for Alternative 8 in Section 2.12.

2.15 ALTERNATIVE 11: 50-METRIC-TON IMMOBILIZATION; IMMOBILIZATION AT HANFORD; PIT CONVERSION AT HANFORD OR PANTEX

2.15.1 Alternative 11A

Hanford: Pit Conversion in FMEF; Immobilization in FMEF and the HLW Vitrification Facility

This alternative would involve immobilizing all the nominal 50 t (55 tons) of surplus plutonium at Hanford. Therefore, only two facilities, the pit conversion and the immobilization facilities, would be needed to accomplish the surplus plutonium disposition mission. The pit conversion facility would be collocated with the immobilization facility in FMEF, as described for Alternative 2 in Section 2.6. However, all the plutonium dioxide produced in the pit conversion facility would be transferred to the immobilization facility, which would be operated at a higher throughput (5 t [5.5 tons] rather than 1.7 t [1.9 tons]) to accommodate the additional approximately 33 t (36 tons) of plutonium that would be received from the pit conversion facility. Also, the operating workforce at the immobilization facility would be increased as discussed in Section 4.20.2.3 to process the additional amount of material. Construction would commence around 2001 with the pit conversion facility, and would continue through completion of the modifications to the FMEF for the immobilization facility about 2005. Operations would commence in about 2004 with the pit conversion facility, and continue until about 2016, when the immobilization facility has completed its mission.

2.15.2 Alternative 11B

Pantex: Pit Conversion in New Construction
Hanford: Immobilization in FMEF and the HLW Vitrification Facility

This alternative would involve immobilizing all the nominal 50 t (55 tons) of surplus plutonium. Therefore, only two facilities, the pit conversion facility and the immobilization facility, would be needed to accomplish the surplus plutonium disposition mission. The pit conversion facility would be located at Pantex as described in Alternative 4A, Section 2.8.1, and the immobilization facility would be located at Hanford as described for Alternative 11A, in Section 2.15.1. All the plutonium dioxide produced in the pit conversion facility would be shipped to the immobilization facility, which would be operated as described in Section 2.15.1.

Construction would commence in about 2001 with the pit conversion facility at Pantex, and would continue through completion of the modifications to the FMEF at Hanford for the immobilization facility in about 2005. Operations would commence in about 2004 with the pit conversion facility, and continue until about 2016, when the immobilization facility has completed its mission.

2.16 ALTERNATIVE 12: 50-METRIC-TON IMMOBILIZATION; IMMOBILIZATION AT SRS; PIT CONVERSION AT PANTEX OR SRS

2.16.1 Alternative 12A

SRS: Pit Conversion in New Construction; Immobilization in New Construction and DWPF

This alternative would involve immobilizing all 50 t (55 tons) of surplus plutonium at SRS. Therefore, only two facilities, the pit conversion facility and the immobilization facility, would be needed to accomplish the surplus plutonium disposition mission. Both the pit conversion and immobilization facilities would be in new construction near the area currently designated for APSF in F-Area, as described in Section 2.7. In addition, the canister receipt area at DWPF in S-Area would be modified to accommodate receipt and processing of the canisters transferred from the immobilization facility for filling with vitrified HLW. The pit conversion and immobilization facilities would be the same as those described for Alternative 3 in Section 2.7, except that all the plutonium dioxide produced in the pit conversion facility would be transferred to the immobilization facility. To accommodate the additional 33 t (36 tons) of plutonium that would be received from the pit conversion facility, the immobilization facility would be operated at a higher throughput (5 t [5.5 tons] rather than 1.7 t [1.9 tons]), and the operating workforce at the immobilization facility would be increased as discussed in Section 4.22.2.3.

Construction would commence in about 2001 with the pit conversion facility, and continue through completion of the immobilization facility in about 2005. Operations would commence in about 2004 with the pit conversion facility, and continue until about 2016, when the immobilization facility has completed its mission.

2.16.2 [Section deleted because alternative deleted.]

2.16.3 Alternative 12B[22]

Pantex: Pit Conversion in New Construction
SRS: Immobilization in New Construction and DWPF

This alternative would involve immobilizing all the nominal 50 t (55 tons) of surplus plutonium. Therefore, only two facilities, the pit conversion facility and the immobilization facility, would be needed to accomplish the surplus plutonium disposition mission. The pit conversion facility would be located at Pantex as described in Alternative 4A, Section 2.8.1, and the immobilization facility would be located at SRS as described for Alternative 12A, in Section 2.16.1. All the plutonium dioxide produced in the pit conversion facility would be shipped to the immobilization facility, which would be operated as described in Section 2.16.1.

Construction would commence in about 2001 with the pit conversion facility at Pantex, and continue through completion of the immobilization facility at SRS in about 2005. Operations would commence in about 2004 with the pit conversion facility, and continue until about 2016, when the immobilization facility has completed its mission.

2.16.4 [Section deleted because alternative deleted.]

[22] This alternative was analyzed as Alternative 12C in the SPD Draft EIS; it has been renumbered as Alternative 12B because SPD Draft EIS Alternative 12B has been deleted.

2.17 LEAD ASSEMBLY FABRICATION AND POSTIRRADIATION EXAMINATION

Five sites are proposed for the fabrication of lead assemblies. They are LLNL, LANL, and three of the four candidate sites for the proposed surplus weapons-grade plutonium disposition activities: Hanford, INEEL (ANL–W facilities), and SRS.[23] These sites have the experience and facilities with safeguards Category I[24] and natural phenomenon hazards protection to handle the plutonium for fabricating the lead assemblies. After irradiation at McGuire, the lead assemblies may be examined at either ANL–W or ORNL. Sites considered for lead assembly activities are shown in Figure 2–1. Lead assembly fabrication and postirradiation examination would be implemented only if required to support NRC licensing activities and fuel qualification efforts. If the MOX fuel approach could be implemented without fabricating lead assemblies, or if DOE decides to immobilize all 50 t (55 tons) of surplus plutonium, then these activities would not occur. This section was developed using data provided by ORNL (O'Connor et al. 1998a–e).

2.17.1 Process Description

Lead assembly fabrication would involve the same basic process described for the full-scale fabrication of MOX fuel in Section 2.4.3.2. Although DOE plans to produce only 2 lead assemblies, as many as 10 could be produced at the lead assembly fabrication facility.[25] The fabrication effort would be implemented in existing facilities at the selected location, and the fabrication phase would be completed in about 3 years. Up to 4 fuel assemblies would be produced in any given year, for a maximum of 10 assemblies at the end of the 3-year fabrication phase. At this rate of production, about 100 kg (220 lb) plutonium would be made into MOX fuel each year. Including hot startup, a total of about 321 kg (708 lb) plutonium would be used. The plutonium would come from pits dismantled during the Pit Disassembly and Conversion Demonstration Project or from existing supplies of surplus metal and oxide at LANL. Two extra MOX fuel rods would be fabricated with each lead assembly to be maintained as unirradiated archives. The archived rods would be stored at the lead assembly facility until the completion of all the lead assembly fabrication, irradiation, and testing. The rods would then be shipped to the MOX facility for storage until it was determined that the rods were no longer needed as archived material for fuel qualification purposes. At that time, the archived rods would either be irradiated, or dismantled and the materials reused in the MOX fabrication process.

At the lead assembly fabrication site, plutonium dioxide would be blended with uranium dioxide originating from depleted uranium hexafluoride in DOE storage at, for example, the Portsmouth Gaseous Diffusion Plant, then formed into pellets, sintered, and loaded into rods. After fabrication, the rods would either be assembled into fuel assemblies and transported to the reactor, or transported as rods to the reactor site for insertion into special assemblies prior to irradiation. The lead assemblies would be inserted into the reactor during a refueling outage and left in the reactor for up to three fuel cycles. After removal from the reactor, the irradiated assemblies would be managed at the reactor site as spent fuel while cooling down for approximately 6 months. After the cooldown period, several fuel rods removed from the lead assemblies at the reactor site would be transported to ANL–W or ORNL for postirradiation examination. The rest of the rods would remain in the spent fuel pool and would be managed as spent nuclear fuel.

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[23] Pantex was not considered for lead assembly fabrication because it does not currently have any facilities capable of MOX fuel fabrication.

[24] DOE protects nuclear materials based on the relative attractiveness of the materials in constructing a weapon and/or improvised nuclear device. Category I facilities provide the highest level of safeguards and security.

[25] As discussed in Sections 2.18.2 and 4.27, should fewer lead assemblies than analyzed be fabricated or irradiated, the potential impacts would be lower than those described.

During postirradiation examination, several of the fuel rods would be subjected to a series of nondestructive and destructive tests to evaluate the physical and chemical changes to the fuel material and cladding resulting from irradiation. Activities would be conducted remotely, with the irradiated fuel rods inside a hot cell. Operators would remain outside the hot cell and would be shielded by the walls and windows of that cell. Any postirradiation examination activities and shipments would comply with the Consent Order and Settlement Agreement in Public Service Company of Colorado vs. Batt (if the work were performed at ANL–W) and all other applicable agreements and orders, including provisions concerning removal of the material from the applicable examination site and limits on the number of truck shipments to the site.

The lead assembly fabrication facility would be operational by October 2002, with the first lead assemblies available for insertion by late 2003. After lead assembly fabrication is completed, deactivation would take about 3 years and could involve conversion of the space for another mission or missions.

2.17.2 Lead Assembly Fabrication Siting Alternatives

If required, lead assembly fabrication and postirradiation examination would be conducted at operating DOE sites in facilities that can accommodate the proposed activities with minimal alteration of interior spaces, are authorized to handle plutonium, and are situated in hardened spaces of thick-walled concrete that meet the standards for processing special nuclear material. Areas of the buildings in which plutonium would be handled are designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with the processing of fissile and radioactive materials.

Security at these facilities, implemented at several levels, would provide maximum protection for the special nuclear materials. Each facility would be on an existing DOE site that has safeguards and security measures in place, including access control. In addition to DOE sitewide security services, each building in which special nuclear materials are handled has physical security and procedures commensurate with the amount and type of material authorized in the area. Physical barriers; access control systems; detection and alarm systems; procedures, including the two-person rule (requiring at least two people to be present during work with special nuclear materials in the facility); and personnel security measures, including security clearance investigations and access authorization levels—all ensure that special nuclear materials are adequately protected. Nuclear material control and accountability are ensured through a system for monitoring storage, processing, and transfers. At any time, the total amount of special nuclear material in each facility, or in any material balance area within a facility, would be known. As appropriate, closed-circuit television, intrusion detection, motion detection, and other automated methods are used as part of the material control and accountability program. Physical measurements and inspections of material are used to verify inventory records.

2.17.2.1 Hanford

The Fuel Assembly Area of FMEF, within Hanford's 400 Area (see Figures 2–2 and 2–20) has been proposed as a location for lead assembly fabrication. FMEF, also proposed as a candidate location for the pit conversion, immobilization, and MOX facilities, is described in detail in Section 2.6.

FMEF consists of several connected buildings. Building 427, the main part of the facility, is a six-level processing building with an attached mechanical wing on the west side and an emergency power wing on the northwest corner. The Fuel Assembly Area (Building 4862) is appended to the southeastern end of FMEF. This area is divided into two sections, the entry (administrative) wing, and the lower-level operations portion, the Fuel Assembly Area, designed for the fabrication of fuel assemblies for FFTF. The lower level of the Fuel Assembly Area would be used for fuel rod and assembly fabrication. The upper level contains independent ventilation equipment. Storage of plutonium feed materials would occur in the operating vaults of Building 427, or in reconfigured below-grade storage tubes in the Fuel Assembly Area.

2.17.2.2 ANL–W

ANL–W is in the southeast portion of INEEL (see Figure 2–3). Established in the mid-1950s, the facility had as its primary mission the support of advanced liquid metal reactor research. In 1995, ANL–W began conducting research in the treatment of DOE spent nuclear fuel and in technologies for reactor decontamination and decommissioning. The ZPPR Vault and Workroom (Building 775), ZPPR Reactor Cell (Building 776), Fuel Manufacturing Facility (FMF, Building 704), and Fuel Assembly and Storage Building, (FASB, Building 787) within ANL–W have been proposed to support lead assembly fabrication (see Figure 2–27). As discussed in Sections 2.17.3 and 2.17.3.1, postirradiation examination could also be conducted at ANL–W.

ZPPR began operations at ANL–W in 1969 and was placed on standby in 1989. The facility is large enough to enable core physics studies of full-scale breeder reactors. The principal experimental area has a very thick foundation and thick concrete walls covered with an earthen mound, and a sand/gravel/HEPA filter roof. FMF, adjacent to the ZPPR facility, is buried under an earthen mound similar to that of ZPPR. This facility is currently supporting a furnace and glovebox operation for the dismantlement of damaged ZPPR fuel plates and the packaging of recovered plutonium oxide for shipment. FMF is also used as a test site for the development of safeguards and security systems. ZPPR and FMF share security assets, including a common security area surrounded by security fences, perimeter intrusion detection, and alarm systems. ZPPR and FMF are both Safeguards Category I, hardened buildings which meet natural phenomenon protection requirements currently approved for handling special nuclear materials.

The ZPPR Workroom has been proposed for fuel manufacture and storage, and the ZPPR Reactor Cell, as the high-bay fuel assembly and inspection area. Space within FMF would be used for fuel storage. The FASB would also be used for lead assembly fabrication. This facility was constructed to provide space, equipment, and services for manufacturing fuel elements and components for an experimental breeder reactor. A metallurgical laboratory is housed in the building's west end. The FASB would provide controlled vault storage for special nuclear materials, including fuel assemblies.

2.17.2.3 SRS

SRS is in the southern portion of South Carolina, approximately 19 km (12 mi) south of Aiken (see Figure 2–5). Chemical processing facilities are situated within the F- and H-Canyon areas at SRS. Their primary mission was to separate special nuclear materials from spent reactor fuels and irradiated targets. A portion of the 221–H Canyon facility, located within the H-Area, has been proposed for the fabrication of lead assemblies (see Figure 2–28). This unused space originally constructed for the Uranium Solidification Facility (USF), was never completed. The 221–H facility is entirely within a protected safeguards and security area. Existing USF utilities, access control, administrative and laboratory space, and waste management systems would also be used for the proposed lead assembly fabrication activities.

2.17.2.4 LANL

LANL, in northern New Mexico, was established in 1943 to design, develop, and test nuclear weapons (see Figure 2–29). Its mission has expanded from the primary task of designing nuclear weapons to include nonnuclear defense programs and a broad array of nondefense programs. Current programs include research and development of nuclear safeguards and security, medium-energy physics, space nuclear systems, biomedicine, computational science, and lasers. As discussed in Section 2.17.1, the plutonium dioxide feed material for the lead assembly fabrication effort is expected to be produced at LANL.

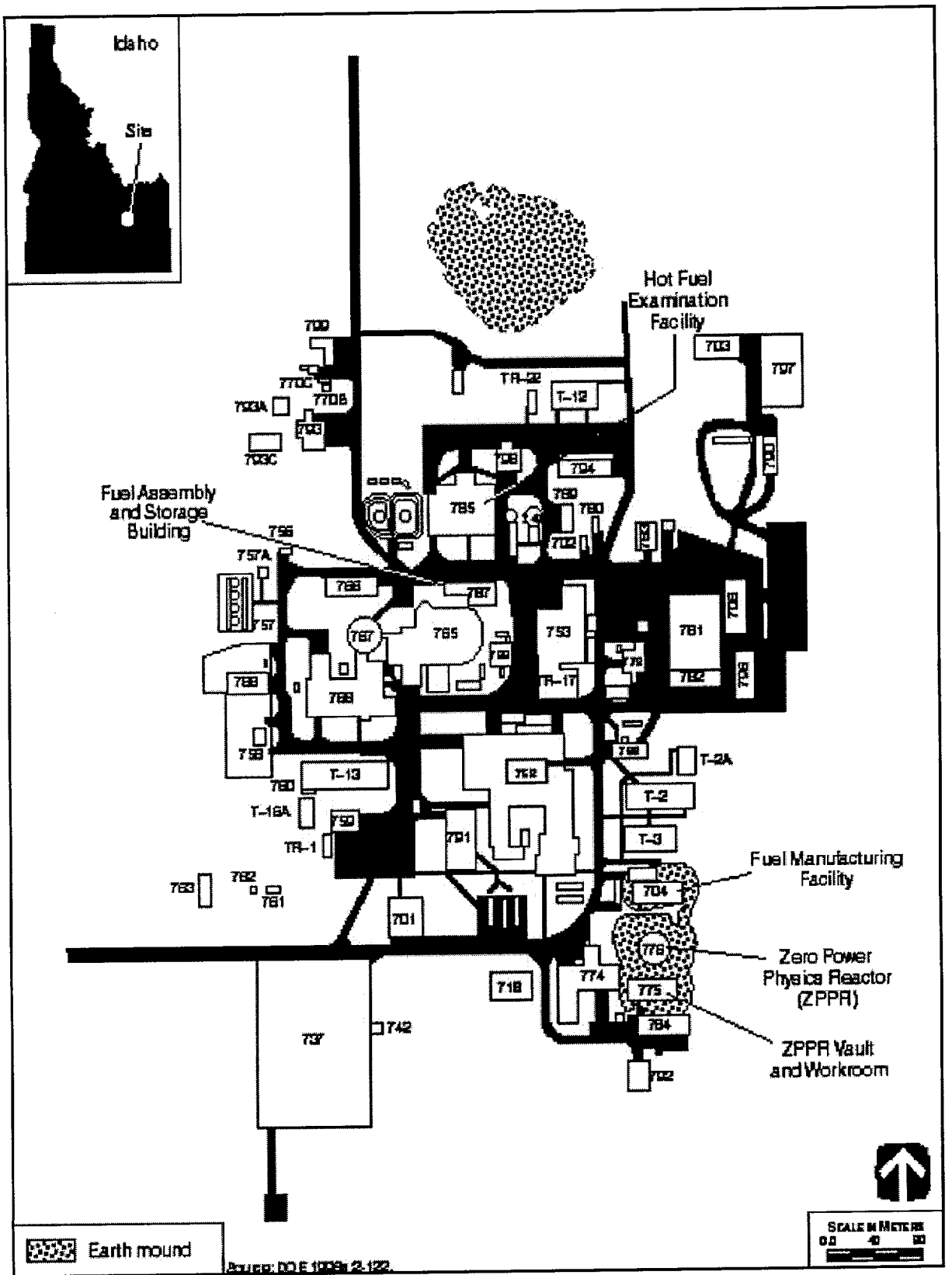

Figure 2–27. Proposed MOX Fuel Lead Assembly Fabrication Facilities, ANL–W at INEEL

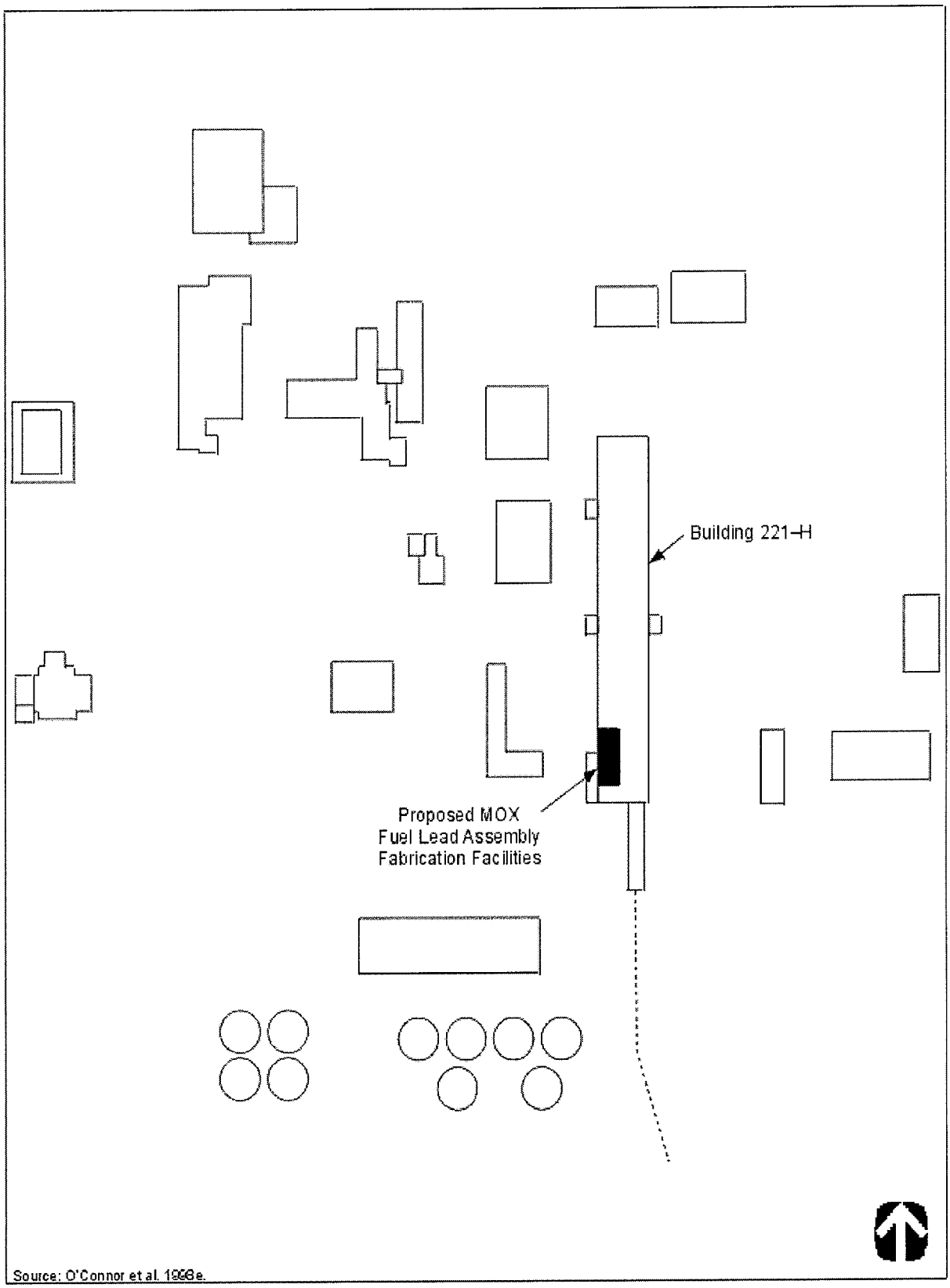

Figure 2–28. Proposed MOX Fuel Lead Assembly Fabrication Facilities, H-Area at SRS

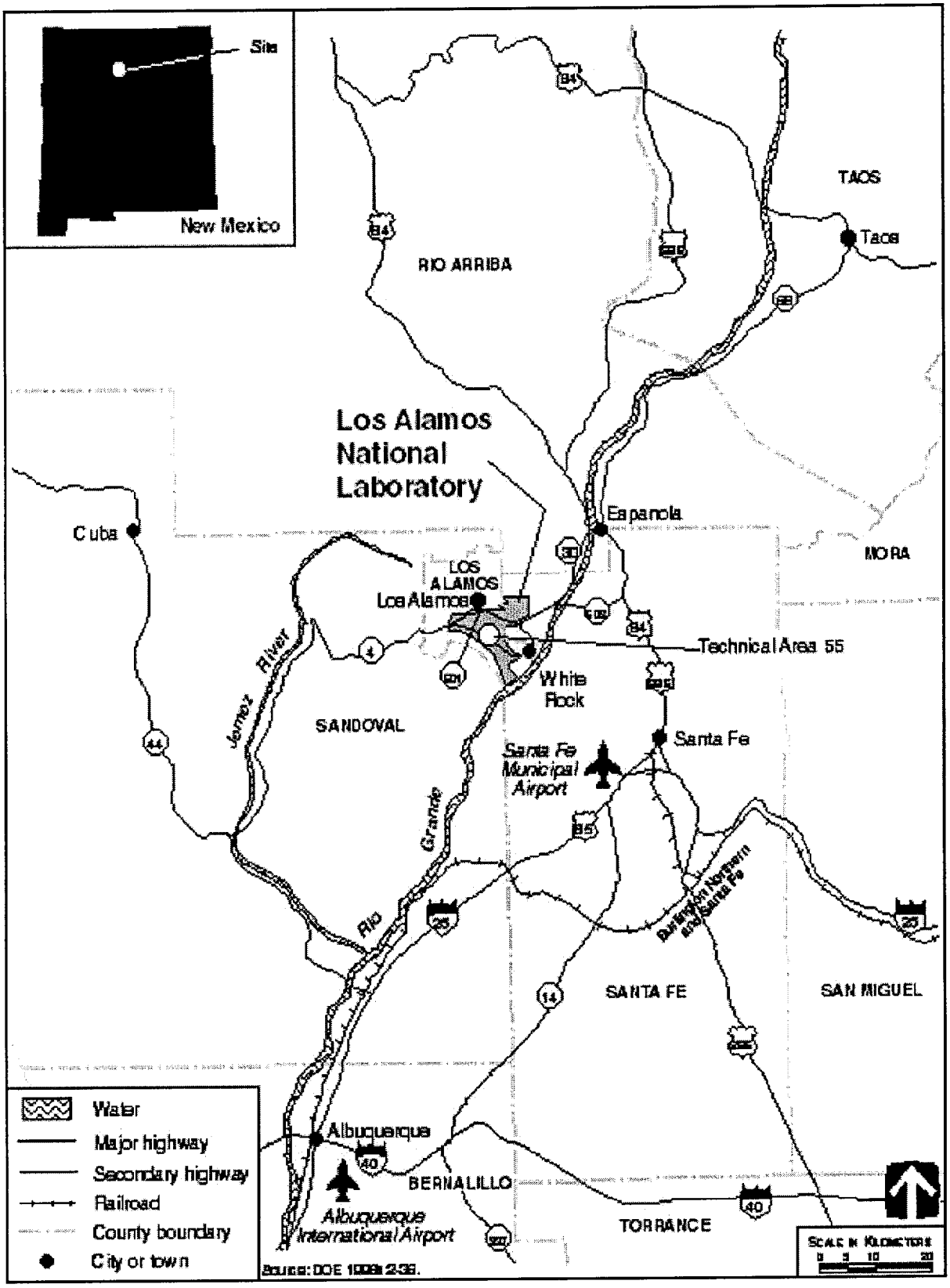

Figure 2–29. LANL, New Mexico

LANL consists primarily of Technical Areas, of which 49 are actively in use. With the exception of the bundle assembly and inspection activities proposed for the Radioactive Materials Research, Operations and Demonstration Facility in TA–50, the facilities proposed for lead assembly fabrication and storage of archived fuel rods are in Building PF–4 within TA–55 (see Figure 2–30). Most of TA–55, including the main complex, is inside a restricted area surrounded by a double security fence. In addition to Building PF–4, the TA–55 main complex consists of the Administration Building (PF–1), Support Office Building (PF–2), Support Building (PF–3), Warehouse (PF–5), and other miscellaneous support buildings.

Fuel fabrication activities have been proposed for currently operational fuel fabrication laboratories in Building PF–4, which became operational in 1978 for conducting state-of-the-art plutonium processing. Current activities in the building include plutonium recovery, fabrication of plutonium components, weapons disassembly, plutonium 238 and actinide processing, and fabrication of ceramic-based reactor fuels.

2.17.2.5 LLNL

The main LLNL site, originally a naval air training station, is approximately 80 km (50 mi) east of San Francisco and 6.4 km (4 mi) from downtown Livermore (see Figure 2–31). LLNL was established in 1952 to conduct nuclear weapons research. Its current mission is research, testing, and development focusing on national defense and security, energy, the environment, and biomedicine. Within recent years, LLNL's mission has broadened to include global security, ecology, and mathematics and science education.

Buildings 332, 334, and 335 are the three primary facilities proposed to support fabrication of lead assemblies. The Plutonium Facility (Building 332) is inside LLNL's Superblock, a 500-ft by 700-ft protected area surrounded by an alarmed double security fence (see Figure 2–32). Building 332 comprises several buildings constructed over the past three decades, including the Plenum Building, an office structure, plutonium-handling laboratories, mechanical shops, office space, a small nonradioactive materials laboratory, two plutonium storage vaults, and a cold machine shop. Current activities in the Plutonium Facility include the receipt, storage, and shipping of special nuclear materials; plutonium and fissile uranium operations and experiments; special nuclear material control and accountability; scrap recovery; and waste operations. For the lead assembly fabrication effort, Building 332 would be used to receive and store bulk plutonium dioxide powder, fabricate MOX pellets, and assemble fuel rods.

Building 334, adjacent to Building 332 in the Superblock, can handle maximum quantities of encapsulated special nuclear materials. This three-floor facility comprises the Engineering Test Bay (ETB) and the Radiation Measurements Facility (RMF). The ETB is used to conduct thermal and dynamic tests on weapon components; the RMF, located in the Intrinsic Radiation (INRAD) bay, to make intrinsic radiation measurements of various components. The INRAD and ETB bays provide primary and secondary confinement of radioactive material. For the proposed lead assembly fabrication, the ETB would be used for assembling, storing, packaging, and shipping fuel assemblies. Building 334 also contains analytical, metallography, scrap recovery, and other equipment to support the proposed activities.

Building 335, also adjacent to Building 332, is used as a staging area for nonradioactive equipment and systems being readied to move into Building 332. There are also areas for training, document storage, and change rooms, as well as access into the radioactive materials area of Building 332. For the lead assembly fabrication effort, Building 335 would be used for assembly and testing of equipment, storage of spare parts and supplies, and electrical and mechanical shop areas. The proposed activities can be accomplished within LLNL's administrative limits for uranium and plutonium inventory as identified in the *Supplement Analysis for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore* (DOE 1999c).

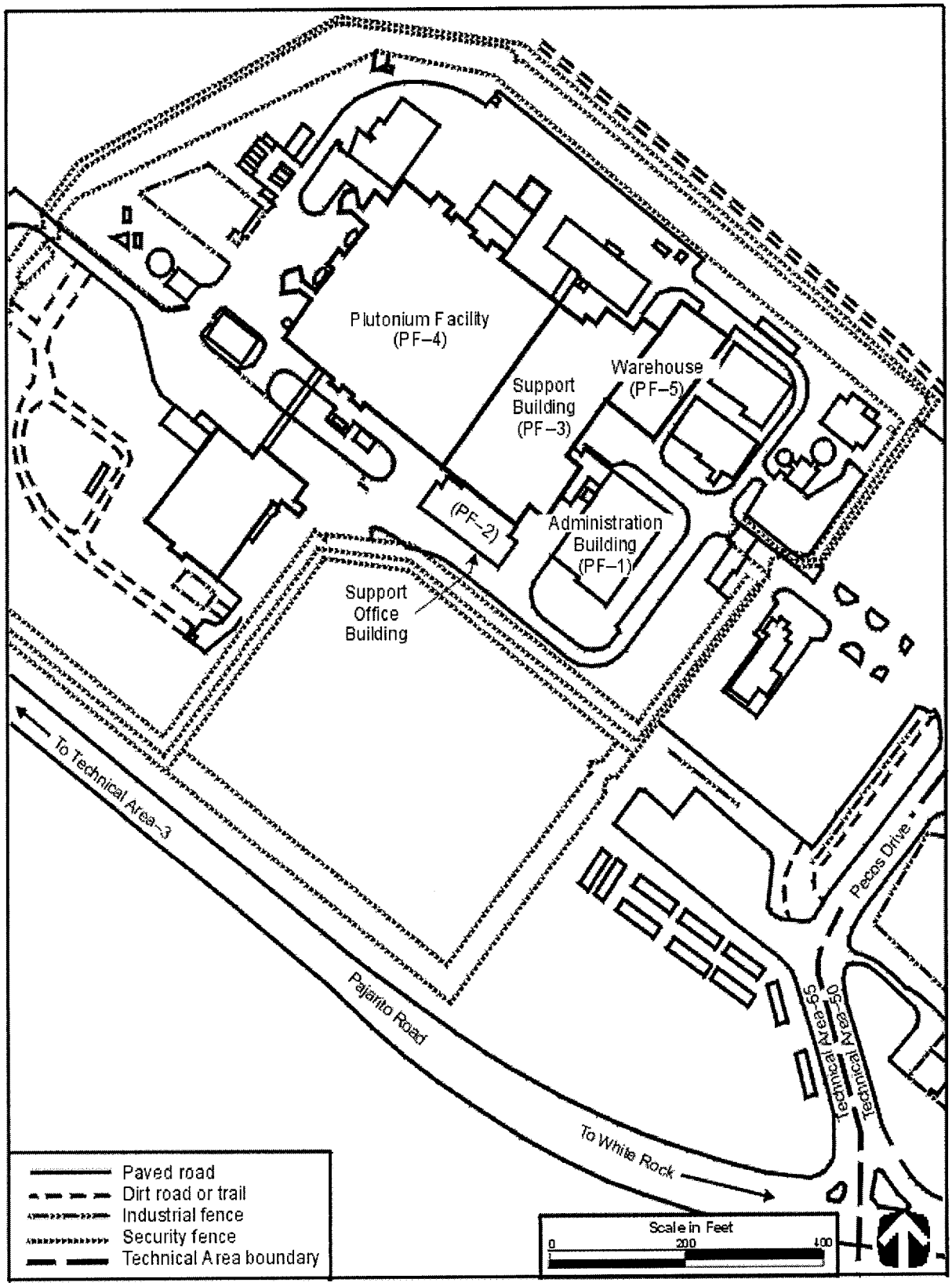

Figure 2–30. Proposed MOX Fuel Lead Assembly Fabrication Facilities, TA–55 at LANL

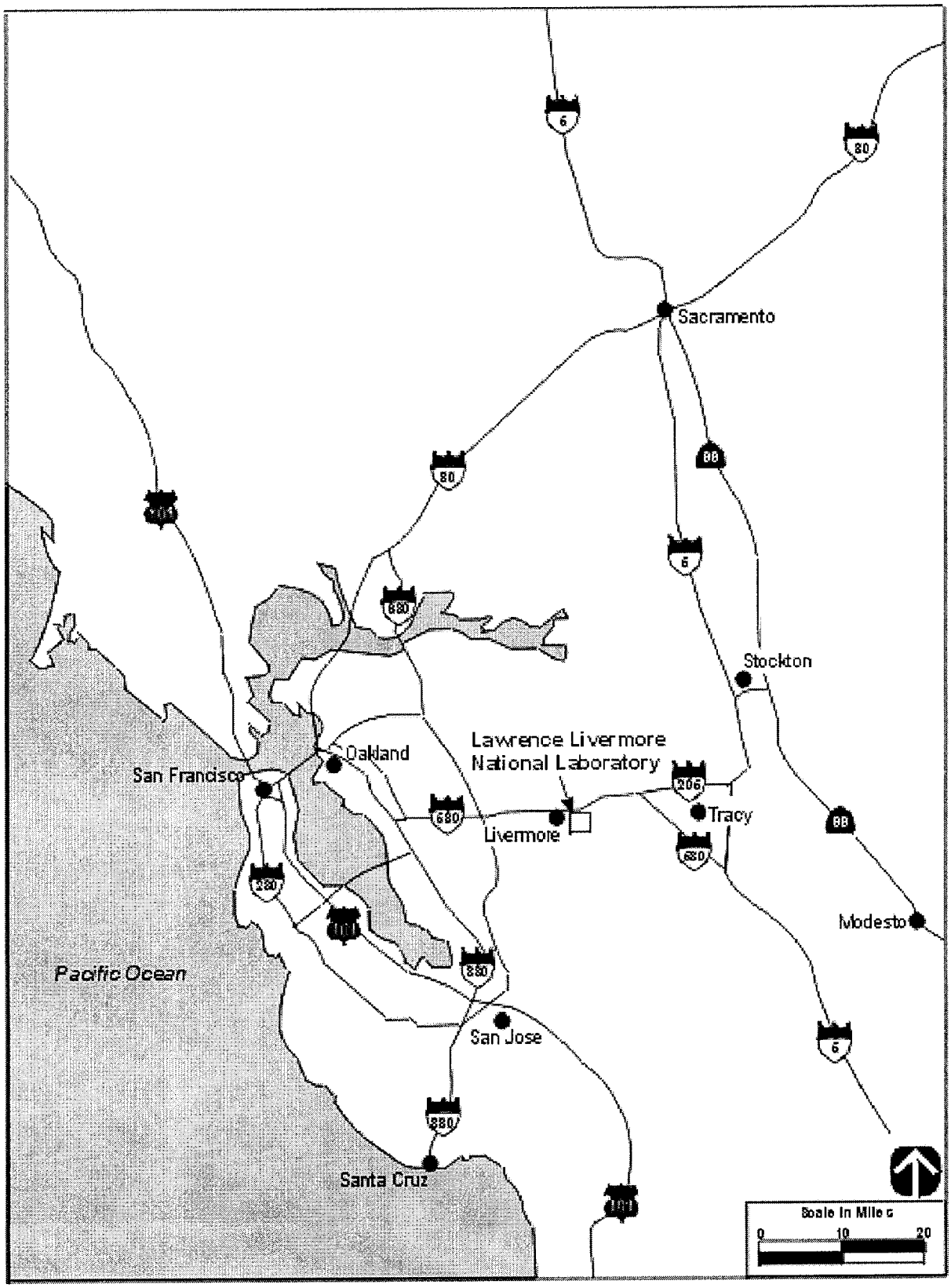

Figure 2–31. LLNL, California

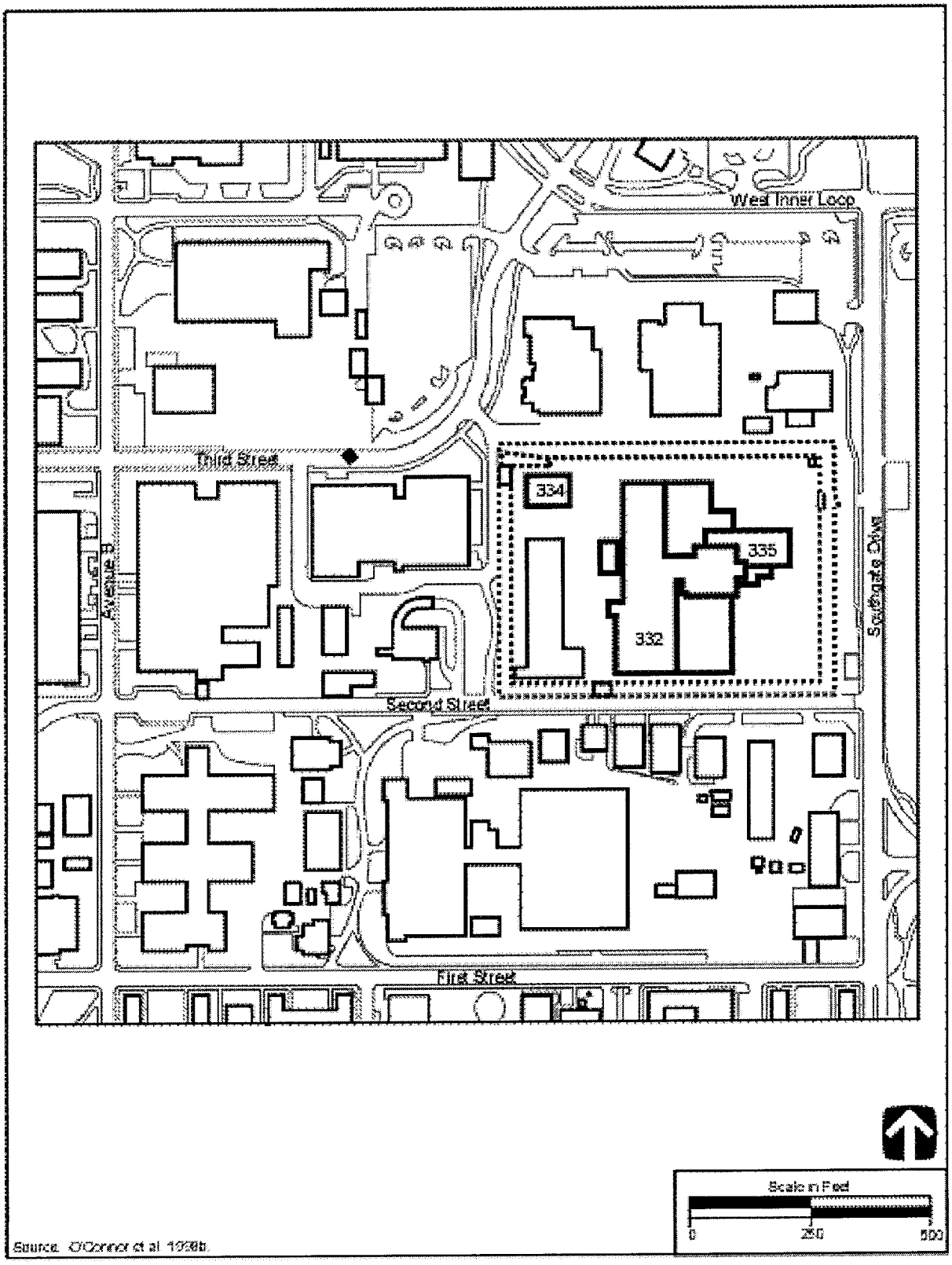

Figure 2–32. Proposed MOX Fuel Lead Assembly Fabrication Facilities, Superblock at LLNL

2.17.3 Postirradiation Examination Siting Alternatives

Postirradiation examination is used to collect information about fuel assemblies after irradiation. Tests on the lead assemblies would begin with remote nondestructive examination, which typically involves a visual examination of the fuel rods to detect signs of damage or wear, as well as the measurement of physical parameters such as length, diameter, and weight. The nondestructive tests would continue with more rigorous tests such as ultrasonic tests, x- or gamma spectroscopy, and neutron radiography. After completion of the nondestructive testing, which does not compromise the integrity of the material being examined, the rods would be subjected to destructive testing: they would be punctured to collect contained gases, then cut into segments for metallurgical and ceramographic testing, chemical analysis, electron microscopy, and other physical testing. Such tests, standard industry and research activities, would provide information on how the fuel material and the cladding responded to being inside the operating reactor. DOE proposes to conduct any required postirradiation examination at either ANL–W or ORNL because these facilities have hot cells (special facilities which are heavily shielded and have remote-handling equipment for working with highly radioactive materials) and testing equipment that are routinely required for these activities. Both sites currently process materials equivalent to those that would be handled during postirradiation examination of these lead assemblies. At either site, only minimal modifications to existing equipment would be required for acceptance of commercial-sized, full-length fuel rods.

Waste generated by destructive testing of the lead assemblies would be managed at the postirradiation examination site as TRU waste. Irradiated fuel rods sent to the postirradiation examination facility that are not destroyed in testing would be managed at the postirradiation examination site as spent fuel, in accordance with the site's spent fuel program. This spent fuel from the lead assembly program may be stored at the postirradiation examination site until transported to INEEL, where it would remain in storage pending disposition at a potential geologic repository pursuant to the NWPA.[26]

2.17.3.1 ANL–W

The Hot Fuel Examination Facility (HFEF) is a hot cell complex for the preparation and examination of irradiated experiments and the characterization and testing of waste forms from conditioning of spent fuel and waste. HFEF is located in a double-fenced compound on the ANL–W site at INEEL (see Figure 2–27). HFEF consists of two adjacent shielded hot cells, a shielded metallographic loading box, an unshielded Hot Repair Area and a Waste Characterization Area. The building is a three-story structure with a basement support area, and has a gross floor area of about 5,200 m^2 (56,000 ft^2).

The HFEF main cell is 21 m (70 ft) long by 9 m (30 ft) wide by 7.5 m (25 ft) high, and has an argon gas atmosphere. The cell is serviced by two electro-mechanical manipulators rated for 340 kg (750 lb) and two 5-ton bridge cranes. There are 15 workstations, each equipped with two master/slave manipulators.

The primary program at HFEF, since October 1994, has been the support of the Experimental Breeder Reactor II (EBR–II) defueling and decommissioning. HFEF was responsible for receiving all the fuel and blanket material from EBR–II and preparing the material for storage in the Radioactive Scrap and Waste Facility.

In addition to the handling of the EBR–II fuel, HFEF is the examination facility for both the metal and ceramic waste form experiments from the Fuel Conditioning Facility. In addition, equipment is being installed and

[26] Transportation and storage at INEEL would be in accordance with decisions made in the ROD for the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement.*

processes tested for the disposal of the plutonium and fission product waste from the conditioning of EBR–II fuel. The testing and characterization of the ceramic waste forms will be performed in HFEF.

HFEF is presently being modified to accept commercial-sized fuel assemblies. All the examination equipment in the cell and the cask handling systems are being modified to handle commercial sized casks and fuel rods for examination. These modification are expected to be complete in mid-1999.

2.17.3.2 ORNL

The Irradiated Fuels Examination Laboratory (IFEL), Building 3525, has been used for fuel research and examination. It is part of ORNL approximately 14 km (8 mi) southwest of the city of Oak Ridge, Tennessee. Over a period of three decades, this facility has handled a wide variety of fuels including aluminum clad research reactor fuel, both stainless and zircaloy clad LWR fuel, coated-particle gas cooled reactor fuel, and numerous one of a kind fuel test specimens. In addition, the facility has also done iridium isotope processing and irradiated capsule disassembly.

The IFEL contains a large horseshoe-shaped array of hot cells which are divided into three work areas. The hot cells are constructed of 3-ft thick concrete walls with oil-filled lead glass viewing windows. The inside of surfaces of the cell bank are lined with stainless steel to provide containment of particulate matter and to facilitate decontamination. Special penetrations are provided for the sealed entry of services such as instrument lines, lights, and electrical power. A pair of manipulators are located at each of 15 window stations for remote cell operations and periscopes allow for magnified views of in-cell objects. Heavy objects within each cell bank can be moved by electromechanical manipulators or a 3-ton crane. Fuel materials enter and leave the cells through three shielded transfer stations provided at the rear face of the North cell.

2.18 SUMMARY OF IMPACTS OF CONSTRUCTION AND OPERATION OF THE PROPOSED SURPLUS PLUTONIUM DISPOSITION FACILITIES

This section summarizes the potential impacts associated with the activities necessary to implement DOE's disposition strategy for surplus plutonium. The summary addresses the environmental information to be considered for each of the decisions contemplated as part of this strategy. This information is compiled from the analyses presented in Chapter 4 of this SPD EIS. Section 2.18.1 summarizes impacts related to the proposed surplus plutonium disposition facilities and provides that information by alternative, and within each alternative, by site. Summarized impacts are presented for the No Action Alternative as well as for each of the 15 alternatives that encompass the range of reasonable alternatives for both the 50-t (55-ton) immobilization and the hybrid approaches to plutonium disposition. Section 2.18.2 compares the potential impacts related to implementation of lead assembly fabrication at five candidate sites and postirradiation examination at two candidate sites. To provide an overview of the impacts associated with full implementation of the MOX fuel approach to disposition, Section 2.18.3 presents an integrated assessment of the potential impacts of the MOX facility, lead assembly fabrication, postirradiation examination, and use of the MOX fuel in domestic, commercial reactors. To facilitate the evaluation of proposed immobilization technologies, the final section compares the impacts associated with the can-in-canister immobilization technology with those described in the *Storage and Disposition PEIS* for the ceramic immobilization and vitrification alternatives.

2.18.1 Summary of Impacts by Alternative and Site

Table 2–4 summarizes the potential impacts of the No Action and surplus plutonium disposition facility alternatives on key environmental resource areas. In addition, the amount of land that would be disturbed and the potential impacts from facility accidents and transportation are summarized. Impacts are presented by

alternative, and within each alternative, by the affected site. For the No Action Alternative, sites that currently store surplus plutonium are included in the table.

Impacts on air quality are expected to be low for all alternatives. Table 2–4 provides the incremental criteria pollutant concentrations from surplus plutonium disposition operations for each alternative. In all cases, the incremental concentrations would contribute less than 2 percent of the applicable regulatory standard. Total site air concentrations, which also factor in the amount associated with the No Action Alternative,[27] would be no more than 21 percent of the annual applicable regulatory standard, with the highest occurring in the alternatives that would have the immobilization facility located at SRS. That particular value represents projected sulfur dioxide concentrations as a percent of the annual National Ambient Air Quality Standards; the corresponding value for the No Action Alternative is also 21 percent, demonstrating that the increment associated with plutonium disposition facilities would be very small.[28]

Expected waste generation by alternative is estimated for TRU waste, LLW, mixed LLW, hazardous waste, and nonhazardous waste[29] from construction activities and 10 years of expected facility operation. As shown in Chapter 4, impacts associated with management of nonhazardous wastes would be minor and would not tend to be a discriminator among alternatives.

TRU waste generation would range from 1,400 m^3 (1,832 yd^3) to 1,810 m^3 (2,368 yd^3), and LLW generation would range from 1,700 m^3 (2,224 yd^3) to 2,400 m^3 (3,140 yd^3). Mixed waste generation would range from 20 m^3 (26 yd^3) for immobilizing all 50 t (55 tons) (Alternatives 11A, 11B, 12A, and 12B) to 50 m^3 (65 yd^3) for each of the hybrid alternatives. Hazardous waste generation would range from 770 m^3 (1,007 yd^3) (Alternatives 11A and 11B) to 940 m^3 (1,230 yd^3) (Alternatives 3, 5, 6A, 6B, 7, and 9).

Impacts on the waste management infrastructure from implementing alternatives for surplus plutonium disposition are expected to be minor. All of the waste expected to be generated from the different alternatives analyzed could be accommodated within existing or planned capacities for waste treatment, storage, and disposal at all of the candidate sites, except for TRU waste at Pantex. At Pantex, a maximum of 860 m^3 (1,125 yd^3) of TRU waste would be generated under Alternative 9 or 10. Because TRU waste is not routinely generated and stored at Pantex, TRU waste storage space would be designated within the pit conversion and MOX facilities. TRU waste would be shipped to WIPP near Carlsbad, New Mexico, for disposal.

Although the proposed facilities are still in the early stages of engineering and design, the surplus plutonium disposition program would integrate pollution prevention practices that include waste stream minimization, source reduction, and recycling, as well as DOE procurement processes that preferentially procure products made from recycled materials. The proposed facility designs would minimize the size of radiologically controlled areas, thereby minimizing the generation of radioactive waste. To the extent practical, solvents or other chemicals which, after use, are regulated by the Resource Conservation and Recovery Act would not be used at the DOE facilities, thereby minimizing the amount of hazardous and mixed waste generated. Wastewater would be recycled to the extent possible to minimize effluent discharge.

The employment column of Table 2–4 summarizes the number of direct jobs that would be generated by the proposed facilities under each alternative. All the action alternatives would generate employment opportunities

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[27] As indicated in Appendix G, the No Action Alternative projects air emissions to the year 2005, when plutonium disposition facility operations under the disposition alternatives would begin, and includes emissions from existing and other planned facilities.

[28] This conclusion assumes that activity levels under the No Action Alternative remain the same beyond 2005.

[29] Waste type definitions may be found in Appendix F.8.

at the facilities. Expected annual peak construction employment ranges from 463 workers (Alternative 11A) to 2,143 workers (Alternative 5).[30] Annual employment during operations would range from 751 workers (Alternatives 12A and 12B) to 1,165 workers (Alternatives 2 and 4B).

Potential effects on human health from facility construction, 10 years of operation, postulated facility accidents and intersite transportation of radioactive materials are also summarized in Table 2–4. Doses to workers from the construction and 10 years of routine operation of the three surplus plutonium disposition facilities at DOE sites would result in up to 2.0 latent cancer fatalities (LCFs) for both the hybrid alternatives and the 50-t (55-ton) immobilization alternatives. No LCFs would be expected to occur in the general population during routine operations. Under the No Action Alternative, continued storage of the surplus plutonium would also not result in any LCFs to the general population during routine operations. Doses to workers from the long-term storage (up to 50 years) of the surplus plutonium would result in up to 2.4 LCFs.

Table 2–4 presents the results of the analysis of the most severe nonreactor design basis accident scenario. For Alternative 4B, a criticality in the MOX facility would result in the most severe consequences. For all other alternatives except the No Action Alternative, a design basis fire in the pit conversion facility resulting in a tritium release would result in the most severe consequences. However, no design basis accident would be expected to result in LCFs in the general population.

No major consequences for the maximally exposed involved worker would be expected from leaks, spills, and smaller fires. These accidents are such that involved workers would either be able to evacuate immediately or would not be affected by the events. Explosions, on the other hand, could result in immediate injuries from flying debris, as well as the uptake of plutonium and uranium particulates through inhalation. If a criticality were to occur, workers within tens of meters could receive very high to fatal radiation exposures from the initial burst. The dose would strongly depend on the magnitude of the criticality (number of fissions), the distance from the criticality, and the amount of shielding provided by the structures and equipment between the workers and the criticality. Beyond-design-basis earthquakes would also have substantial consequences, ranging from workers being killed by debris from collapsing equipment and structures to high radiation exposures and uptakes of radionuclides. For most accidents, immediate emergency response actions should reduce the consequences to workers near the accident.

Materials transportation is analyzed to determine potential radiological and nonradiological impacts from routine and accident conditions. These results are summarized in Table 2–4. Transportation includes the movement of surplus plutonium from storage and among the proposed disposition facilities; depleted uranium hexafluoride from, for example, Portsmouth to a conversion facility; uranium dioxide from the conversion facility to the immobilization and/or MOX facilities; recovered HEU from the pit conversion facility to ORR; MOX fuel to Catawba, McGuire, and North Anna; spent nuclear fuel resulting from lead assembly irradiation at McGuire to the postirradiation examination site and then to storage at INEEL; and the immobilized plutonium to a potential geologic repository.[31] No traffic fatalities from nonradiological accidents or LCFs from radiological exposures or vehicle emissions would be expected. For the hybrid alternatives, the number of trips would range from 1,917 (Alternative 10) to 2,530 (Alternatives 3, 6A, 6B, and 7), and the cumulative distances traveled would range from 3.6 million km (2.2 million mi) (Alternative 10) to 8.7 million km (5.4 million mi) (Alternatives 6A and 6B).

[30] These values represent the combined peak annual construction workforce at each site. Peak construction employment under Alternative 11A is composed of the 463 construction workers at Hanford in 2003. Peak construction employment under Alternative 5 is composed of the 451 construction workers at Pantex in 2002 and the 1,692 construction workers at SRS in 2003.

[31] Shipments of spent fuel to the potential geologic repository are analyzed in the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250D) (DOE 1999b).

Immobilization-only alternatives would require from 1,877 trips for Alternative 11B to 2,236 trips for Alternative 12A. Cumulative distances traveled for the immobilization-only alternatives would range from 2.5 million km (1.5 million mi) (Alternative 11B) to 4.4 million km (2.7 million mi) (Alternative 12A).

Table 2–4 also provides the total land area that would be disturbed at each site for each alternative. Land disturbance relates directly to impacts on ecological resources, cultural resources, geology and soils, and land use and visual resources. The amount of land that would be disturbed for the hybrid alternatives would range from 19 hectares (47 acres) in Alternative 8, to 32 hectares (79 acres) in Alternatives 3, 5, and 9. Because these land areas are in or adjacent to previously disturbed areas and represent a very small percent of the land available at the candidate sites, the impacts on geology and soils and land use would be minor. Land disturbance associated with immobilizing approximately 50 t (55 tons) of surplus plutonium would range from 9.5 hectares (23 acres) in Alternative 11B, to 20 hectares (49 acres) in Alternative 12A or 12B. Construction and operation of the proposed facilities would not effect a significant change in any natural features of visual interest in the area of any of the candidate sites. No major impact is anticipated for any threatened or endangered species because there have been no sightings near the proposed facility locations at the candidate sites. Cultural resource impacts would be minor at all sites because at all sites except SRS, construction of facilities would be in mostly disturbed or developed areas; at SRS, cultural resource areas would be avoided. Archaeological investigations near F-Area have discovered five sites that could be impacted by construction of surplus plutonium disposition facilities. Two of these sites have been recommended to the South Carolina State Historic Preservation Officer (SHPO) as eligible for nomination to the National Register of Historic Places. Potential adverse impacts could be mitigated through either avoidance or data recovery. DOE currently plans to mitigate impacts by avoiding sites that are eligible or potentially eligible for nomination to the National Register. Cultural resource compliance activities would be conducted in accordance with the *Programmatic Memorandum of Agreement for the Savannah River Site* (SRARP 1989:179–188).

Impacts were also assessed on water availability and quality and infrastructure including requirements for roads, electricity, and fuel. These evaluations indicated that all impacts would be minor. [Text deleted.] None of the alternatives were found to pose a significant risk (when probability is considered) to the general population, nor would implementation of any of the alternatives result in a significant risk of disproportionately high and adverse impacts on minority or low-income groups within the general population.

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 1: No Action							
Hanford	No change	No change	No change	None	Dose Public: 4.7×10^{-2} Workers: 46 LCFs Public: 1.2×10^{-3} Workers: 0.92	NA	None
INEEL	No change	No change	No change	None	Dose Public: 7.6×10^{-5} Workers: 1.5 LCFs Public: 1.9×10^{-6} Workers: 2.9×10^{-2}	NA	None
Pantex	No change	No change	No change	None	Dose Public: 6.3×10^{-6} Storage Workers: 3 Packaging Workers: 16 LCFs Public: 1.6×10^{-7} Storage Workers: 6.0×10^{-2} Packaging Workers: 6.4×10^{-2}	NA	None

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
SRS	No change	No change	No change	None	Dose Public: 2.9×10^{-4} Workers: 7.5 LCFs Public: 7.2×10^{-6} Workers: 0.15	NA	None
LLNL	No change	No change	No change	None	Dose Public: 6.7×10^{-3} Workers: 25 LCFs Public: 1.7×10^{-4} Workers: 0.50	NA	None
LANL	No change	No change	No change	None	Dose Public: 2.7 Workers: 12.5 LCFs Public: 6.8×10^{-2} Workers: 0.25	NA	None
RFETS	No change	No change	No change	None	Dose Public: 0.10 Workers: 25 LCFs Public: 2.5×10^{-3} Workers: 0.50	NA	None

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 2: Pit Conversion in FMEF, Immobilization in FMEF and HLWVF, and MOX in New Construction at Hanford							
Hanford	CO: 0.651 NO_2: 0.0873 PM_{10}: 0.00541 SO_2: 0.00496	TRU: 1,800 LLW: 2,300 MLLW: 50 Haz: 800	Construction: 1,235 Operations: 1,165	22	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 7.2 Workers: 488 LCFs Public: 3.6×10^{-2} Workers: 2.0	Tritium release at pit conversion facility: 0.11 LCF	LCFs: 6.1×10^{-2} Traffic fatalities: 7.4×10^{-2} Kilometers traveled: 7.5M Additional risk of LCFs at Pantex: 8.3×10^{-2}

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 3: Pit Conversion, Immobilization, and MOX in New Construction at SRS							
SRS	CO: 0.37 NO_2: 0.0634 PM_{10}: 0.00423 SO_2: 0.124	TRU: 1,800 LLW: 2,400 MLLW: 50 Haz: 940	Construction: 1,968 Operations: 1,120	32 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 4.1 LCFs: 1.6×10^{-3} Operations Dose Public: 1.8 Workers: 456 LCFs Public: 9.0×10^{-3} Workers: 1.8	Tritium release at pit conversion facility: 5.0×10^{-2} LCF	LCFs: 8.1×10^{-2} Traffic fatalities: 5.3×10^{-2} Kilometers traveled: 4.3M Additonal risk of LCFs at Pantex: 8.3×10^{-2}
[Text deleted because alternative deleted.][h]							

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 4A: Pit Conversion in New Construction at Pantex, and Immobilization in FMEF and HLWVF and MOX in New Construction at Hanford							
Pantex	CO: 0.381 NO_2: 0.0374 PM_{10}: 0.00215 SO_2: 0.00064	TRU: 180 LLW: 600 MLLW: 10 Haz: 20	Construction: 451 Operations: 400	5.0	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.58 Workers: 192 LCFs Public: 2.9×10^{-3} Workers: 0.77	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 5.7×10^{-2} Traffic fatalities: 6.5×10^{-2} Kilometers traveled: 6.3M Additional risk of LCFs at Pantex: 0
Hanford	CO: 0.374 NO_2: 0.052 PM_{10}: 0.00367 SO_2: 0.00343	TRU: 1,600 LLW: 1,700 MLLW: 40 Haz: 780	Construction: 1,148 Operations: 720	16	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.30 Workers: 264 LCFs Public: 1.5×10^{-3} Workers: 1.1	Nuclear criticality at MOX facility: 1.9×10^{-2} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 4B: Pit Conversion in New Construction at Pantex, and Immobilization in FMEF and HLWVF and MOX in FMEF at Hanford							
Pantex	CO: 0.381 NO_2: 0.0374 PM_{10}: 0.00215 SO_2: 0.00064	TRU: 180 LLW: 600 MLLW: 10 Haz: 20	Construction: 451 Operations: 400	5.0	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.58 Workers: 192 LCFs Public: 2.9×10^{-3} Workers: 0.77	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 5.7×10^{-2} Traffic fatalities: 6.5×10^{-2} Kilometers traveled: 6.3M Additional risk of LCFs at Pantex: 0
Hanford	CO: 0.507 NO_2: 0.0707 PM_{10}: 0.00499 SO_2: 0.00468	TRU: 1,600 LLW: 1,700 MLLW: 40 Haz: 780	Construction: 1,064 Operations: 765	17.4	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.15 Workers: 296 LCFs Public: 7.3×10^{-4} Workers: 1.2	Nuclear criticality at MOX or immobilization facility: 1.9×10^{-2} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 5: Pit Conversion in New Construction at Pantex, and Immobilization in New Construction and DWPF and MOX in New Construction at SRS							
Pantex	CO: 0.381 NO_2: 0.0374 PM_{10}: 0.00215 SO_2: 0.00064	TRU: 180 LLW: 600 MLLW: 10 Haz: 20	Construction: 451 Operations: 400	5.0	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.58 Workers: 192 LCFs Public: 2.9×10^{-3} Workers: 0.77	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 7.7×10^{-2} Traffic fatalities: 5.0×10^{-2} Kilometers traveled: 3.8M Additional risk of LCFs at Pantex: 0
SRS	CO: 0.275 NO_2: 0.0347 PM_{10}: 0.0024 SO_2: 0.0829	TRU: 1,600 LLW: 1,800 MLLW: 40 Haz: 920	Construction: 1,692 Operations: 720	27 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 2.7 LCFs: 1.1×10^{-3} Operations Dose Public: 1.8×10^{-2} Workers: 264 LCFs Public: 9.2×10^{-4} Workers: 1.1	Nuclear criticality at MOX facility: 8.0×10^{-3} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 6A: Pit Conversion in FMEF and MOX in New Construction at Hanford, and Immobilization in New Construction and DWPF at SRS							
Hanford	CO: 0.247 NO_2: 0.031 PM_{10}: 0.00143 SO_2: 0.00123	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 844 Operations: 785	14	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 7.2 Workers: 214 LCFs Public: 3.6×10^{-2} Workers: 0.86	Tritium release at pit conversion facility: 0.11 LCF	LCFs: 9.6×10^{-2} Traffic fatalities: 9.1×10^{-2} Kilometers traveled: 8.6M Additional risk of LCFs at Pantex: 8.3×10^{-2}
SRS	CO: 0.152 NO_2: 0.0242 PM_{10}: 0.00181 SO_2: 0.0442	TRU: 950 LLW: 810 MLLW: 10 Haz: 890	Construction: 1,014 Operations: 335	15 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 1.5 LCFs: 6.0×10^{-4} Operations Dose Public: 2.8×10^{-3} Workers: 242 LCFs Public: 1.4×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 8.0×10^{-4} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 6B: Pit Conversion and MOX Collocated in FMEF at Hanford, and Immobilization in New Construction and DWPF at SRS							
Hanford	CO: 0.247 NO_2: 0.031 PM_{10}: 0.00143 SO_2: 0.00123	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 655 Operations: 785	14	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 7.0 Workers: 214 LCFs Public: 3.5×10^{-2} Workers: 0.86	Tritium release at pit conversion facility: 0.11 LCF	LCFs: 9.6×10^{-2} Traffic fatalities: 9.1×10^{-2} Kilometers traveled: 8.6M Additional risk of LCFs at Pantex: 8.3×10^{-2}
SRS	CO: 0.152 NO_2: 0.0242 PM_{10}: 0.00181 SO_2: 0.0442	TRU: 950 LLW: 810 MLLW: 10 Haz: 890	Construction: 1,014 Operations: 335	15 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 1.5 LCFs: 6.0×10^{-4} Operations Dose Public: 2.8×10^{-3} Workers: 242 LCFs Public: 1.4×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 8.0×10^{-4} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 7: Pit Conversion in FPF and MOX in New Construction at INEEL, and Immobilization in New Construction and DWPF at SRS							
INEEL	CO: 0.762 NO_2: 0.144 PM_{10}: 0.00833 SO_2: 0.345	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 866 Operations: 743	14	Construction (workforce) Dose: 2.0 LCFs: 7.7×10^{-4} Operations Dose Public: 2.2 Workers: 192 LCFs Public: 1.1×10^{-2} Workers: 0.77	Tritium release at pit conversion facility: 4.4×10^{-3} LCF	LCFs: 9.4×10^{-2} Traffic fatalities: 8.3×10^{-2} Kilometers traveled: 7.5M Additional risks of LCFs at Pantex: 8.3×10^{-2}
SRS	CO: 0.152 NO_2: 0.0242 PM_{10}: 0.00181 SO_2: 0.0442	TRU: 950 LLW: 810 MLLW: 10 Haz: 890	Construction: 1,014 Operations: 335	15 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 1.5 LCFs: 6.0×10^{-4} Operations Dose Public: 2.8×10^{-3} Workers: 242 LCFs Public: 1.4×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 8.0×10^{-4} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 8: Pit Conversion in FPF and MOX in New Construction at INEEL, and Immobilization in FMEF and HLWVF at Hanford							
INEEL	CO: 0.762 NO_2: 0.144 PM_{10}: 0.00833 SO_2: 0.345	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 866 Operations: 743	14	Construction (workforce) Dose: 2.0 LCFs: 7.7×10^{-4} Operations Dose Public: 2.2 Workers: 192 LCFs Public: 1.1×10^{-2} Workers: 0.77	Tritium release at pit conversion facility: 4.4×10^{-3} LCF	LCFs: 5.9×10^{-2} Traffic fatalities: 6.5×10^{-2} Kilometers traveled: 6.3M Additional risks of LCFs at Pantex: 8.3×10^{-2}
Hanford	CO: 0.271 NO_2: 0.0376 PM_{10}: 0.00265 SO_2: 0.00249	TRU: 950 LLW: 800 MLLW: 10 Haz: 750	Construction: 414 Operations: 335	4.5	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 7.8×10^{-3} Workers: 242 LCFs Public: 3.9×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 2.7×10^{-3} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 9: Pit Conversion and MOX in New Construction at Pantex, and Immobilization in New Construction and DWPF at SRS							
Pantex	CO: 0.705 NO_2: 0.0736 PM_{10}: 0.00531 SO_2: 0.00265	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 1,048 Operations: 785	17	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.61 Workers: 214 LCFs Public: 3.0×10^{-3} Workers: 0.86	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 8.1×10^{-2} Traffic fatalities: 5.2×10^{-2} Kilometers traveled: 4.8M Additional risk of LCFs at Pantex: 0
SRS	CO: 0.152 NO_2: 0.0242 PM_{10}: 0.00181 SO_2: 0.0442	TRU: 950 LLW: 810 MLLW: 10 Haz: 890	Construction: 1,014 Operations: 335	15 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 1.5 LCFs: 6.0×10^{-4} Operations Dose Public: 2.8×10^{-3} Workers: 242 LCFs Public: 1.4×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 8.0×10^{-4} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 10: Pit Conversion and MOX in New Construction at Pantex, and Immobilization in FMEF and HLWVF at Hanford							
Pantex	CO: 0.705 NO_2: 0.0736 PM_{10}: 0.00531 SO_2: 0.00265	TRU: 860 LLW: 1,500 MLLW: 40 Haz: 50	Construction: 1,048 Operations: 785	17	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.61 Workers: 214 LCFs Public: 3.0×10^{-3} Workers: 0.86	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 4.6×10^{-2} Traffic fatalities: 4.3×10^{-2} Kilometers traveled: 3.6M Additional risk of LCFs at Pantex: 0
Hanford	CO: 0.271 NO_2: 0.0376 PM_{10}: 0.00265 SO_2: 0.00249	TRU: 950 LLW: 800 MLLW: 10 Haz: 750	Construction: 414 Operations: 335	4.5	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 7.8×10^{-3} Workers: 242 LCFs Public: 3.9×10^{-5} Workers: 0.97	Nuclear criticality at immobilization facility: 2.7×10^{-3} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 11A: Pit Conversion in FMEF and Immobilization in FMEF and HLWVF at Hanford (No MOX)							
Hanford	CO: 0.548 NO_2: 0.0729 PM_{10}: 0.0044 SO_2: 0.00401	TRU: 1,400 LLW: 1,700 MLLW: 20 Haz: 770	Construction: 463 Operations: 812	11	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 6.9 Workers: 490 LCFs Public: 3.4×10^{-2} Workers: 2.0	Tritium release at pit conversion facility: 0.11 LCF	LCFs: 7.4×10^{-2} Traffic fatalities: 5.4×10^{-2} Kilometers traveled: 3.7M Additional risk of LCFs at Pantex: 8.3×10^{-2}

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 11B: Pit Conversion in New Construction at Pantex and Immobilization in FMEF and HLWVF at Hanford (No MOX)							
Pantex	CO: 0.381 NO_2: 0.0374 PM_{10}: 0.00215 SO_2: 0.00064	TRU: 180 LLW: 600 MLLW: 10 Haz: 20	Construction: 451 Operations: 400	5.0	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.58 Workers: 192 LCFs Public: 2.9×10^{-3} Workers: 0.77	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 7.07×10^{-2} Traffic fatalities: 4.5×10^{-2} Kilometers traveled: 2.5M Additional risk of LCFs at Pantex: 0
Hanford	CO: 0.271 NO_2: 0.0376 PM_{10}: 0.00265 SO_2: 0.00249	TRU: 1,300 LLW: 1,100 MLLW: 10 Haz: 750	Construction: 414 Operations: 367	4.5	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 1.6×10^{-2} Workers: 266 LCFs Public: 8.0×10^{-5} Workers: 1.1	Nuclear criticality at immobilization facility: 2.7×10^{-3} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 12A: Pit Conversion in New Construction and Immobilization in New Construction and DWPF at SRS (No MOX)							
SRS	CO: 0.246 NO_2: 0.0529 PM_{10}: 0.00364 SO_2: 0.0852	TRU: 1,500 LLW: 1,700 MLLW: 20 Haz: 910	Construction: 1,196 Operations: 751	20 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 2.9 LCFs: 1.2×10^{-3} Operations Dose Public: 1.6 Workers: 446 LCFs Public: 8.0×10^{-3} Workers: 1.8	Tritium release at pit conversion facility: 5.0×10^{-2} LCF	LCFs: 0.152 Traffic fatalities: 8.1×10^{-2} Kilometers traveled: 4.4M Additional risk of LCFs at Pantex: 8.3×10^{-2}

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

Site	Air Quality[a] (incremental pollutant concentrations in g/m^3)	Waste Management[b] (m^3)	Employment[c] (direct)	Land Disturbance[d] (ha)	Human Health Risk[e] (dose in person-rem)	Facility Accidents[f]	Transportation[g]
Alternative 12B: Pit Conversion in New Construction at Pantex, and Immobilization in New Construction and DWPF at SRS (No MOX)							
Pantex	CO: 0.381 NO_2: 0.0374 PM_{10}: 0.00215 SO_2: 0.00064	TRU: 180 LLW: 600 MLLW: 10 Haz: 20	Construction: 451 Operations: 400	5.0	Construction (workforce) Dose: 0 LCFs: 0 Operations Dose Public: 0.58 Workers: 192 LCFs Public: 2.9×10^{-3} Workers: 0.77	Tritium release at pit conversion facility: 1.8×10^{-2} LCF	LCFs: 0.148 Traffic fatalities: 7.8×10^{-2} Kilometers traveled: 3.9M Additional risk of LCFs at Pantex: 0
SRS	CO: 0.152 NO_2: 0.0242 PM_{10}: 0.00181 SO_2: 0.0442	TRU: 1,300 LLW: 1,100 MLLW: 10 Haz: 890	Construction: 1,014 Operations: 351	15 Disturbance could impact a site potentially eligible for the National Register of Historic Places	Construction (workforce) Dose: 1.5 LCFs: 6.0×10^{-4} Operations Dose Public: 5.8×10^{-3} Workers: 254 LCFs Public: 2.9×10^{-5} Workers: 1.0	Nuclear criticality at immobilization facility: 8.0×10^{-4} LCF	

Table 2–4. Summary of Impacts of Construction and Operation of Surplus Plutonium Disposition Facilities by Alternative and Site

[a] Values represent the incremental criteria pollutant concentrations associated with surplus plutonium disposition operations for the annual averaging period for nitrogen dioxide (NO_2), particulate matter with an aerodynamic diameter smaller than or equal to 10 microns (PM_{10}), and sulfur dioxide (SO_2), and for the 8-hour averaging period for carbon monoxide.

[b] Values are based on a construction period of approximately 3 years and 10 years of operation.

[c] Values are for the peak year of construction for each site and for the annual operation of all facilities for each alternative. Personnel needed to operate the planned HLW vitrification facility at Hanford, or DWPF at SRS, are not included.

[d] Values represent the total land disturbance at each site from construction and operations.

[e] Values for Alternative 1 represent impacts over 50 years of operation under No Action. Those for the remaining alternatives are for the period of construction and 10 years of operation. Public dose values represent the annual radiological dose (in person-rem) to the population within 80 km (50 mi) of the facility location for the year 2030 under Alternative 1, or for 2010 under Alternatives 2 through 12. Worker dose values represent the total radiological dose to involved workers at the facility (in person-rem/year). Public LCFs represent the 50-year LCFs estimated to occur in the population within 80 km (50 mi) for the year 2030 under Alternative 1, or the 10-year LCFs estimated to occur for the year 2010 under Alternatives 2 through 12. Worker LCFs represent the associated 50-year or 10-year LCFs estimated to occur in the involved workforce.

[f] The most severe of the design basis accidents (based on 95 percent meteorological conditions) is used to obtain the population LCF. Higher LCFs would be associated with postulated beyond-design-basis accidents as presented in Chapter 4 and described in detail in Appendix K.

[g] For alternatives that involve more than one site, the transportation impacts for the entire alternative are shown in the first site listed in the alternative. LCFs are from the radiological exposure associated with incident-free operations, radiological accidents, and fatalities expected as a result of vehicle emissions. Traffic fatalities are from nonradiological vehicle accidents. LCFs at Pantex are associated with repackaging requirements if the pit conversion facility were located elsewhere.

[h] Alternatives 3B, 5B, 6C, 6D, 7B, 9B, 12B, and 12D in the SPD Draft EIS have been deleted. Alternative 12C has been renumbered as 12B. Table entries for deleted alternatives have likewise been deleted.

Key: DWPF, Defense Waste Processing Facility; FMEF, Fuels and Materials Examination Facility; FPF, Fuel Processing Facility; Haz, hazardous; HLWVF, high-level-waste vitrification facility; LCF, latent cancer fatality; LLW, low-level waste; MLLW, mixed low-level waste; NA, not applicable; TRU, transuranic.

2.18.2 Summary of Lead Assembly Fabrication and Postirradiation Examination Impacts

The impacts on key resources from fabrication of lead assemblies at the five candidate sites (ANL–W, Hanford, LLNL, LANL, and SRS) evaluated in Section 4.27 are summarized in Table 2–5. These areas include waste management, human health risk during normal operations, facility accidents, and transportation. The transportation analysis includes the shipment of plutonium dioxide from LANL to the candidate site; depleted uranium hexafluoride from the representative DOE storage site at the Portsmouth Gaseous Diffusion Plant to the representative conversion facility in Wilmington, North Carolina; uranium dioxide from the conversion facility to the lead assembly fabrication facility; MOX fuel rods from the lead assembly facility to the McGuire reactor for irradiation; and irradiated fuel rods from McGuire to a postirradiation examination facility.[32] Total distance traveled, in kilometers, is provided for each proposed fabrication site. Because facility modification activities would occur inside existing buildings (i.e., no new buildings would be constructed and no additional land would be disturbed), there should be little increase in air pollutants; land disturbances would be minimal; and the number of construction workers would be low. Little or no impacts are expected on any other resources areas.

Impacts from lead assembly and postirradiation examination activities are based on the fabrication of 10 assemblies, although it is likely that only 2 would be needed. If less than 10 lead assemblies were fabricated, the impacts would be lower than those presented in this SPD EIS. Impacts from facility modifications would not be expected to change because the facility modifications would be the same regardless of the number of assemblies produced. Impacts from routine operations, such as resources used, personnel exposure, waste generation, and transportation, would be expected to be reduced in proportion to the number of assemblies produced. The consequences of facility and transportation accidents would be expected to remain the same because the material at risk at any one time would likely not change. However, the risk of these accidents occurring would be reduced as the number of lead assemblies decreased.

There are no appreciable differences in environmental impacts among the five lead assembly candidate sites. There would be little difference in the volume of waste generated at any of the sites. The small differences in TRU waste and LLW would be due to wastes generated during modification of contaminated areas of existing buildings at ANL–W and LANL. In addition, less than 5 m^3 (6.5 ft^3) of hazardous waste would be generated during facility modification and lead assembly fabrication. The total amount of nonhazardous waste generated, primarily sanitary wastewater, would range from 8,700 to 13,500 m^3 (11,380 to 17,658 yd^3). No LCFs for either workers or the public would be expected to result from fabrication of lead assemblies at any of the proposed locations during routine operations. Impacts from facility accidents also show that no LCFs would be expected in the general population at any site from the postulated bounding design basis accident. Comparison of transportation impacts shows little differences among the sites, with no expected traffic fatalities or LCFs. Likewise, there are not expected to be any appreciable differences between the two postirradiation examination sites.

No major consequences for the maximally exposed involved worker would be expected from leaks, spills, and smaller fires. These accidents are such that involved workers would either be able to evacuate immediately or would not be affected by the events. Explosions, on the other hand, could result in immediate injuries from flying debris, as well as the uptake of plutonium and uranium particulates through inhalation. If a criticality were to occur, workers within tens of meters could receive very high to fatal radiation exposures from the initial burst. The dose would strongly depend on the magnitude of the criticality (number of fissions), the distance from the criticality, and the amount of shielding provided by the structures and equipment between the workers and the criticality. Beyond-design-basis earthquakes would also have substantial consequences, ranging from workers

[32] Shipments of spent fuel to the potential geologic repository are analyzed in the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250D) (DOE 1999b).

being killed by debris from collapsing equipment and structures to high radiation exposures and uptakes of radionuclides. For most accidents, immediate emergency response actions should reduce the consequences to workers near the accident.

The impacts of postirradiation examination at ANL–W and ORNL, as evaluated in Section 4.27.6, would be minimal. No construction waste would be generated. With the exception of nonhazardous wastewater at ANL–W, all categories of waste generated during routine operations would use less than 1 percent of either site's applicable treatment, storage, and disposal capacity. Nonhazardous wastewater at ANL–W would use about 6 percent of that site's applicable capacity. Transportation impacts for postirradiation examination at ANL–W are included in the lead assembly impacts presented in Table 2–5. Transportation impacts for postirradiation examination at ORNL would be lower than those listed in Table 2–5 because the distance traveled would be less.

Table 2–5. Summary of Impacts of Lead Assembly Fabrication at the Candidate Sites[a]

Candidate Site	Waste Management[b] (m^3)	Human Health Risk[c] (dose in person-rem)	Facility Accidents[d]	Transportation[e]
ANL–W	Total TRU waste: 132 Total LLW: 736 Total MLLW: 4 Total Haz: 0	Dose Public: 0.011 Workers: 28 LCFs Public: 5.5×10^{-6} Workers: 0.011	Nuclear criticality LCFs: 1.7×10^{-4}	Radiological LCFs: 8.1×10^{-3} Traffic fatalities: 1.8×10^{-3} Kilometers traveled: 77,000
Hanford	Total TRU waste: 132 Total LLW: 700 Total MLLW: 4 Total Haz: 0	Dose Public: 0.025 Workers: 28 LCFs Public: 1.2×10^{-5} Workers: 0.011	Nuclear criticality LCFs: 2.7×10^{-3}	Radiological LCFs: 8.1×10^{-3} Traffic fatalities: 1.9×10^{-3} Kilometers traveled: 89,000
LLNL	Total TRU waste: 132 Total LLW: 700 Total MLLW: 4 Total Haz: 0	Dose Public: 1.1 Workers: 28 LCFs Public: 5.5×10^{-4} Workers: 0.011	Nuclear criticality LCFs: 3.2×10^{-2}	Radiological LCFs: 8.4×10^{-3} Traffic fatalities: 1.8×10^{-3} Kilometers traveled: 73,000
LANL	Total TRU waste: 137 Total LLW: 705 Total MLLW: 4 Total Haz: 0	Dose Public: 0.025 Workers: 28 LCFs Public: 1.2×10^{-5} Workers: 0.011	Nuclear criticality LCFs: 3.2×10^{-3}	Radiological LCFs: 8.1×10^{-3} Traffic fatalities: 1.6×10^{-3} Kilometers traveled: 49,000
SRS	Total TRU waste: 132 Total LLW: 700 Total MLLW: 4 Total Haz: 2	Dose Public: 6.6×10^{-3} Workers: 28 LCFs Public: 3.3×10^{-6} Workers: 0.011	Nuclear criticality LCFs: 6.5×10^{-4}	Radiological LCFs: 8.3×10^{-3} Traffic fatalities: 1.6×10^{-3} Kilometers traveled: 67,000

[a] Impacts are based on the fabrication of 10 lead assemblies and irradiation of 8. Should only two lead assemblies be fabricated and irradiated, impacts would be lower than indicated.

[b] Totals for 2-year modification and 3-year operation of lead assembly facility.

[c] Annual dose for public residing within 80 km (50 mi) of the candidate site. Worker dose is the same at all five facilities because estimated number of workers and estimated dose to worker does not vary by site. Estimated dose to public varies based on projected population within 80 km (50 mi) of candidate site.

[d] The most severe of the design basis accidents is listed.

[e] LCFs are from the radiological exposure associated with incident-free operations and radiological accidents; traffic fatalities, from nonradiological traffic accidents.

Key: ANL–W, Argonne National Laboratory–West; LANL, Los Alamos National Laboratory; LCF, latent cancer fatality; LLNL, Lawrence Livermore National Laboratory; LLW, low-level waste; MLLW, mixed-low-level waste; TRU, transuranic.

No LCFs would be expected to either workers or the public from routine postirradiation examination activities. There would be no routine releases of radioactivity to the environment, and thus, radiological impacts on the public. The average annual dose to facility workers would be 177 mrem, for an annual dose to the total facility

workforce of 1.8 person-rem. The most severe accident would be a nuclear criticality. Such an accident could result in high, though probably not fatal, radiological exposures to hot cell workers. No LCFs would be expected in the general population.

If DOE were to decide to immobilize all 50 t (55 tons) of surplus plutonium, no lead assembly activities would be required. Should DOE decide to pursue the MOX option, but to not fabricate lead assemblies, such activities would not occur at any of the five sites. Under both of these scenarios, current operations would continue at the sites and the environmental conditions would remain at baseline levels. (See Chapter 3 for a description of the current environmental conditions at the sites.)

2.18.3 MOX Fuel Integrated Impacts

The impacts from implementing the MOX fuel fabrication alternatives would not be limited to those associated with the MOX facility, but would also include impacts from lead assembly fabrication, irradiation, and postirradiation examination, and the use of reactors for irradiation of the MOX fuel assemblies. Any new construction would occur at existing DOE sites. MOX-related operations at all sites would be compatible with, or similar to, activities already occurring at those locations.

Tables 2–6 through 2–11 describe the potential impacts of implementation of the MOX alternatives, from fabrication of the MOX fuel assemblies and lead assemblies to irradiation of the assemblies in domestic, commercial reactors, and the transportation for all radioactive material movements. While these impacts would be cumulative over the life of the campaign, they would not all be concurrent. The data presented are those reported in Chapter 4.

Air emissions, presented in Table 2–6, would result primarily from building heating and vehicular emissions. Releases of criteria pollutants are provided as a range, with the lowest emissions at Hanford, where electricity is the method of heating, and the highest at INEEL, where coal-fired boilers produce steam for heating and travel distances for personnel result in vehicular emissions double those estimated for other candidate sites. Lead assembly fabrication and postirradiation examination activities are relatively small efforts that are not expected to measurably increase air emissions at any of the candidate sites. There are no nonradiological emissions from these facilities that are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAPs). As discussed in Section 4.32, radiological NESHAPs emissions would be monitored and maintained as part of the total site limit of 10 mrem/yr from all sources. There would be no incremental difference in the air emissions from Catawba, McGuire, or North Anna related to using MOX fuel. Criteria, toxic, and hazardous pollutant emissions are not related to the type of reactor fuel. Rather, emission of these pollutants from the reactor sites would be related to ancillary processes such as operation of diesel generators, periodic testing of emergency diesel generators, and facility operations.

TRU waste and LLW would be generated during operation of both the lead assembly and full-scale MOX facilities (see Table 2–7). The amount of waste generated would be process-specific, and would not vary appreciably by site. Lead assembly fabrication would result in a total of 132 m^3 (173 yd^3) of TRU waste and 700 m^3 (916 yd^3) of LLW waste. The larger amount of waste generated on an annual basis by lead assembly fabrication, as compared to full-scale fabrication, would be attributed to operational differences between fabricating MOX fuel on a laboratory rather than commercial scale. Similarly, activities such as material recycle may not be implemented to as great an extent on the smaller scale. No increase is expected in the amount of waste generated at the reactor sites as a result of using MOX fuel.

Table 2–6. Potential Impacts on Air Quality of MOX Fuel Fabrication and Irradiation

Criteria Pollutant	MOX Facility[a] (kg/yr)	L.A. Fab. and Postirrad. Exam. (kg/yr)	Reactor Operation Increment (kg/yr)	Total MOX Fuel Increment (kg/yr)
Carbon monoxide	35K to 83K	0	0	35K to 83K
Nitrogen dioxide	11K to 32K	0	0	11K to 32K
PM_{10}	31K to 60K	0	0	31K to 60K
Sulfur dioxide	0.1K to 73K	0	0	0.1K to 73K
Volatile organic compounds	4K to 10K	0	0	4K to 10K
Total suspended particulates[b]	31K to 60K	0	0	31K to 60K

[a] Includes vehicle emissions.

[b] Total suspended particulates assumed to be the same as PM_{10}.

[Text deleted.]

Table 2–7. Potential Impacts on Waste Generation of MOX Fuel Fabrication and Irradiation

Waste Type	MOX Facility (m^3)	L.A. Fab. and Postirrad. Exam. (m^3)	Reactor Operation Increment	Total MOX Fuel Increment[a] (m^3)
TRU waste	680	143	0	823
Low-level waste	940	840	0	1,780
Mixed LLW	30	5	0	35
Hazardous	30	1	0	31
Nonhazardous				
Liquid[b]	260K	7.9K	0	268K
Solid	4.4K	5.3K	0	9.7K

[a] Total contribution of MOX effort; based on total lead assembly and postirradiation examination activities and 10 years of MOX fuel fabrication.

[b] Primary contributor is sanitary use, not process-related activities.

More spent fuel would be generated at the reactor sites as a result of the proposed disposition of surplus plutonium as MOX fuel. As discussed in Section 4.28, it is expected that approximately 5 percent additional spent fuel would be generated as a result of MOX fuel irradiation at the proposed reactor sites. Even so, there would be sufficient space at the reactor sites (in either the spent fuel pools or dry storage) to store the additional spent fuel until it could be sent to a potential geologic repository pursuant to the NWPA. DOE's draft environmental impact statement for a potential geologic repository (DOE/EIS-0250D, July 1999) includes the MOX fuel that would be generated from this program.

Existing infrastructure would be adequate to support the MOX fuel alternatives, although it has been estimated that up to 2 km (0.62 mi) of new roads would be needed for the MOX facility (see Table 2–8). Consumption of coal, natural gas, and electricity vary greatly from site to site, for both the MOX and the lead assembly fabrication facilities, depending on the type of fuel used for heating. For example, electricity needed for MOX fuel fabrication would be 30,000 MWh/yr at all sites but Hanford. Hanford, which is estimated to use one and one-half times the electricity of the other sites (46,000 MWh/yr), uses electricity to heat its buildings. INEEL and SRS use coal for heating, and Pantex, natural gas. No additional infrastructure needs would result from the use of MOX fuel at the proposed reactors.

Table 2–9 compiles information about expected radiological impacts on workers during routine operations. The impacts on workers at the MOX facility are based on operating experience at existing MOX facilities in

Table 2–8. Potential Impacts on Infrastructure of MOX Fuel Fabrication and Irradiation

Requirement	MOX Facility	L.A. Fab. and Postirrad. Exam.	Reactor Operation Increment
Electricity (MWh/yr)	30K to 46K	0.7K to 1.2K	0
Water (l/yr)	68M	1.6M	0
Fuel			
Oil (l/yr)	63K	12K to 61K	0
Natural gas (m^3/yr)	0 to 1.1M	0 to 55K	0
Coal (t/yr)	0 to 2.1K	0 to 0.06K	0
Transportation			
Roads (km)	1.0 to 2.0	0	0
Rail (km)	0	0	0

Table 2–9. Potential Radiological Impacts on Workers of MOX Fuel Fabrication and Irradiation

Impact	MOX Facility (over 10 years)	L.A. Fab. and Postirrad. Exam. (over 6 years)	Reactor Operation Increment (over 16 years)
Average worker dose (mrem/yr)	65	451	0
Latent fatal cancer risk	2.6×10^{-4}	1.1×10^{-3}	0
Total dose (person-rem/yr)	22	15	0
Latent fatal cancers	0.088	0.035	0

Europe (DOE 1999a). Impacts on workers at the postirradiation examination facility are based on operating experience at ORNL (O'Connor et al. 1998a). The impacts at the lead assembly fabrication facilities are based on an average annual dose rate of 500 mrem/yr. (This is an administrative limit that has been set in accordance with as-low-as-is-reasonably-achievable principles.) The exposure over the life of the MOX campaign (10 years for the MOX facility, 3 years for lead assembly fabrication and 3 years for postirradiation examination) would result in an increased risk of fatal cancer of 2.6×10^{-4} at the MOX facility, 6.0×10^{-4} at the lead assembly site, and 2.2×10^{-4} at the postirradiation examination facility. The corresponding number of LCFs for MOX facility, lead assembly, and postirradiation examination workers from the MOX campaign would be 0.088, 0.033, and 0.002, respectively. No increase in the incremental dose to workers is expected at the proposed reactors from using MOX fuel.

The potential radiological impacts on the general population from routine operations would be very small. Table 2–10 shows that from routine operations annual doses from the MOX facility to the maximally exposed individual (MEI) range from 1.8×10^{-3} to 1.5×10^{-2} mrem/yr, which translates to an increased risk of fatal cancer of 9.0×10^{-9} to 7.5×10^{-8} for 10 years of exposure. The lowest dose would be received at Hanford; the highest, Pantex. However, the population around Pantex would receive the lowest total population dose, and the lowest annual dose to the average individual. Estimated results at Hanford would be at the high end of the range for both of these parameters, 2.9×10^{-1} person-rem/yr and 7.5×10^{-4} mrem/yr, respectively. The annual dose to the average individual would still be extremely small, and would result in only a 3.8×10^{-9} increased risk of fatal cancer for 10 years of exposure. Offsite dose to the MEI resulting from lead assembly fabrication ranges from a low at SRS of 5.5×10^{-5} to 6.4×10^{-2} mrem/yr at LLNL. The associated risk of fatal cancer would be extremely low for the same MEI, ranging from 8.3×10^{-11} to 9.6×10^{-8}. Annual doses to the average individual at SRS and LLNL would be 8.8×10^{-6} and 1.4×10^{-4} mrem, respectively; risk of LCFs to the same individuals would be 1.3×10^{-11} and 2.1×10^{-10}. Offsite dose to the MEI resulting from postirradiation examination would not be expected to change because the activities would not be additive, but would displace similar activities already being done in these facilities. No change would be expected in the radiation dose to the general population from normal operations associated with the disposition of MOX fuel at the proposed reactors (see Table 2–10).

Table 2–10. Potential Radiological Impacts on the Public of MOX Fuel Fabrication and Irradiation

Impact	MOX Facility (over 10 years)	L.A. Fab. and Postirrad. Exam. (over 6 years)	Reactor Operation Increment (over 16 years)
Annual dose to MEI (mrem)	1.8×10^{-3} to 1.5×10^{-2}	0 to 6.4×10^{-2}	0
Fatal cancer risk	9.0×10^{-9} to 7.5×10^{-8}	0 to 9.6×10^{-8}	0
Annual population dose (person-rem)	0.027 to 0.29	0 to 1.1	0
Fatal cancers	1.4×10^{-4} to 1.5×10^{-3}	0 to 1.7×10^{-3}	0
Annual dose to average ind. (mrem)	8.8×10^{-5} to 7.5×10^{-4}	0 to 1.4×10^{-4}	0
Fatal cancer risk	4.4×10^{-10} to 3.8×10^{-9}	0 to 2.1×10^{-10}	0

Transportation impacts are summarized in Table 2–11, and include radiological dose to the truck crew and the general population, nonradiological emissions from vehicle operation, potential traffic accident fatalities, and LCFs resulting from an accident involving a breach of containment and release of radioactive materials. Shipments analyzed include all those listed in Table 2–3 for the MOX, lead assembly, and postirradiation examination facilities, and shipments of fresh MOX fuel to the proposed reactor sites. The analysis shows that no traffic fatalities or LCFs would be expected from either routine transportation activities or accidents.

Table 2–11. Potential Overland Transportation Risks of MOX Fuel Fabrication and Irradiation

Impact	MOX Facility	L.A. Fab. and Postirrad. Exam.	Total MOX Fuel Increment
Routine radiological			
Crew (LCFs)	6.7×10^{-4} to 1.1×10^{-3}	7.1×10^{-5} to 5.6×10^{-4}	7.4×10^{-4} to 1.6×10^{-3}
Public (LCFs)	5.3×10^{-3} to 7.2×10^{-3}	6.0×10^{-4} to 4.8×10^{-3}	5.9×10^{-3} to 1.2×10^{-2}
Routine nonradiological, emissions (LCFs)	6.2×10^{-3} to 2.3×10^{-2}	7.7×10^{-5} to 3.7×10^{-4}	6.2×10^{-3} to 2.4×10^{-2}
Accidental, traffic (fatalities)	1.7×10^{-2} to 5.9×10^{-2}	4.7×10^{-4} to 1.9×10^{-3}	1.8×10^{-2} to 6.1×10^{-2}
Accidental, radiological (LCFs)	3.2×10^{-3} to 3.8×10^{-3}	5.6×10^{-4} to 3.0×10^{-3}	3.8×10^{-3} to 6.8×10^{-3}

Key: LCFs, latent cancer fatalities.

Accidents are unplanned events which would be different for each type of facility needed to implement the MOX approach. The accidents analyzed for the disposition facilities are presented in detail in Appendix K and the consequences summarized by alternative in Chapter 4 (Sections 4.3 through 4.19 for Alternative 2 through 10, respectively, Section 4.27 for the lead assembly and postirradiation examination alternatives, and Section 4.28 for the reactors). The design basis accident with the most severe consequences postulated for the MOX facility is a criticality. This accident would result in an estimated dose at a distance of 1 km (0.62 mi) from the facility of from 0.15 rem at Hanford to 0.75 rem at INEEL. This same accident would result in doses at the site boundaries ranging from 1.6×10^{-2} rem at INEEL and SRS to 4.7×10^{-2} rem at Pantex. Population doses and LCFs within 80 km (50 mi) would range from 1.0 person-rem and 5.2×10^{-4} LCF at INEEL to 55 person-rem and 2.8×10^{-2} LCF at Hanford. The frequency of such an accident is estimated to be between 1 in 10,000 and 1 in 1,000,000 per year.

The postulated design basis accident with the most severe consequences for proposed lead assembly operations using MOX fuel would be associated with a nuclear criticality. The accident would result in an incremental increase in estimated dose at the site boundaries ranging from 9.3×10^{-4} rem at SRS to 5.3×10^{-1} rem at LLNL. The same accident would result in incremental changes in population doses and LCF probabilities within 80 km (50 mi), ranging from 3.4×10^{-1} person-rem and 1.6×10^{-4} LCF at ANL–W to 6.6 person-rem and 3.2×10^{-3} LCF at LANL, respectively. The frequency of such an accident is estimated to be between 1 in 10,000 and 1 in 1,000,000 per year. A nuclear criticality would also be the most severe accident at the postirradiation

examination facilities, but the amount of spent fuel necessary for such an accident to be physically possible is at least one to two orders of magnitude greater than would normally be available.

The design basis accident with the most severe consequences postulated for the proposed reactors using MOX fuel is a loss-of-coolant accident. This accident would result in an increase in the estimated dose at a distance of 640 m (2,100 ft) from the reactor of 0.001 rem at North Anna to 0.15 rem at McGuire. The same accident would result in incremental increases in doses at the site boundaries ranging from 2.0×10^{-4} rem at North Anna to 0.06 rem at McGuire. The incremental change in population doses and LCFs within 80 km (50 mi) of the reactors would range from 0.9 person-rem and 5×10^{-4} LCF at North Anna to 110 person-rem and 0.06 LCF at Catawba. The frequency of such an accident is estimated to be between 1 in 48,000 and 1 in 130,000 per year.

This SPD EIS also evaluates the potential impacts from a set of postulated highly unlikely accidents with potentially severe consequences at the proposed reactors using both uranium-only and MOX cores. [Text deleted.] Regarding effects of MOX fuel on accident probabilities, the National Academy of Sciences states, ". . . no important overall adverse impact of MOX use on the accident probabilities of the LWRs involved will occur; if there are adequate reactivity and thermal margins in the fuel, as licensing review should ensure, the main remaining determinants of accident probabilities will involve factors not related to fuel composition and hence unaffected by the use of MOX rather than LEU fuel" (NAS 1995:352). Regarding the effects of MOX fuel on accident consequences, the report states, ". . . it seems unlikely that the switch from uranium-based fuel could worsen the consequences of a postulated (and very improbable) severe accident in a LWR by no more than 10 to 20 percent. The influence on the consequences of less severe accidents, which probably dominate the spectrum value of population exposure per reactor-year of operation would be even smaller, because less severe accidents are unlikely to mobilize any significant quantity of plutonium at all" (NAS 1995:355).

The incremental effects of using MOX fuel in the proposed reactors in place of LEU fuel were derived from a quantitative analysis of several highly unlikely severe accident scenarios for MOX and LEU fuel. The analysis considers severe accidents where sufficient damage could occur to cause the release of plutonium or uranium through a breach of the plant's containment. The consequences of these accident releases on the general population were found to range from minus 4 to plus 14 percent[33] compared with LEU fuel, depending on the accident release scenario. This analysis was based on existing probabilistic risk assessments of severe accidents, and the release scenarios were modeled assuming projected population distributions near the proposed reactors in 2015.

The highest consequence accident at all three of the proposed reactors is an interfacing systems loss-of-coolant accident. However, there is an extremely small chance that this beyond-design-basis accident would ever occur. The likelihood of this accident occurring is 1 chance in 15 million at Catawba, 1 chance in 1.6 million at McGuire, and 1 chance in 4.2 million at North Anna. Were this accident to occur, the increases in the estimated dose at the site boundary for MOX fuel as compared to LEU fuel would be 2,000 rem at Catawba; 2,400 rem at McGuire; and 2,200 rem at North Anna. These increases are 14 percent, 12 percent, and 22 percent, respectively, above the doses expected from the same accident using LEU fuel. The incremental change in population doses and LCFs within 80 km (50 mi) of the reactors have been estimated to be 3.2×10^{6} person-rem and 1,300 LCFs (from 15,600 to 16,900 LCFs) at Catawba; 1.8×10^{6} person-rem and 800 LCFs (from 11,900 to 12,700) at McGuire; and 7.3×10^{5} person-rem and 410 LCFs (from 2,980 to 3,390 LCFs) at North Anna. Prompt fatalities from this accident would be expected to increase from 815 to 843 at Catawba, from 398 to 421 at McGuire, and from 54 to 60 at North Anna. The increase in risk to the population from this accident as a result of using MOX

[33] Accidents severe enough to cause a release of plutonium involve combinations of events that are highly unlikely. Estimates and analyses presented in Section 4.28 indicate an incremental range of postulated LCFs due to the use of MOX fuel of minus 7 to plus 1,300 (in the population within 80 km [50 mi] of the release point), with incremental attendant risks of LCFs over 16 years of reactor operation with MOX fuel of minus 1.3×10^{-3} and plus 1.4×10^{-3}, respectively.

fuel would be 1.4×10^{-3} at Catawba, 8.0×10^{-3} at McGuire, and 1.6×10^{-3} at North Anna over the estimated 16-year life of the MOX fuel irradiation program.

[Text deleted.]

2.18.4 Comparison of Immobilization Technology Impacts

To provide a basis for evaluating alternative immobilization forms and technologies, the environmental impacts associated with operating the ceramic and glass can-in-canister immobilization facilities evaluated in this SPD EIS were compared with the corresponding environmental impacts associated with operating the homogenous ceramic immobilization and vitrification facilities evaluated in the *Storage and Disposition PEIS* (DOE 1996a).

Section 4.29 presents the comparable impacts for key environmental resources (e.g., air quality, waste management, human health risk, and resource requirements) at Hanford and SRS for the homogenous ceramic immobilization/vitrification facilities and the can-in-canister immobilization facilities. Impacts associated with facility accidents, intersite transportation, and environmental justice are also discussed. The results of the comparative analysis are summarized here.

The comparison of impacts is based on immobilizing the full 50 t (55 tons) of surplus plutonium. The *Storage and Disposition PEIS* impact analyses are based on operating facilities that would convert the plutonium into an oxide in one new facility and immobilize it into a homogenous ceramic or glass form in another new facility. Impacts for a plutonium conversion facility are evaluated and itemized separately from the impacts for a ceramic immobilization or vitrification facility. In contrast, this SPD EIS considers the use of both new and existing facilities, and is based on a collocated plutonium conversion and immobilization capability. To compare the impacts, it was therefore necessary to combine the separate *Storage and Disposition PEIS* impact values, as appropriate, to establish a suitable standard of comparison.

Generally, air quality impacts associated with the ceramic or glass can-in-canister technologies would be lower or about the same as those evaluated in the *Storage and Disposition PEIS* for ceramic immobilization or vitrification. With the exception of sulfur dioxide in the ceramic can-in-canister process, all criteria pollutant concentrations associated with either can-in-canister technology would range from being the same to being much lower. Pollutant levels would not be expected to differ between the ceramic and glass can-in-canister processes.

Potential volumes of most waste types resulting from operation of the ceramic or glass can-in-canister technologies would be considerably less than the waste volumes expected from either ceramic immobilization or vitrification technology evaluated in the *Storage and Disposition PEIS*. For example, operation of a can-in-canister facility using the ceramic process at Hanford or SRS is estimated to result in TRU waste volumes of 126 m^3/yr (165 yd^3/yr), compared to the 647 m^3/yr (846 yd^3/yr) of TRU waste estimated in the *Storage and Disposition PEIS* from operation of the homogenous ceramic immobilization facility. Factors contributing to the reduced waste levels associated with the can-in-canister technology would include the use of dry-feed preparation techniques, coordination with existing HLW vitrification operations and the need for a smaller operating work force. Waste volumes would not be expected to differ appreciably between the ceramic and glass can-in-canister processes.

Section 4.29 also presents the potential radiological exposure and cancer risk to the public and involved workers from normal operation of the immobilization facilities. The potential risks to the public associated with either can-in-canister technology would be slightly higher than the homogeneous technologies at Hanford, but lower at SRS. For example, operation of a can-in-canister facility using the ceramic process at Hanford or SRS is estimated to result in population doses of 1.6×10^{-2} or 5.8×10^{-3} person-rem/yr, respectively, compared to the

population doses of 8.4×10^{-3} (at Hanford) or 6.6×10^{-2} person-rem/yr (at SRS) resulting from operation of the homogenous ceramic immobilization facility evaluated in the *Storage and Disposition PEIS*. These variations may be attributable to the incorporation of updated source terms, meteorology, population distribution, and other modeling variables in the analysis of the can-in-canister technologies. A comparison between the ceramic and glass can-in-canister technologies indicates operation of the ceramic process would result in slightly higher potential offsite impacts, regardless of whether it is located at Hanford or SRS. For example, the dose associated with operation of the can-in-canister facility at Hanford would result in a population dose of 1.6×10^{-2} person-rem/yr using the ceramic process and 1.5×10^{-2} person-rem/yr using the glass process; the same facility at SRS would result in a population dose of 5.8×10^{-3} person-rem/yr using the ceramic process, and a dose of 5.3×10^{-3} person-rem/yr using the glass process.

The estimated average worker dose and associated cancer risk for the can-in-canister technologies are slightly higher than estimated in the *Storage and Disposition PEIS* for the homogenous technologies. In all cases, however, worker dose would be within the DOE design objective of 1,000 mrem/yr. Potential radiological impacts on involved workers are not expected to differ appreciably between the ceramic and glass can-in-canister processes.

Although some potential hazardous chemical impacts were determined for the homogenous ceramic immobilization/vitrification technologies evaluated in the *Storage and Disposition PEIS*, none are expected for either the ceramic or glass can-in-canister technology because no hazardous chemical emissions would occur from operations.

Because of substantial differences between the *Storage and Disposition PEIS* and the SPD EIS in terms of the specific accident scenarios and supporting assumptions used in the determination of facility accident impacts, a standard basis for comparing homogenous technology and can-in-canister technology accidents is not available. For example, a design basis earthquake scenario was not evaluated in the *Storage and Disposition PEIS* for the plutonium conversion facility, nor were any other design basis accidents evaluated for that facility that could be incorporated with like impacts to the ceramic immobilization or vitrification facility for direct comparison to the accident scenarios presented in this SPD EIS. A design basis earthquake associated with the homogenous approach at Hanford would result in 5.8×10^{-8} and 3.2×10^{-6} LCF in the general population for ceramic immobilization and vitrification, respectively; a design basis earthquake affecting the same facilities at SRS would result in 6.2×10^{-8} and 3.4×10^{-6} LCF, respectively. As discussed earlier in this paragraph these values do not reflect the impact of such accidents on a plutonium conversion facility, and are therefore not directly comparable with the results for the can-in-canister approach shown in this SPD EIS. Comparison of the ceramic and glass can-in-canister processes indicates slightly higher impacts would be associated with the ceramic process. For example, a design basis earthquake at Hanford would result in 9.6×10^{-5} LCF in the general population using the ceramic process, and 8.4×10^{-5} LCF using the glass process. Similarly, a design basis earthquake at SRS would result in 3.6×10^{-5} LCF in the general population using a ceramic process, and 3.1×10^{-5} LCF using a glass process.

In terms of resource requirements, operation of the can-in-canister technologies would require lower amounts of electricity, fuel, land area, and water than would the homogenous technologies evaluated in the *Storage and Disposition PEIS*. Fewer workers would be required to operate the can-in-canister technologies, which in turn would result in lower socioeconomic impacts. Resource requirements differ between the ceramic and glass can-in-canister processes in that electricity requirements would be greater to support the ceramic process at either site (i.e., the ceramic process would require 29,000 or 24,000 MWh/yr at Hanford or SRS, respectively, compared to the 28,500 or 23,000 MWh/yr, respectively, required for the glass process).

The *Storage and Disposition PEIS* analysis assumes that canisters of plutonium immobilized with radionuclides would be transported to a potential geologic repository via rail. This SPD EIS analysis, however, conservatively

assumes that the immobilized canisters would be shipped by truck from the immobilization site to the repository, with one canister being transported per truck shipment.[34] The ceramic and glass can-in-canister technologies would result in fewer total potential fatalities from intersite transportation than would the homogenous ceramic immobilization/vitrification technologies evaluated in the *Storage and Disposition PEIS*. Because the ceramic can-in-canister process would produce fewer canisters, it would result in somewhat lower routine and accidental transportation impacts than the glass can-in-canister process.

Evaluations of both the homogenous ceramic immobilization/vitrification technologies and can-in-canister technologies included routine facility operations and transportation as well as accidents. No significant risk to the general population would be expected to occur for normal operations or in the event of a design basis accident. [Text deleted.] Similarly, implementation of these technologies would not result in a significant risk of disproportionately high and adverse impacts on minority or low-income groups within the general population.

[34] The *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250D) (DOE 1999b) analyzes spent fuel shipments by rail and truck. No decision has been made as to the mode of transportation.

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