



# 1.0 INTRODUCTION

This Introduction contains the following information:

- Background of the Plutonium Finishing Plant Facility
- Scope of this Environmental Impact Statement
- Contents of this Environmental Impact Statement

The presence of significant quantities of plutonium-bearing materials in the Plutonium Finishing Plant (PFP) Facility, Hanford Site, Washington, poses unacceptable risks to workers, the public, and the environment.

On October 24, 1994, the United States Department of Energy (DOE) announced, in an initial mailing to 1,500 interested parties, its intent to prepare an Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [U.S.C.] 4321 et seq.), DOE's NEPA Implementation Procedures (10 Code of Federal Regulations [CFR] 1021), and the Council on Environmental Quality (40 CFR 1500) regulations. This EIS evaluates the impacts on the human environment of:

- Stabilization of residual, plutonium-bearing materials at the PFP Facility to a form suitable for interim storage at the PFP Facility
- Immobilization of residual plutonium-bearing materials at the PFP Facility
- Removal of readily retrievable, plutonium-bearing materials left behind in process equipment, process areas, and air and liquid waste management systems as a result of historic uses
- No action.

All stabilized materials would be stored in the PFP Facility pending a DOE decision on future disposition. Any immobilized plutonium-bearing materials would be managed at Hanford Site solid waste management facilities. Disposition decisions would be contained in the Record of Decision for the *Storage and Disposition of Weapons-Usable Fissile Material Programmatic Environmental Impact Statement* (DOE, 1996). The draft of the Programmatic EIS was published in February 1996 (DOE, 1995). The alternatives being considered under the Programmatic EIS are beyond the scope of the *PFP Stabilization EIS*. The Programmatic EIS will evaluate alternatives for:

- Disposition of United States weapons-usable plutonium declared surplus to national defense needs by the President
- Disposition of surplus uranium-233 (U-233) and minor actinides (if needed)
- Long-term storage of national security and programmatic inventories of highly enriched uranium, plutonium, and minor actinides
- Long-term storage of surplus weapons-usable fissile materials that are not able to go directly from interim storage to disposition (DOE, 1996).

A Notice of Intent, published in the *Federal Register* (FR) on October 27, 1994 (59 FR 53969), identified the purpose, scope, and preliminary alternatives for the *PFP Stabilization EIS*. A subsequent Notice of Intent was published in the FR on November 23, 1994 (59 FR 60358), announcing two additional public scoping meetings.

The Notice of Intent provided a descriptive title for the proposed action to be covered by the EIS, "To Clean Out and Deactivate the Hanford, Washington Plutonium Finishing Plant (PFP) Complex (Except for Storage Areas), to Stabilize PFP Plutonium-Bearing Materials and to Store the Stabilized Material." This title was shortened in the body of the Notice of Intent and during scoping to the "Plutonium Finishing Plant Cleanout EIS." Subsequently, it was determined that "stabilization," as commonly used at Hanford, rather than "cleanout" more accurately described the range of actions to be evaluated in this EIS. Stabilization in the context of this EIS means the combination of steps or activities to secure, convert, and/or confine radioactive and/or hazardous material along with other activities needed to bring the Facility to a minimal surveillance level. Therefore, the title of this EIS will be *Plutonium Finishing Plant Stabilization*

### *Environmental Impact Statement (PFP Stabilization EIS).*

The scoping and public participation process was held over a 45-day period to identify issues to be considered in the *PFP Stabilization EIS*. During this period, public scoping meetings were conducted in six cities in Washington and Oregon. Written and oral comments were received. The public scoping process, initiated on October 24, 1994, ended on December 12, 1994. The Implementation Plan for the *PFP Stabilization EIS* was issued in October 1995 (DOE, 1995a).

The *Plutonium Finishing Plant Stabilization Draft Environmental Impact Statement*, DOE/EIS-0244-D, was issued in November 1995 (DOE, 1995b). The Draft EIS presented alternatives that would achieve the purpose and need and included analyses of the potential environmental impacts that would result.

On December 5, 1995, a Notice of Availability was published in the *Federal Register* (60 FR 62244) which formally announced the release and availability of the *PFP Stabilization EIS*. The public hearing date, time, and location were also published and public comment was requested. On December 15, 1995, a subsequent notice was published in the *Federal Register* (60 FR 64423) which extended the date for the end of the comment period provided in the Notice of Availability.

A public meeting on the *PFP Stabilization EIS* was held in Pasco, Washington, on January 11, 1996. The public comment period, initiated on December 5, 1995, officially ended on January 23, 1996. However, DOE made a decision to accommodate comments received through February 15, 1996. Both oral and written comments were received during the comment period.

Based on a draft DOE policy and a comment received during the public hearing, DOE decided to evaluate another alternative not contained in the *PFP Stabilization Draft EIS*. This alternative would involve immobilization of up to 272 kilograms (kg) (599 pounds [lb]) of material that have an associated plutonium content that would not warrant rigorous stabilization measures and continued vault storage at the PFP Facility. These materials would be immobilized through a cementation process, packaged and transported to a Hanford Site solid waste management facility for continued storage as waste. The plan to include this alternative in the Final *PFP Stabilization EIS* was announced in the FR on May 3, 1996 for a 21-day comment period. Comments received will be considered in the Record of Decision.

## **1.1 BACKGROUND OF THE PLUTONIUM FINISHING PLANT FACILITY**

The federal government began operating the Hanford Site, near Richland, Washington, in 1943 as part of the Manhattan Project to produce plutonium for national defense needs. Metallic uranium fuel was irradiated in nuclear reactors at the Hanford Site to produce plutonium. Chemical processing separated the plutonium from the other elements in the irradiated fuel. The product of this processing was plutonium nitrate, which needed further processing to produce the metallic form used in nuclear weapons. Initially, the plutonium nitrate was shipped offsite for this additional processing. Construction of the PFP Facility eliminated this necessity.

The PFP Facility is located in Hanford's 200 West Area, approximately 51 kilometers (km) (32 miles [mi]) northwest of Richland. Construction of the PFP Facility was started in 1947, and production of plutonium metal began on July 5, 1949. Facilities at the PFP Facility include production areas, such as the Remote Mechanical A and C (RMA, RMC) Lines for conversion of plutonium nitrate solutions to plutonium metal, the Plutonium Reclamation Facility (PRF) for removal of plutonium from process residues, laboratories for routine analysis and for actinide research, and secure vaults for storage of plutonium in various forms. About 240 employees are currently assigned to the PFP Facility. Additional staff are located outside the fence line, bringing the total to 592.

Most of the residues left in the PFP Facility when production operations stopped in 1989 still remain at the Facility, either in storage containers or on surfaces in enclosed process areas as hold-up.

These plutonium-bearing materials need to be either stabilized or immobilized for interim storage pending a DOE decision on the ultimate disposition of plutonium-bearing material. Stabilization is intended to minimize safety concerns, reduce radiation exposure to PFP Facility and Hanford Site workers, and reduce public risk. When stabilized, the material has minimal chemical reactivity and remains in solid form with a low water and organic content to minimize radiolysis.

During the the EIS process, actions continued to be taken to resolve immediate safety concerns. These actions are listed below. Additional actions could be proposed prior to the Record of Decision to address other specific safety concerns. All actions are or would be covered by appropriate NEPA documentation.

- Complete other small projects, such as maintaining or upgrading ventilation or electrical systems, which have limited impacts and do not limit alternatives in the *PFP Stabilization EIS*.
- Clean up radioactive surface contamination to reduce worker exposure at the PFP Facility.
- Remove portions of exhaust ventilation ductwork, vacuum piping, and process equipment containing residual plutonium from two buildings at the PFP Facility to reduce potential personnel radiation exposure during current activities.
- In the 232-Z Building, remove sections of service piping, exhaust ventilation ductwork, equipment within gloveboxes, and a firebrick lining containing residual plutonium. Clean process enclosures and gloveboxes in this building to minimize the onsite radiation dose in the event of an earthquake that exceeds building strength standards and to reduce PFP Facility worker exposure during surveillances and routine maintenance.
- Perform routine operations and maintenance.
- In October 1994, a Finding of No Significant Impact was issued for sludge stabilization. Under this Environmental Assessment, chemically reactive plutonium-bearing sludge from unshielded gloveboxes was stabilized and the resulting stable powder was stored in the PFP vaults (DOE, 1994a). These actions were completed during the summer of 1995. An additional Environmental Assessment to support continuation of this activity has been issued with its associated Findings of No Significant Impact (DOE, 1995c).

## 1.2 SCOPE OF THIS ENVIRONMENTAL IMPACT STATEMENT

The decisions that could result from the *PFP Stabilization EIS* may include implementing alternatives for stabilizing residual plutonium-bearing materials at the PFP Facility, storing stabilized materials in existing vaults at the PFP Facility, immobilizing plutonium-bearing materials for subsequent management at Hanford Site solid waste management facilities, or no action. The Record of Decision would include reasonable requirements to mitigate potential health, safety, and environmental impacts associated with the decision. The mitigation measures and plans for implementing them would be included in a Mitigation Action Plan, which would be published after the Record of Decision.

Plutonium-bearing materials are located in several buildings at the PFP Facility. The buildings contain equipment and surfaces that are contaminated with plutonium-bearing materials considered to be in an unstable condition. The plutonium-bearing materials must be removed and stabilized or immobilized before storage. These materials are grouped in the following four categories:

- 1) Plutonium-bearing solutions
- 2) Oxides, fluorides, and process residues
- 3) Metals and alloys
- 4) Polycubes and combustibles.

DOE's preferred alternative would involve the removal and stabilization of plutonium-bearing materials at the PFP Facility to a form suitable for management and storage. Readily retrievable plutonium-bearing materials would be

removed from exhaust and ventilation ducts, service piping, glovebox surfaces, process equipment, enclosures, walls, floors, or other areas of the PFP Facility where it may be found.

The removed and stored plutonium-bearing materials would undergo glovebox-size treatment processes. When stabilized, the material would have minimal chemical reactivity and would remain in solid form with a low water or organic content to minimize radiolysis. To achieve material stabilization, the following preferred alternative is proposed:

- 1) Plutonium-bearing solutions - Ion exchange, vertical calcination, and thermal stabilization
- 2) Oxides, fluorides, and process residues - Thermal stabilization using a continuous furnace
- 3) Metals and alloys - Repackaging
- 4) Polycubes and combustibles - Pyrolysis.

All stabilized material would be stored at the PFP Facility in accordance with DOE's *Criteria for Safe Storage of Plutonium Metals and Oxides*, DOE-STD-3013-94 (DOE storage standard) (DOE, 1994b) or the *Addendum to the Department of Energy Implementation Plan for DNFSB Recommendation 94-1, Criteria for Interim Safe Storage of Plutonium-bearing Solid Materials* (DOE, 1995d).

## 1.3 CONTENTS OF THIS ENVIRONMENTAL IMPACT STATEMENT

The EIS consists of a summary and eight sections as follows:

- Section 1 Introduction
- Section 2 Purpose and Need for Agency Action
- Section 3 Description of Proposed Alternatives
- Section 4 Affected Environment
- Section 5 Environmental Impacts
- Section 6 Cumulative Impacts
- Section 7 Statutory and Regulatory Requirements
- Section 8 List of Preparers

The introduction section provides background information, explains important features of the PFP Facility, and discusses the limits of the issues to be addressed within the scope of the EIS. It also describes the overall structure of the document and specifies the type of information provided in each section.

The purpose and need requiring DOE response in considering the proposed alternatives is stated and discussed in Section 2. Section 2 includes those factors, such as safety concerns, for which the alternatives are solutions.

Section 3 includes a brief history of the PFP Facility at Hanford, information on the nature of the problem requiring solutions, a discussion of the alternative selection process, identification of alternatives to solve the problems facing the PFP Facility, and finally, a comparative summary of anticipated impacts of alternatives.

Section 4 provides the description of the affected environment, which is the basis for analysis of the proposed action and alternatives.

Section 5 identifies and analyzes the environmental impacts of the proposed alternatives. Those impacts that are or might be significant are presented in greater detail than those judged to be insignificant. The concepts used to identify environmental impacts, such as worst case analysis, along with primary and secondary impacts, are explained. Data that support the analysis are presented in the appendices, as appropriate.

Section 6 assesses the consequences to the environment from the combined effects of each of the proposed alternatives and other current or reasonably foreseeable actions at the Hanford Site.

Statutory and regulatory requirements are discussed in Section 7. This section provides the status of all licenses, permits, and other approvals for each of the proposed alternatives to be obtained from federal, state, and local authorities for the protection of the environment. The listing cites relevant statutory or other authority-requiring approvals with respect to each of the proposed alternatives. This section also examines the ability of the proposed alternatives to meet regulatory standards and requirements. Finally, agencies consulted during the preparation of the EIS are identified.

The individuals who prepared the technical sections of the EIS including their names, titles, organizations, and qualifications in their field are included in Section 8.

### References:

10 CFR 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*.

40 CFR 1500, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

59 FR 53969, "Notice of Intent for the Preparation of an Environmental Impact Statement (EIS) To Clean Out and Deactivate the Hanford, Washington Plutonium Finishing Plant (PFP) Complex (Except for Storage Areas), to Stabilize PFP Plutonium-bearing Materials and to Store the Stabilized Material," *Federal Register*, October 27, 1994.

59 FR 60358, "Notice of Additional Public Scoping Meetings; Preparation of an Environmental Impact Statement (EIS) to Clean Out and Deactivate the Hanford, Washington Plutonium Finishing Plant (PFP) Complex (Except for Storage Areas), to Stabilize PFP Plutonium-Bearing Materials and to Store the Stabilized Material," *Federal Register*, November 23, 1994.

60 FR 62244, "Notice of Availability, Draft Environmental Impact Statement for the Plutonium Finishing Plant Stabilization, Hanford Site, Richland, Benton County, Washington," *Federal Register*, December 5, 1995.

60 FR 64423, "Extension of comment period, Draft Environmental Impact Statement for the Plutonium Finishing Plant Stabilization Hanford Site, Richland, Benton County, Washington", *Federal Register*, December 15, 1995.

42 U.S.C. §§ 4321 et seq., "National Environmental Policy Act of 1969," *United States Code*, as amended.

DOE, 1994a, *Environmental Assessment, Sludge Stabilization at the Plutonium Finishing Plant, Hanford Site, Richland, Washington*, DOE/EA-0978, Predecisional Draft, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE, 1994b, *Criteria for Safe Storage of Plutonium Metals and Oxides*, DOE-STD-3013-94, U.S. Department of Energy, Washington, D.C.

DOE, 1995a, *Implementation Plan for the Plutonium Finishing Plant Stabilization Environmental Impact Statement*, DOE/EIS-0244-IP, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE, 1995b, *Plutonium Finishing Plant Stabilization Draft Environmental Impact Statement*, DOE/EIS-0244-D, U.S. Department of Energy, Richland, Operations Office, Richland, Washington.

DOE, 1995c, *Environmental Assessment, Sludge and Solid Residue Stabilization at the Plutonium Finishing Plant Hanford Site, Richland, Washington* U.S. Department of Energy, DOE/EA-1112, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE, 1995d, *Addendum to the Department of Energy Implementation Plan for DNFSB Recommendation 94-1*,

*Criteria for Interim Safe Storage of Plutonium-bearing Solid Materials* and cover letter dated January 25, 1996, U.S. Department of Energy, Washington, D.C.

DOE, 1996, *Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement*, DOE/EIS-0229-D, Summary and Volumes I - III, U.S. Department of Energy, Office of Fissile Materials Disposition, Washington, D.C.





## 2.0 PURPOSE AND NEED FOR AGENCY ACTION

According to Council on Environmental Quality regulations (40 CFR 1502.13), an EIS must briefly specify the underlying purpose and need to which the agency is responding. In general, the purpose and need should reflect the goal to be achieved, and it should provide the basis for identifying reasonable alternatives to be considered in this EIS.

The purpose and need section is arranged as follows:

- 2.1 Statement
- 2.2 Background
- 2.3 Specific Vulnerabilities Facing the PFP Facility.

### 2.1 STATEMENT

The following is the purpose and need for the proposed action:

*Unstable forms of plutonium in the PFP Facility pose risks to workers, the public, and the environment. DOE needs to expeditiously and safely reduce radiation exposure to workers and the risk to the public; reduce future resources needed to safely manage the Facility; and remove, stabilize, store, and manage plutonium, pending DOE's future use and disposition decisions.*

### 2.2 BACKGROUND

The continued presence of relatively large quantities of chemically reactive plutonium-bearing materials in their present form and location in the PFP Facility poses an unacceptable long-term risk to the workers and the environment. Consequently, in 1993, DOE announced its proposal to operate certain processes in the PFP Facility to stabilize these materials and to prepare an Environmental Assessment pursuant to NEPA (DOE, 1993).

As part of the NEPA process for the proposed Environmental Assessment, DOE conducted public meetings in the summer and fall of 1993 in Richland, Seattle, and Spokane, Washington; and Portland and Hood River, Oregon to discuss the proposal to stabilize the chemically reactive materials. As a result of the public comments received, DOE decided that an EIS would be the appropriate level of NEPA review. DOE also decided to expand the scope of the NEPA review to include the removal of readily retrievable process residues held up in pipes, process equipment, gloveboxes, and ductwork as the result of more than 40 years of Facility operations.

On January 24, 1994, the Secretary of Energy commissioned a comprehensive assessment to identify and prioritize the environmental, safety, and health vulnerabilities that arise from the storage of plutonium in DOE facilities and determine which are the most dangerous and urgent. Vulnerabilities were defined as "conditions or weaknesses that may lead to unnecessary or increased radiation exposure of the workers, release of radioactive materials to the environment, or radiation exposure to the public." The DOE-wide assessment, commonly referred to as The Plutonium Vulnerability Study, identified 299 environmental, safety, and health vulnerabilities of which 15 were identified at the PFP Facility. The PFP Facility-specific vulnerabilities included storage of unstable forms of plutonium, a potential for criticality accidents, and seismic weaknesses (DOE, 1994). Additional information can be found in Subsection 2.3 of this EIS.

On May 26, 1994, shortly after the Secretary commissioned The Plutonium Vulnerability Study, the Defense Nuclear Facilities Safety Board (DNFSB) issued *Defense Nuclear Facilities Safety Board Recommendation 94-1 to the*

*Secretary of Energy (Recommendation 94-1)* (DNFSB, 1994). The DNFSB is chartered by Congress to review and evaluate the content and implementation of the standards relating to the design, construction, operation, and decommissioning of DOE's defense nuclear facilities (including applicable DOE Orders, regulations, and requirements). The DNFSB recommended to the Secretary of Energy those specific measures that should be adopted to ensure that public health and safety are adequately protected. In *Recommendation 94-1*, the DNFSB noted that it was concerned that the halt in production of materials to be used in nuclear weapons froze the manufacturing pipeline in a state that, for safety reasons, should not be allowed to persist unremediated. Specifically, the DNFSB expressed concern about liquids and solids containing fissile materials, like plutonium, located in spent fuel storage pools, reactor basins, reprocessing canyons, and various other facilities, such as the PFP Facility, once used for processing and weapons manufacture. Many of the DOE-wide and Hanford vulnerabilities associated with materials and packaging identified in The Plutonium Vulnerability Study are specifically covered or encompassed by the DNFSB's *Recommendation 94-1*.

In *Recommendation 94-1*, the DNFSB specifically advised: "that an integrated program plan be formulated on a high priority basis, to convert within two to three years the materials" (plutonium metal that is in contact with or in proximity to plastic) "to forms or conditions suitable for safe interim storage;" that the plan "will require attention to limiting worker exposure and minimizing generation of additional waste and emission of effluents to the environment;" and finally, that the plan "should include a provision that, within a reasonable period of time (such as eight years), all storage of plutonium metal and oxide should be in conformance with the DOE standard on storage of plutonium" (DNFSB, 1994).

DOE acknowledged the DNFSB's concerns and on February 28, 1995, published a report entitled, *The Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan* as the integrated program plan recommended by the DNFSB. This implementation plan provides the schedules and major milestones (including those associated with the proposed action which is the subject of this EIS) for achieving the DNFSB's recommended environment, safety, and health objectives (DOE, 1995).

If all the plutonium-bearing materials were suitably stabilized and placed in interim storage in the PFP Facility vaults, the number of required workers, the worker dose, and the associated cost to safely manage the PFP Facility could be reduced. Also, completion of the stabilizing activities would allow DOE to bring the Facility to a minimum surveillance level consistent with the continued operation and security of the plutonium storage vaults.

## **2.3 SPECIFIC VULNERABILITIES FACING THE PFP FACILITY**

The sudden halt in the production of weapons-grade plutonium in the late 1980s froze the existing PFP Facility manufacturing pipeline in a state that was unsuited for long-term storage. This has caused problems with plutonium-bearing materials remaining at the PFP Facility. The resulting specific concerns focus on certain liquids and solids containing fissile materials. The major areas of concern are:

### **Nitrate Solutions**

Plutonium-bearing nitrate solutions are stored at the PFP Facility. Some of these containers are suspected of having potentially explosive buildups of hydrogen gas. Plastic bottles inside others may be embrittled because of exposure to acid, radiation, and gas pressure. The embrittlement would make them susceptible to breakage during handling and draining (DOE, 1994).

### **Reactive Scrap**

The PFP Facility has unstable and reactive plutonium scrap/residues stored in vaults. The design life of the packaging is unknown. Radiolysis, gas generation, and corrosion could have caused breaches. Increased worker exposures are probable and must be considered (DOE, 1994).



## **Aging Polycubes**

Plutonium-bearing polycubes are also stored at the PFP Facility. Polycubes are polystyrene blocks impregnated with plutonium dioxide powder and coated with aluminum and/or organic paint. Radiolysis of the organic material has the potential to cause hydrogen gas generation, which could result in a potential fire and/or explosion hazard (DOE, 1994).

## **Incomplete Material Content and Packaging Information**

There is incomplete information about the contents and packaging of some plutonium packages at the PFP Facility, casting doubts about storage stability. Some of the packages may have plutonium in direct contact with plastic, which will cause hydrogen buildup, reaction with stored material, and/or container corrosion. Continued chemical and radiolytic reactions in these 15- to 27-year-old packages will eventually lead to container failure. Packaging failure could result in worker exposures (DOE, 1994).

## **Aging Gloveboxes**

Gloveboxes used to store plutonium in the PFP Facility have deteriorating windows, seals, gaskets, and gloves. Organic materials used in construction have been damaged by radiation and chemical degradation, shortening the life of the materials and necessitating frequent surveys and replacements. Failure of this equipment could cause worker contamination and exposure (DOE, 1994).

## **Earthquake Vulnerability**

The PFP Facility includes several separate or adjoining buildings with distinct functions. Seismic evaluations of key buildings at the PFP Facility show that they can withstand a design basis earthquake.

However, a small quantity of plutonium-bearing material is tightly adhered to the exhaust ducts downstream of the PFP Facility high efficiency particulate air (HEPA) filters. Some of this plutonium-bearing material could be dislodged during an earthquake and be directly released to the environment (DOE, 1994).

## **Hold-up**

Routine operations have resulted in the accumulation of plutonium in many locations (hold-up) at the PFP Facility, including the floor of the PRF canyon and the PFP Facility ventilation ducts. This poses a source of increased radiation exposure to workers from plutonium and from the increasing concentrations of Am-241 resulting from plutonium decay. Process drain lines at the PFP Facility contain unknown amounts of plutonium that have leaked contamination and are likely to do so again (DOE, 1994).

PFP Facility gloveboxes, exhaust ducts, and HEPA filters have been corroded by hydrogen fluoride. This historical use of hydrogen fluoride increases the likelihood for equipment failure. Hydrogen fluoride is no longer used at the PFP Facility. However, the potential for equipment failure could cause additional worker exposure (DOE, 1994).

## **References:**

40 CFR 1500, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

DNFSB, 1994, Recommendation 94-1 to the Secretary of Energy, pursuant to 42 U.S.C. §2286 a(5) Atomic Energy Act of 1954, as amended," Defense Nuclear Facilities Safety Board, Washington, D.C.

DOE, 1993, "Stabilizing Reactive Plutonium at Hanford's Plutonium Finishing Plant," Citizen Bulletin, U.S. Department of Energy, Richland Operations Office, Richland, Washington, July.

DOE, 1994, *Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage*, DOE/EH-0415 Volume I: Summary, U.S. Department of Energy, Washington,

D.C.

DOE, 1995, *Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan*, U.S. Department of Energy, Washington, D.C.





## 3.0 DESCRIPTION OF PROPOSED ALTERNATIVES

This section provides a brief description of the PFP Facility; information on the nature of the safety issues facing the Facility (including a description of the materials for stabilization, removal, and/or immobilization); a description of each alternative that would reasonably resolve the safety issues; a comparison of the anticipated environmental impacts for each alternative; and finally, a discussion of the alternatives selection methodology.

This description of the proposed alternatives is arranged as follows:

- 3.1 Description of Plutonium-bearing Materials Potentially Suitable for Stabilization, Removal, and/or Immobilization
- 3.2 Description of the Preferred Alternative
- 3.3 Description of Alternatives
- 3.4 Description of the No Action Alternative
- 3.5 Comparison of the Anticipated Environmental Impacts of the Alternatives
- 3.6 Alternative Selection Methodology and Alternatives Dismissed.

### Facility Description

The PFP Facility is comprised of several buildings located in the 200 West Area and occupies approximately 23 hectares (58 acres). The PFP Facility is separated from the rest of the 200 West Area by a double-fenced security enclosure. Only personnel having duties and responsibilities associated with the operation of the PFP Facility have security clearances for access to the protected area. A simplified layout and the location of the PFP Facility is shown in Figures 3-1, 4-1, and 4-2. A more detailed description is provided in Appendix A.

Historically, the PFP Facility was used to conduct diversified plutonium processing, storage, and support operations for national defense. Those operations included:

- Special nuclear material handling and storage
- Plutonium recovery
- Plutonium conversion
- Laboratory support
- Waste handling
- Shutdown and operational facility surveillances.

[HREF="/nepa/dbgraphics/eishtml/eis-0244/0244f45.gif">Figure 3-1. The PFP Facility](#)

All PFP Facility operations related to production of plutonium were stopped in 1989.

### Preferred Alternative

The PFP Facility contains a variety of reactive plutonium-bearing materials that are chemically and physically dissimilar. These materials have been grouped into four inventory categories. The preferred alternative for stabilization would involve processing the plutonium-bearing materials at the PFP Facility into a form suitable for interim storage in existing PFP Facility vaults. This preferred alternative includes the following processes for the four inventory groups:

- 1) Plutonium-bearing solutions - Ion exchange, vertical calcination, and thermal stabilization
- 2) Oxides, fluorides, and process residues - Thermal stabilization using a continuous furnace
- 3) Metals and alloys - Repackaging

#### 4) Polycubes and combustibles - Pyrolysis.

The preferred alternative also would involve removing and stabilizing plutonium-bearing material currently in hold-up at the PFP Facility. This is material that has accumulated or been retained in PFP Facility gloveboxes, hoods, process equipment, piping, exhaust and ventilation systems, and the PRF canyon as a result of 40 years of plutonium-processing operations at the Facility. The removal activities would be limited to materials that are readily retrievable. Due to the nature and location of the material in hold-up, various technologies would be employed to remove the material for subsequent stabilization.

### **Alternatives**

In addition to the preferred alternative identified above, the following alternatives have been identified:

- Plutonium-bearing solutions - Hydroxide precipitation followed by thermal stabilization
- Oxides, fluorides, and process residues - Batch thermal stabilization using muffle furnaces; and immobilization of candidate materials
- Metals and alloys - Batch thermal stabilization using muffle furnaces
- Polycubes and combustibles - Batch thermal stabilization; molten salt oxidation; and immobilization of candidate materials.

Any process identified above could be substituted for a comparable process described under the preferred alternative.

### **No Action**

The no action alternative provides an environmental baseline against which the impacts of the preferred and other alternatives can be compared. Under this alternative, actions would be limited to ongoing maintenance and security activities necessary for safe and secure management of the PFP Facility. Plutonium-bearing materials stored at the PFP Facility would not be stabilized or immobilized, and plutonium-bearing hold-up material would not be removed.

## **3.1 DESCRIPTION OF PLUTONIUM-BEARING MATERIALS POTENTIALLY SUITABLE FOR STABILIZATION, REMOVAL, AND/OR IMMOBILIZATION**

The PFP Facility contains a variety of reactive plutonium-bearing materials. For analysis purposes, the reactive materials have been grouped into four inventory categories. Each group contains materials that are chemically and physically dissimilar to materials in the other groups. The four groups are:

- 1) Plutonium-bearing solutions
- 2) Oxides, fluorides, and process residues
- 3) Metals and alloys
- 4) Polycubes and combustibles.

In addition to the plutonium-bearing materials listed above, the PFP Facility contains plutonium-bearing materials that are contained in PFP systems (e.g., ventilation, process equipment, piping, walls, floors, etc.). This material has accumulated gradually over 40 years of processing plutonium for defense and other needs. For the purposes of this EIS, the accumulated material will be referred to as hold-up material.

Subsection 3.1.1 provides a description and estimate of the materials that would undergo stabilization. Subsection 3.1.2 provides a description and estimate of the hold-up material in the PFP Facility. Subsection 3.1.3 provides a description of the plutonium-bearing materials potentially suitable for immobilization.

### 3.1.1 Materials Potentially Suitable for Stabilization

Detailed information on each of the four categories of plutonium-bearing materials is provided in the next four subsections. The descriptions include the quantity of plutonium associated with the respective inventory category. Table 3-1 provides a summary of each inventory category.

#### 3.1.1.1 Plutonium-bearing Solutions

Approximately 4,800 liters (l) (1,268 gallons [gal]) of plutonium-bearing solutions containing 335 kg (738 lb) of plutonium are stored at the PFP Facility (WHC, 1995a). These solutions are currently stored in configurations that were not designed for extended storage. Some of the solutions are in plastic bottles inside stainless steel containers. Some are in 8.5-l (2.2-gal) stainless steel vessels inside product receiver containers.

**Table 3-1 Summary of Plutonium Inventory Categories at the PFP Facility**

Description of Inventory Category	Number of Items	Volume (liters)	Plutonium Mass (kg)
Plutonium-bearing Solutions	459	4,800	335
Oxides <ul style="list-style-type: none"> <li>• Oxides &gt;50 wt% Pu</li> <li>• Oxides &lt;50 wt% Pu</li> <li>• Mixed oxides<sup>a</sup></li> </ul>	5,496	N/A	2,263
Process Residues <ul style="list-style-type: none"> <li>• Asha</li> <li>• Slag and crucibles<sup>a</sup></li> <li>• Other/misc. sources<sup>a</sup></li> </ul>	1,138	N/A	154
Fluorides <sup>b</sup>	14	N/A	3
Metals and Alloys	477	N/A	770
Polycubes and Combustibles	273	N/A	35
<b>Total</b>	<b>7,857</b>	<b>4,800</b>	<b>3,560</b>

**Notes:**a. Corresponds to a material type from Table 3-1 of WHC, 1995<sup>a</sup>.

b. Fluorides are a subset of "Compounds" in Table 3-1 of WHC, 1995a.

Pu =Plutonium

#### 3.1.1.2 Oxides, Fluorides, and Process Residues

The oxides inventory consists of solids containing 2,263 kg (4,986 lb) of plutonium (WHC, 1995a). These oxides have previously undergone thermal treatment and contain very low moisture and no organic materials. However, additional stabilization would be required to meet the long-term storage criteria recommended by the DNFSB.

Approximately 154 kg (339 lb) of plutonium are contained in the process residue inventory (WHC, 1995a). This inventory consists of ash, slag, and crucibles, and other miscellaneous residues and sources used for calibrating equipment at the PFP Facility. An additional 3 kg (6.6 lb) of plutonium are contained in fluoride-bearing compounds at the PFP Facility (WHC, 1995a). Fluorides and process residues are considered unstable for continued storage due to their corrosive or chemically reactive nature. These materials are particularly unstable when they are exposed to air and moisture through potential air leaks inherent in the current package design or from packaging failure stemming from radiolysis and pressure buildup.

#### **3.1.1.3 Metals and Alloys**

Approximately 770 kg (1,697 lb) of plutonium metals and alloys are stored at the PFP Facility (WHC, 1995a). The current storage configuration of plutonium metals and alloys is not considered stable for extended storage. This is due to the potential for oxidation of the metal resulting in volume increases in the storage containers or for radiolysis of organics, resulting in hydrogen gas generation and pressurization or failure of the storage containers.

#### **3.1.1.4 Polycubes and Combustibles**

Approximately 35 kg (75 lb) of plutonium are contained in polycubes and combustibles stored at the PFP Facility (WHC, 1995a). Polycubes are polystyrene blocks containing plutonium oxides powder and coated with aluminum and/or organic paint or tape. Combustibles include paper, rags, chemical wipes, graphite, wood, and plastics.

The proximity of the plutonium to the organic constituents of the polycubes and combustibles could cause radiolysis and hydrogen gas generation. The potential for fire or explosions leaves the polycubes and combustibles in a condition unacceptable for extended storage.

### **3.1.2 Plutonium-bearing Hold-up Materials Potentially Suitable for Removal**

Plutonium-bearing hold-up consists of materials that have gradually accumulated as a result of Facility operations and operational upsets. A summary of the plutonium-bearing hold-up is shown in Table 3-2.

The hold-up inventory at the PFP Facility is predominantly associated with the E-4 Exhaust System ductwork and Process Vacuum System piping, the plutonium-handling gloveboxes and hoods, and the PRF canyon floor. Smaller quantities of plutonium are associated with exhaust manifolds, HEPA filters and filterboxes, sump tanks, waste transfer lines, tunnels, and pits in the PFP Facility.

Plutonium in ductwork, process vacuum system piping, gloveboxes/hoods, and on the PRF canyon floor is targeted for removal under this EIS. These represent locations where the greatest quantity of plutonium can be removed with the least personnel radiation exposure and cost.

#### **3.1.2.1 E-4 Exhaust System/Manifolds**

The 234-5Z (process ventilation) Exhaust System, known as E-4, carries potentially contaminated air from gloveboxes, open hoods, and vaults through two independent stages of HEPA filters and out the 291-Z-1 stack to the environment. Approximately 6 kg (13.2 lb) of plutonium have migrated beyond the individual glovebox/hood filters (WHC, 1995b).

**Table 3-2 Plutonium-bearing Hold-up Material**

System	Description	Estimated Plutonium (kg)	Form
E-4 Exhaust System	Approximately 1,200 m linear of 5-cm to 173-cm diameter ducts	6.0	Solid
Exhaust Manifolds (Downstream from Final Filters)	3,558 m linear of 335-cm x 335-cm ductwork	0.02	Adhered Solid
Process Vacuum System	Approximately 210 m of 5.1-, 7.6-, 10.2-cm diameter stainless steel piping	4.3	Solid
HEPA Filter and Filter Boxes	40 primary filterboxes	0.7	Powder
Plutonium Handling Gloveboxes/Hoods	150 plutonium handling gloveboxes and hoods	31	Sludge
PRF Canyon Floor and Airlock	9.8 m x 15.8 m x 7.9 m canyon; 10.7 m x 4.0 m airlock	12.5	Sludge
241-Z Sumps	4 active and 1 inactive 16,000-l sump tanks	0.14	Liquid
291-Z Sumps	Suspected recoverable residual plutonium-bearing material	0.04	Sludge

The E-4 (process ventilation) exhaust system consists of approximately 1,200 meters (m) (3,960 feet [ft]) of ductwork ranging in diameter from 5 to 173 centimeters (cm) (2 to 68 inches [in]) (WHC, 1995b). The bulk of the plutonium associated with the E-4 system is held up in about 100 m (330 ft) of ductwork. Approximately 20 m (70 ft) of this ductwork containing approximately 2.5 kg (5.5 lb) of plutonium is expected to be removed prior to the issuance of this EIS. NEPA review of this activity was completed independently of this EIS (DOE, 1994a). Approximately 2 kg (4.4 lb) of plutonium in the remaining 80 m (260 ft) of ductwork will be considered for removal under this EIS.

The plutonium-bearing materials in the ductwork are expected to be in the form of solid residues of plutonium oxides or plutonium fluoride. Over the years, americium-241 (Am-241) and other radionuclides have been produced from radioactive decay of plutonium.

### 3.1.2.2 Plutonium-bearing Process Vacuum System Piping

The 234-5Z Process Vacuum System piping was used for transferring liquids from tank to tank in support of various processes at the PFP Facility. A transfer routing error in the mid-1980s resulted in 4.3 kg (9.5 lb) of plutonium becoming entrained in the pipe.

Plutonium is held up in approximately 30 m (100 ft) of the 10-cm (4-in) diameter header line on the PFP Facility duct level (WHC, 1995b). The plutonium is expected to be in the form of solid residues of plutonium oxides. Other radionuclides (e.g., Am-241) are expected to be present as a result of normal radioactive decay. All 4.3 kg (9.5 lb) of plutonium would be targeted for removal.

### 3.1.2.3 Plutonium-bearing Gloveboxes and Hoods

The gloveboxes and hoods were designed to provide protected hands-on workspace and equipment for the plutonium purification operations at the PFP Facility. There are over 150 plutonium-handling gloveboxes and hoods at 59 locations in the PFP Facility. Approximately 31 kg (68 lb) of plutonium have accumulated in these gloveboxes and hoods as the result of leaks and spills during operations. Most of the plutonium is on the floor of the gloveboxes, with the remainder on the walls and equipment. The plutonium is expected to be in an oxide state in the form of a sludge.

The inventory of plutonium in gloveboxes and hoods indicates that over 90 percent of the total plutonium hold-up is associated with 25 of the gloveboxes. Removal actions would be focused upon these 25 gloveboxes in order to maximize plutonium recovery while attempting to minimize personnel radiation exposure and cost.

#### **3.1.2.4 Plutonium in the PRF Canyon**

The PRF Canyon was used for plutonium reclamation operations. The canyon is 15.8 m (52 ft) long, 9.8 m (32 ft) wide, and 7.9 m (26 ft) high. Access to the canyon is through an air lock 10.7 m (35 ft) long and 4.0 m (13 ft) wide. To prevent criticality in the event of a leak or spill, the stainless steel floor is divided into rectangular grids referred to as trays. The equipment (e.g., tanks, piping, and solvent exchange columns) was designed and installed so that the lowest points are several feet above the floor. There are currently two aluminum ladders and a disassembled tank on the floor.

Approximately 12.5 kg (27.5 lb) of plutonium has been deposited on the floor of the canyon as the result of leaks and spills. The plutonium is expected to be in an oxide state in the form of a sludge. All 12.5 kg (27.5 lb) of plutonium would be targeted for removal.

#### **3.1.2.5 Other Areas with Hold-up**

The following facilities and equipment have less than 1 kg (2.2 lb) of hold-up material distributed among them:

- Building 241-Z consists of four active and one inactive underground stainless steel sump tanks. These tanks have a working capacity of 16,000 l (4,200 gal). These sump tanks are estimated to contain 0.14 kg (0.3 lb) of plutonium and are currently used for temporary storage of the PFP Facility's liquid waste.
- Building 241-Z Waste Transfer Lines - Plutonium-bearing radioactive liquid wastes generated at the PFP Facility are routed through stainless steel pipes to be temporarily stored and treated at Building 241-Z prior to being transferred to the double-shell tank storage at the 200 Area Tank Farms. Where these waste lines exit the respective buildings, they are buried in concrete trenches with cover blocks that extend to Building 241-Z.
- Tunnels, Pits, and Pipe Chases - A series of tunnels underneath Building 234-5Z house the drain lines that take waste solutions from the first floor processing areas and direct them to the waste tanks in Building 241-Z. Miscellaneous pits exist under the floors of Building 234-5Z. These pits have been sealed for many years with no specific history that plutonium-bearing material contamination exists in them. However, the existence of a small amount of plutonium-bearing material is suspected in these pits.
- E-4 Exhaust Manifolds - Over the years, 0.02 kg (0.046 lb) of plutonium has migrated downstream of the final filters. The plutonium solids are expected to adhere to the exhaust manifolds.
- HEPA Filters and Filterboxes - The E-4 exhaust system has three stages of HEPA filters beginning with those installed in exhaust ducts from hoods and gloveboxes. The first filter is located at the glovebox or hood. The second filter is called the primary filter and is located in a filter box located some distance downstream of the glovebox. One primary filter typically serves multiple gloveboxes. The third filter is called the final filter. These are consolidated in the final filter rooms. Plutonium gradually accumulated in these filterboxes over the years. There is estimated to be less than 1 kg (2.2 lb) of plutonium spread across 40 primary filterboxes in Building 234-5Z.

### **3.1.3 Description of Plutonium-bearing Materials Potentially Suitable for Immobilization**



Portions of the plutonium-bearing inventory categories considered in Subsection 3.1 could be suitable for immobilization without stabilization. Two sources of potentially suitable plutonium-bearing materials exist. The first consists of some materials currently stored in PFP Facility vaults. The second consists of readily retrievable hold-up materials that would be removed from PFP Facility ductwork, process piping, gloveboxes, and the PRF canyon. The materials potentially suitable for immobilization are summarized in Table 3-3.

### Vault Materials

Approximately 222 kg (490 lbs) of plutonium contained in 1,500 items that are currently stored in PFP Facility vaults are candidates for immobilization (WHC, 1996a). The plutonium content and chemical nature of these materials vary from item to item due to differing sources of the materials. The major categories of materials are oxides, process residues, and miscellaneous/other combustibles.

**Table 3-3 Plutonium-bearing Materials Potentially Suitable for Immobilization**

Description of Inventory Category	Plutonium Content (kg)
Vault Materials	.
Oxides · Oxides < 50 wt% Plutonium	91
Process Residues · Ash · Slag and Crucibles	81 43
Miscellaneous/Other Combustibles	7
Readily Retrievable Hold-up Materials	.
• Removed from Ductwork	4.5
• Removed from Piping	4.3
• Removed from Gloveboxes	28
• Removed from PRF Canyon	12.5
Total	272

**Source:** WHC, 1996a

Plutonium-bearing oxides in this inventory contain very little moisture and no organic materials. Process residues consist primarily of sand, slag, crucibles, and furnace ash. Sand and crucibles are composed primarily of magnesium oxide. Slag is composed of calcium iodide, calcium fluoride, residual plutonium metal left after removing the plutonium metal from the crucibles, and small amounts of elemental calcium and iodine, along with fluoride salts. Miscellaneous/other combustibles consist of items such as contaminated rags and paper. The size of these materials

varies from fine particulates to large articles.

### **Readily Retrievable Hold-up Materials**

Up to 50 kg (110 lb) of plutonium would be recovered from PFP Facility hold-up. Up to 4.5 kg (9.9 lb) of plutonium would come from the E-4 ventilation system ductwork; up to 4.3 kg (9.5 lb) of plutonium would come from the process piping; up to 28 kg (62 lb) of plutonium would come from the gloveboxes and hoods; and up to 12.5 kg (28 lb) of plutonium would come from the PRF canyon. The plutonium concentration in these materials is not known. An assay would be performed to determine whether some or all of these materials would meet the criteria for immobilization.

## **3.2 DESCRIPTION OF THE PREFERRED ALTERNATIVE**

Previous subsections of this EIS describe conditions associated with unstable plutonium-bearing materials at the PFP Facility. These conditions suggest a need to take actions at the Facility that will mitigate risks of radiation exposure to PFP Facility workers and to the public and reduce the cost of operating the Facility. The plutonium-bearing materials at the PFP Facility can be separated into two categories: 1) materials that are containerized and stored in vaults or gloveboxes; and 2) materials that are not containerized and referred to as hold-up. This subsection describes the preferred methodology for handling each of these groups. In the case of the containerized items, the preferred alternative describes a methodology for chemically and physically stabilizing the inventory such that it can be packaged and stored in vaults at the PFP Facility in accordance with the DOE storage standard (DOE, 1994b). In the case of the hold-up, the preferred alternative describes a methodology for characterizing and removing readily retrievable hold-up material such that it can be stabilized and stored.

Other additional actions not specified under the preferred alternative would be ongoing during the time frame of the proposed alternative. These activities include:

- Maintenance of the Safety Boundary of the PFP Facility
- Corrective and Preventive Maintenance
- Surveillances (e.g., operational safety requirements, nuclear process, radiological control, power operator, and environmental)
- General Laboratory Support
- Engineering Support
- Management of Special Nuclear Material
- Safeguards and Security.

### **3.2.1 Description of the Preferred Alternative for Stabilization**

The preferred alternative for stabilization would involve the installation and operation of processes to stabilize reactive plutonium-bearing materials at the PFP Facility. Four separate processes would be assembled to accommodate differing plutonium inventory groups. In most cases, the processes would involve two or more treatment technologies. The preferred alternative would include the following four processes:

- Ion exchange, vertical calcination, and thermal stabilization of plutonium-bearing solutions
- Thermal stabilization of oxides, fluorides, and process residues using a continuous furnace
- Repackaging of metals and alloys
- Pyrolysis of polycubes and combustibles.

A description of the preferred alternative for stabilization is provided in Subsections 3.2.1.1 through 3.2.1.4.

### 3.2.1.1 Ion Exchange, Vertical Calcination, and Thermal Stabilization of the Plutonium-bearing Solutions

#### Overview

In this alternative, plutonium-bearing solutions would be stabilized primarily by thermal treatment using a vertical calciner. A similar process was tested at the PFP Facility during the 1960s to convert plutonium nitrate solutions to plutonium dioxide powder (Stiffler and Hopkins, 1962). For this application, the feed material would include plutonium nitrate solutions, solutions containing chlorides, caustic solutions, and dissolved plutonium fluoride.

In order to utilize the vertical calcination process, some of the plutonium-bearing solutions would require pretreatment by ion exchange to remove chemical constituents that are not compatible with the vertical calcination process or the process equipment. In addition, the calciner product may require further thermal stabilization in order to meet the requirements of the DOE storage standard (DOE, 1994b).

The combined ion exchange/vertical calciner/thermal treatment process would be capable of processing the entire inventory of plutonium nitrate and chloride solutions. It also would be able to process the plutonium fluoride solids if they are first dissolved and converted to the nitrate form using an acid dissolution pretreatment operation. This would increase the quantity of material to be stabilized under this alternative from 335 kg (738 lb) plutonium to 338 kg (745 lb) of plutonium associated with 4,800 l (1,268 gal) of solution.

#### Process Description

A block diagram for this alternative is shown in Figure 3-2. The central component of this process is a liquid-fed vertical calciner similar to the one used at the PFP Facility during the early 1960s. A more detailed block diagram and material balance for this alternative is included in Appendix B.

#### Inventory Retrieval and Feed Preparation

The plutonium-bearing solutions to be stabilized under this alternative would be retrieved from their current storage location and loaded into a glovebox at the PFP Facility for feed preparation. Approximately one-third of the solutions would require ion exchange pretreatment. Approximately two-thirds of the inventory of plutonium-bearing solutions would not require pretreatment and would be transferred directly to the vertical calciner. The caustic solutions would be filtered and the solids sent to thermal stabilization. Filtrates would be blended with the feed to ion exchange.

#### Ion Exchange Pretreatment

Chloride- and fluoride-bearing solutions would be processed by ion exchange prior to vertical calcination. This process would remove chemical constituents that could cause corrosion or interfere with the operation of the calciner. Removal of these constituents also would improve the chemical stability of the product oxide and reduce the corresponding dose rate by removing americium.

#### [Figure 3-2. Ion Exchange, Vertical Calcination, and Thermal Stabilization of Plutonium-bearing Solutions](#)

Ion exchange columns would be operated in a cyclic mode consisting of the following process steps: 1) column loading; 2) washing to remove impurities; 3) product elution; and 4) reconditioning. Plutonium nitrate would be adsorbed onto the resin during column loading. The column would then be washed with nitric acid or other reagents to remove americium and other impurities. After washing, the plutonium would be removed from the column with dilute nitric acid or other reagents. The resin would then be reconditioned with nitric acid to prepare it for the next loading cycle. The purified plutonium nitrate solution would be fed to the vertical calciner.

#### Vertical Calciner Operation

The vertical calciner can be simply described as two concentric heated stainless steel pipes mounted vertically. Calcination takes place in the annular space between these two pipes.

The calciner would be electrically heated to operate at a temperature between 800 and 1,050 degrees Celsius ( $^{\circ}\text{C}$ ) (1,472 and 1,922 degrees Fahrenheit [ $^{\circ}\text{F}$ ]). This high temperature has the advantage of producing a more stable product.

Plutonium solutions would be slowly introduced into the bottom of the calciner. The feed rate would depend upon the concentration of plutonium in the solution being processed, varying from 1 to 4 liters per hour (l/hr) (0.26 to 1.1 gal/hr). As the liquid feed enters the calciner, the water evaporates rapidly. Denitration occurs as the nitric acid is converted to nitrogen oxide gases. Finally, the plutonium undergoes oxidation, forming an oxide powder. The stirred bed of hot plutonium oxide powder provides a reaction surface for fresh feed and also enhances heat transfer from the chemical reactor wall. The oxide powder travels upward through the bed as new feed is introduced below it and flows out of the reactor at the top of the bed through a tube. The impure plutonium oxide product is collected in a heated receiver vessel to prevent vapor condensation. Offgas from the vertical calciner is routed through a ceramic filter to an adjacent scrubber unit.

### **Thermal Stabilization**

Additional thermal stabilization might be required to meet the DOE storage standard (DOE, 1994b). Batch thermal stabilization, if required, could be performed in a muffle furnace located near the vertical calcination process. Alternatively, a continuously operated thermal stabilization furnace could be coupled with the vertical calciner and potentially decrease PFP Facility worker exposure. Following thermal stabilization, a sample of the product would be taken and sent to the analytical laboratory to verify that the material meets the DOE storage standard.

### **Packaging and Transfer to Storage**

Acceptable plutonium dioxide product would be transferred to a storage container, weighed, sealed out of the glovebox, and packaged in storage containers in accordance with existing procedures. Product that did not meet the DOE storage standard would be thermally stabilized a second time. A nondestructive analysis would be performed on the packaged product to determine the isotopic composition prior to transfer to the PFP Facility for storage. The product could be retrieved and repackaged to meet the DOE storage standard when a bagless transfer system has been developed. A more detailed description of the repackaging process is located in Subsection 3.2.1.3.

### **Offgases and Effluents**

The vertical calciner offgas stream would contain primarily air, water, and nitrogen oxides. The offgas would be treated prior to discharge to the Facility ventilation system and ultimately the 291-Z-1 stack. Offgas treatment consists of filters and the combination condenser/scrubber. The condenser would remove most of the water, and the scrubber would remove much of the nitrogen oxides using a sodium hydroxide scrubber solution. The expected maximum emission rate for nitrogen oxides after scrubbing would be  $9.8 \times 10^{-3}$  grams per second (g/sec) ( $2.2 \times 10^{-5}$  lb/sec). A total of 84 kg (186 lb) of nitrogen oxides would be discharged to the environment.

Additional offgas would be generated during thermal stabilization of the vertical calciner product. This gas would include air, water vapor, and entrained oxides. For the purposes of this EIS, a theoretical maximum release to the environment of 0.042 grams (g) ( $9.3 \times 10^{-5}$  lb) of plutonium oxides is assumed for this alternative.

### **Liquid Effluent**

Anticipated liquid effluents from the ion exchange process would be the combined liquid waste from the load, wash, and regeneration steps. The wastes would primarily be concentrated nitric acid containing less than 0.013 g/l ( $1 \times 10^{-4}$  lb/gal) plutonium. Other waste constituents would include americium, chlorides, fluorides, and other metallic impurities. These liquid wastes could be transferred to the 200 Area Tank Farms or transferred to a glovebox for cementation and disposal as transuranic waste. The total liquid waste volume is estimated to be 8,300 l (2,200 gal). If cemented and disposed of as solid waste, the total volume would be about 12 cubic meters ( $\text{m}^3$ ) (16 cubic yards [ $\text{yd}^3$ ]). A maximum of 108 g (0.24 lb) of plutonium could be disposed of as waste.

The vertical calciner also would produce a liquid waste stream from the offgas condenser/caustic scrubber. This liquid

waste stream could be transferred to the 241-Z tanks where the pH would be adjusted, if necessary, then transferred to the 200 Area Tank Farms. Alternatively, the scrubber bottoms could be transferred to another glovebox for solidification in cement and disposed of as transuranic waste. A total of 32,000 l (12,100 gal) of solution would be generated during vertical calcination. A maximum of 28 g (0.062 lb) of plutonium could be disposed of as waste.

### **Solid Waste**

Solid transuranic waste would be generated during glovebox operations. Solid transuranic waste might include feed packaging material and plastic storage containers. This waste would be sent to Hanford Site solid waste management facilities for storage.

Spent ion exchange resin would be generated periodically and would be stabilized and treated for storage as solid transuranic waste. A total of 60 l (16 gal) of spent resin could be generated during ion exchange. A maximum of 55 g (0.1 lb) of plutonium could be disposed of as waste.

### **Facilities and Equipment**

Solution receipt, unpacking, and load-in could be performed with existing equipment in Glovebox HC-227. This glovebox has tanks for holding and transferring solutions and was previously used as the nitrate feed load-in station for the RMC production line. Some liquid transfer lines to other gloveboxes exist, but additional lines to new gloveboxes and equipment in Building 234-5Z would be required.

The ion exchange process would be installed in a new glovebox connected to the existing RMC glovebox system at the PFP Facility. New equipment would be required, including tanks, columns, associated piping, valves, and instrumentation. Liquid transfer lines to the vertical calciner glovebox and to liquid waste treatment would be required. Assuming operations 24 hr/day, five days per week, and a total operational efficiency of 70 percent, the ion exchange processing could be completed in 6.5 weeks.

A vertical calciner would be fabricated and installed in a new or existing glovebox connected to the PFP Facility glovebox system. It would receive feed from both the nitrate solution load-in glovebox and the ion exchange system glovebox. Assuming operations 24 hr/day, five days per week, and a total operational efficiency of 70 percent, the vertical calcination could be completed in 26 weeks. If additional stabilization is required, up to 10 muffle furnaces, each processing 1,200-g (2.6-lb) batches, 24 hr/day would require an additional 10.5 weeks. The total operational duration for employing ion exchange, vertical calcination, and supplemental thermal stabilization in series would thus require 43 weeks.

Equipment may be installed to allow close-coupling of the final thermal treatment step for stabilization. For example, a muffle furnace or continuous feed furnace may be installed in the same glovebox as the vertical calciner or in an adjacent box.

#### **3.2.1.2 Thermal Stabilization of Oxides, Fluorides, and Process Residues Using a Continuous Furnace**

### **Overview**

This alternative uses a continuous furnace to thermally stabilize plutonium-bearing oxides, fluorides, and process residues. The objective of this alternative is to produce a resultant oxide product capable of meeting DOE stability requirements for packaging and vault storage.

The oxides and process residues would be loaded continuously into a furnace similar to the continuous fluorinator used in the RMC Line at the PFP Facility. The furnace would operate at 1,000·C (1,832·F) with a continuous air feed. The high-temperature air environment would facilitate conversion of incompletely oxidized plutonium to plutonium dioxide and would also reduce the residual moisture level of the feed solids.

Plutonium fluorides may not be processed through the continuous furnace due to the corrosive nature of the hot hydrogen fluoride gases that would be generated. Plutonium fluorides could be pretreated using an acid dissolution

process (discussed in Subsection 3.3.2.2) and blended with the nitrate and chloride solutions. Some of the process residues may also not be amenable to continuous processing due to their size, moisture content, or high organic content (greater than 2 weight percent organic). Hydrolysis is considered to be an appropriate pretreatment measure for high organic-content residues and is discussed further in Subsection 3.3.2.2.

A total of 2,417 kg (5,326 lb) of plutonium would be stabilized using this alternative. The resultant plutonium dioxide would be tested in accordance with the DOE storage standard. Product determined to be acceptable would be packaged using existing packaging capabilities and placed in the vault(s) at the PFP Facility for storage. Product not meeting the DOE storage standard would be rerun through the continuous furnace. The product could be retrieved and repackaged at a later date to meet the DOE storage standard specifying organic-free containers, when a bagless transfer system becomes available at the Hanford Site.

### **Process Description**

A block diagram of the continuous thermal stabilization process is shown in Figure 3-3. A more detailed block diagram and material balance for this alternative is included in Appendix B.

### **Inventory Retrieval and Feed Preparation**

Oxides and process residues would be retrieved from the vaults and other storage locations and transferred to a glovebox for processing. The containers would be subsequently unpackaged and the contents transferred manually into the continuous furnace feed mechanism.

Oxide feed streams (i.e., those originally processed at temperatures between 800 and 1,000·C) would be tested prior to continuous thermal stabilization. Oxides meeting the DOE storage standard would forgo additional thermal stabilization measures and would be repackaged. Oxides that fail to meet the DOE storage standard would be processed through the continuous furnace.

### **Continuous Thermal Stabilization**

A continuous feed mechanism would be used to supply the oxides and residues into the top of the continuous furnace. Inside the furnace, the temperature of the feed material would be raised to 1,000·C (1,832·F). The furnace would be a tube configuration, inclined slightly from the horizontal. Gravity, combined with a vibrational furnace motion, would convey the feed material to an outlet at the lower end of the furnace. As the feed material moves through the furnace, dry air would flow countercurrent toward the inlet. The dry air serves as a source for oxygen so complete oxidation of the plutonium would occur.

#### [Figure 3-3. Thermal Stabilization of Oxides and Process Residues Using a Continuous Furnace.](#)

The thermally stabilized product would flow from the furnace and be collected in a powder pan placed below the furnace. A sample of the product would be taken and sent to the analytical laboratory to verify that the material meets the DOE storage standard. Product failing to meet the storage standard would be recycled through the furnace.

It is estimated that the continuous furnace would be capable of handling a feed rate of about 1,200 g (2.6 lb) of plutonium-bearing material per hour. Push-through furnaces also could be used with similar processing rates.

### **Product Packaging and Transfer to Storage**

Product meeting the DOE storage standard would be packaged using the existing packaging system. A nondestructive analysis would then be performed on the packaged product to determine the isotopic composition prior to transfer to the vault(s) at the PFP Facility for storage. The product could be retrieved and repackaged (see Subsection 3.2.1.3) to meet the DOE storage standard specifying organic-free containers when a bagless transfer system has been developed and installed at Hanford.

### **Offgases and Effluents Offgases**

The offgas from the continuous furnace would consist of air, water vapor, and small amounts of entrained plutonium oxides and other miscellaneous metal oxides. Solids entrained in the offgas would be significantly reduced by a ceramic filter and HEPA filters in the PFP Facility ventilation control system. The maximum rate of plutonium oxide release to the environment through the 291-Z-1 stack is estimated to be  $1.9 \times 10^{-8}$  g/sec ( $4.3 \times 10^{-11}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of 0.31 g ( $6.8 \times 10^{-4}$  lb) of plutonium oxides is assumed for this alternative.

### **Solid Waste**

Solid transuranic waste will be generated during glovebox operations. Solid transuranic waste might include feed packaging material and would be sent to Hanford Site solid waste management facilities for storage.

### **Facilities and Equipment**

A continuous thermal stabilization system would be installed in a new glovebox or in one of the existing gloveboxes. The equipment used would be similar to the fluorinator configuration used in the RMC Line at the PFP Facility. The fluorinator is a platinum-iridium lined Hastelloy-C tube that is at its maximum 10 cm (4 in) across and is 1.58 m (5.25 ft) long.

Assuming a continuous processing rate of 1,200 g/hr (2.6 lb/hr) and 24 hr/day, the estimated operational duration for this alternative is 58 weeks. This estimate assumes a total operational efficiency of 70 percent and a 10 percent recycle for failure to meet the DOE storage standard.

#### **3.2.1.3 Repackaging of the Metals and Alloys**

##### **Overview**

In this alternative, plutonium metals and alloys would be repackaged using methods that do not rely upon organic seals or plastic bags. The repackaged materials would be stored in the vault(s) at the PFP Facility and routinely monitored until final disposition. A description of the metals and alloys is contained in Subsection 3.1.1.3. A total of 770 kg (1,697 lb) would be stabilized by this alternative.

##### **Process Description**

The repackaging process removes metals and alloys from their existing containers and packages them without using plastic bags or organic seals. A packaging procedure meeting the current DOE storage standard has not been developed for use at the PFP Facility. This type of packaging is complicated by the need to control surface contamination without use of plastic bags.

DOE's Savannah River Site is developing a prototype bagless transfer system (Bigler, et al., 1994) that uses a hollow plug insert. The Savannah River packaging process is shown in Figure 3-4. Also under consideration is a slip lid container, a metal storage container with an oversized lid that slides over the top. This modified bagless transfer concept is illustrated in Figure 3-5. Other processing and transfer concepts are being developed to accommodate DOE complex-wide packaging concerns.

Once a packaging procedure has been developed, repackaging of metals and alloys would be similar to the existing repackaging process for containers suspected of pressurization. Figure 3-6 provides a simplified block diagram of the repackaging process. A more detailed block diagram and material balance for this alternative is included in Appendix B.

##### **Inventory Retrieval and Feed Preparation**

Plutonium metals and alloys would be retrieved from the vaults and transferred to a glovebox at the PFP Facility dedicated to repackaging. The seal-in procedure involves placing the container inside a plastic sleeve, sealing the end

of the sleeve, and inverting the sleeve's contents in the glovebox. The containers would be vented and the contents removed.

### **Oxide Removal and Thermal Stabilization**

The plutonium metal would be inspected for loose oxide which may have accumulated on the surface. Any loose oxide would be brushed from the metal and collected in a slip lid container. When a suitable quantity of oxide has been collected in the container, the contents would be thermally stabilized.

### **Repackaging**

The plutonium metal and alloy product would be packaged using a bagless transfer system developed in accordance with the requirements of the DOE storage standard. Nondestructive analysis would be performed on the packaged product to determine the isotopic composition prior to transfer to the vault at the PFP Facility for storage.

**Source:** Bigler, et al., 1994

[Figure 3-4. Savannah River Bagless Transfer System](#)

[Figure 3-5. Modified Bagless Transfer Concept Modified Bagless Transfer Concept](#)

[Figure 3-6. Repackaging of Metals and Alloys](#)

### **Offgases and Effluents Offgases**

The repackaging process does not generate any offgases. However, small quantities of argon purge gas used during packaging would be removed by the glovebox ventilation system.

Additional offgas would be generated during thermal stabilization of the removed oxides. This gas would include air, water, and entrained oxides. For the purposes of this EIS, a theoretical maximum release to the environment of  $5.6 \times 10^{-3}$  g ( $1.2 \times 10^{-5}$  lb) of plutonium oxides is assumed for this alternative.

### **Solid Waste**

Solid transuranic waste will be generated during glovebox operations. Solid transuranic wastes might include feed packaging material and would be sent to the Hanford Site solid waste management facilities for storage.

### **Facilities and Equipment**

Repackaging would be accomplished at the PFP Facility. New equipment is required to accomplish repackaging. Although plutonium-bearing materials have been packaged at the PFP Facility in the past, these methods do not satisfy the current DOE storage standard for plutonium metals and alloys. The DOE standard requires packaging of plutonium metals and alloys in containers that are free of organic materials, such as plastics, elastomeric gaskets, and organic coatings. Because previous packaging methods used plastic bags to control contamination, a new packaging method would be required.

Assuming a processing rate of 2 kg (4.4 lb) per shift, 24 hr/day, the estimated operational duration for repackaging is 49 weeks. This duration assumes a total operational efficiency of 70 percent. An additional week would be required to thermally stabilize the oxides removed from metal brushing, resulting in a total operational duration of 50 weeks for this alternative.

#### **3.2.1.4 Pyrolysis of Polycubes and Combustibles**

### **Overview**



Pyrolysis is intended to stabilize the inventory of polycubes currently stored in the vaults and gloveboxes at the PFP Facility. This alternative is a thermal process, distillation and decarbonization, that separates the plutonium oxides from the polystyrene. The product, stable plutonium oxides, is packaged and returned to the vaults at the PFP Facility.

The pyrolysis process has the capability for processing other combustibles such as rags and polyethylene (Kathios, 1995). If part of the inventory of combustibles is not suitable for pyrolysis, those combustibles may be sent to the Hanford Site solid waste management facilities for storage. This pyrolysis alternative would primarily focus upon polycubes, since the majority of the plutonium in this inventory group is contained in these cubes.

A total of 35 kg (77 lb) of plutonium would be stabilized by this alternative. The resultant plutonium oxide would be thermally tested in accordance with the DOE storage standard. Product determined to be acceptable would be packaged using existing packaging capabilities and placed in the 2736-ZB vault(s) at the PFP Facility for storage. Product not meeting the DOE storage standard would be run through the pyrolysis process a second time.

### **Process Description**

Pyrolysis is a two-step process in which plutonium oxide is separated from polycubes by distillation and subsequent decarbonization. Figure 3-7 is a simplified block diagram of the pyrolysis process. The process described here is essentially the same process previously used in the PFP Facility Glovebox MT-4 (Felt, 1971).

The capacity of Glovebox MT-4 was two 125 cubic centimeters (cm<sup>3</sup>) (8 cubic inches [in<sup>3</sup>]) cubes per feed charge. In the Glovebox MT-4 process, each charge took approximately two hours to process. Additional processing may be required to remove aluminum coatings from polycubes prior to distillation, when such coatings are present. Testing is being performed to determine an efficient method of thermally stabilizing polycubes and treating the offgas. The actual process may, therefore, vary slightly from the following description. The material balances, however, will be essentially the same. A more detailed block diagram of the process and material balance is included in Appendix B.

### **Inventory Retrieval and Feed Preparation**

The containers holding polycubes would be retrieved from storage and transferred to a glovebox at the PFP Facility dedicated to pyrolysis. Feed preparation activities including coating removal and/or crushing of the polycubes may be required.

Polycubes have a variety of coatings. Some coatings include aluminum paint, which must be removed. Cubes are typically covered with a coating of aluminum about 2.5 x 10<sup>-3</sup> cm (0.001 in) thick. The aluminum is covered with an outer layer of latex and krylon or plastic tape.

Aluminum coating removal is a two-step process. The outer coating (latex and krylon or plastic tape) is loosened by placing the cube in a hot water bath for 5 to 10 minutes. This "lifts" the coating, which is peeled off in a glovebox, exposing the aluminum. The aluminum is then removed by placing the cube in a hot solution of sodium hydroxide and sodium nitrate. Dejacketed cubes are rinsed with water.

Polycubes from later production runs have no aluminum coating. These cubes are typically coated with an organic paint that would not require removal prior to distillation. It is assumed that coating removal, if required, would occur in a glovebox adjacent to the pyrolysis system. This avoids the need for an additional operation to move the cubes out of one glovebox and into another.

The polycubes may need to be ground into smaller pieces (Miller, 1990).

### **[Figure 3-7. Pyrolysis of Polycubes and Combustibles](#)**

### **Distillation**

Dejacketed or aluminum-free cubes would be loaded into a crucible and placed in the distillation furnace (still). The maximum charge is two 125-cm<sup>3</sup> (8-in<sup>3</sup>) cubes, or an equivalent volume of smaller crushed cubes. The still is an

aluminum-coated stainless steel vessel located in a nitrogen-filled glovebox. During charging, the still is kept at a temperature of less than 400·C (752·F).

After the charge is loaded, the temperature of the still would be raised to 600·C (1,112·F) and maintained at that temperature for about 30 minutes. Nitrogen flow through the crucible would sweep out the distillation products. The distillation process step is completed when vapors no longer appear in the condenser catch pot. Following distillation, the still lid would be removed and the still would be allowed to cool to 400·C (752·F) or less. The crucible is then removed and transferred to the decarbonizing furnace.

### **Condensation and Granular Activated Carbon Treatment**

Distillation offgas would include styrene and styrene thermal degradation products. This offgas would be condensed and collected in a catch pot. In the past, the offgas was scrubbed with carbon tetrachloride. The process described here would use granular activated carbon treatment in place of carbon tetrachloride.

### **Decarbonization**

Crucibles removed from the still would be fed to the decarbonizing furnace, where their contents would be burned in a stream of air between 950 and 1,000·C (1,742 and 1,832·F) for at least 60 minutes. Additional thermal stabilization would be required if the product does not meet the DOE storage standard.

After burning, the crucible would be removed from the furnace and allowed to cool. A sample of the product would be taken and sent to the analytical laboratory to verify that the material meets the DOE storage standard.

### **Product Packaging and Transfer to Storage**

The plutonium oxides product would be transferred to a container, weighed, sealed out of the glovebox, and packaged in storage containers in accordance with existing procedures. Product not meeting the DOE storage standard would be cycled through the pyrolysis process a second time. A nondestructive analysis would then be performed on the packaged product to determine the isotopic composition prior to transfer to the vault(s) at the PFP Facility for storage. The product could be retrieved and repackaged to meet the DOE storage standard when a bagless transfer system has been developed (see Subsection 3.2.1.3).

### **Offgases and Effluents**

Offgas from the distillation furnace would be condensed and treated with granular activated carbon as discussed above. The granular activated carbon offgas would include nitrogen and trace amounts of entrained plutonium oxides.

Offgas would also be generated during the decarbonization step. This gas would be filtered, cooled, refiltered, and diluted with nitrogen to ensure noncombustibility prior to being vented to the PFP Facility ventilation control system. This gas would consist primarily of air with some carbon dioxide, carbon monoxide, water vapor, styrene and trace amounts of plutonium oxides. The rate of release to the environment through the 291-Z-1 Stack is estimated to be: styrene,  $7.4 \times 10^{-4}$  g/sec ( $1.6 \times 10^{-6}$  lb/sec); carbon monoxide,  $1.7 \times 10^{-3}$  g/sec ( $3.7 \times 10^{-6}$  lb/sec); and plutonium oxides,  $2.8 \times 10^{-9}$  g/sec ( $6.1 \times 10^{-12}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of 1,700 g (3.8 lb) of styrene, 3,850 g (8.5 lb) of carbon monoxide and  $6 \times 10^{-3}$  g ( $1.3 \times 10^{-5}$  lb) of plutonium oxides is assumed for this alternative.

### **Solid Waste**

Solid transuranic waste would be generated during glovebox operations. Solid transuranic wastes might include feed packaging material and would be sent to a Hanford Site solid waste management facilities for storage. Solid wastes from aluminum-coated polycubes also would include small quantities of latex and krylon or plastic tape which would be disposed of with other packaging waste.

Exhausted carbon canisters from the granular activated carbon treatment of condenser offgas will generate an

additional solid waste stream. If operating 24 hr/day, five days per week, it is estimated that one 55-gallon drum of carbon would be generated. Approximately 55 kg (120 lb) carbon, 200 g (0.4 lb) of plutonium and 14 kg (31 lb) of styrene would be bound to the waste carbon canisters.

### **Liquid Effluent**

Coating removal, if required for aluminum-coated polycubes, would produce a caustic solution that would be pH-adjusted (if necessary) sampled for plutonium content, and sent to the 200 Area Tank Farms. Approximately 20 l (5.3 gal) of solution containing approximately 100 g (0.22 lb) of plutonium dioxide is expected to be generated during coating removal.

A liquid waste stream also would be generated by the condensation process. This stream would primarily be condensed styrene. A total of about 143 l (38 gal) of styrene containing 400 g (0.88 lb) plutonium dioxide is expected to be generated. This styrene would be immobilized on an absorbing material and converted into a solid waste stream.

### **Facilities and Equipment**

Previous evaluations of the Glovebox MT-4 pyrolysis system (located in Building 236-Z at the PFP Facility) identified modifications that would be required prior to reactivating the system. Required upgrades to improve its performance and to resolve safety issues include:

- Furnace containment of combustible vapors
- Furnace offgas improvements
- Furnace boat-loading
- Nitrogen-filled atmosphere.

Assuming an average processing rate of two 500-g (1.1-lb) batches per shift, 24 hr/day, the estimated operational duration for this alternative is 21 weeks. This estimate assumes a total operational efficiency of 70 percent and a 10 percent recycle for failure to meet the DOE storage standard.

### **3.2.2 Description of the Preferred Alternative for Removal**

The preferred alternative for addressing hold-up inventory at the PFP Facility would involve the removal of that portion which is readily retrievable. Four areas of the Facility have been identified for removal of readily retrievable hold-up material. These areas and the estimated quantity of plutonium associated with them (described in Subsection 3.1.2) include the following:

- Ductwork
- Process vacuum system piping
- Gloveboxes and hoods
- PRF canyon floor.

These areas of the Facility have been selected because they represent locations where relatively large amounts of plutonium-bearing materials exist as hold-up and where removal actions would be beneficial in reducing the exposure risk. The readily retrievable plutonium associated with these categories is defined as that material which is on the surface of the host structure (e.g., glovebox interior, canyon floor, process piping), does not require extraordinary means to extract, and is potentially suitable for subsequent stabilization. The quantity of readily retrievable material actually removed at each location would be based on as low as reasonably achievable (ALARA) principles. The preferred alternative encompasses those actions necessary to remove this readily retrievable plutonium. A detailed description of the removal actions associated with each of these categories is provided in Subsections 3.2.2.1 through 3.2.2.4.

### 3.2.2.1 Removal of Readily Retrievable Plutonium from Ductwork

Removal of readily retrievable plutonium held up in the ductwork would include:

- Characterization of ductwork contamination
- Ductwork segmentation
- Removal of plutonium from the segmented ducts
- Decontamination and disposal of equipment and duct segments.

#### Characterization of Ductwork

Characterization of ductwork contamination would be necessary to validate current estimates for the distribution of plutonium. It would also be useful in identifying other chemicals or hazardous materials that pose health or safety hazards to PFP Facility workers. Characterization could be performed using direct-contact or remote methods.

Direct-contact methods include taking samples for laboratory analysis and conducting nondestructive assay measurements.

Laboratory analysis involves cutting or drilling into the ducts, collecting samples, and sending samples to a laboratory for analysis. Laboratory analysis is slow and likely to generate a secondary waste. However, it is usually more accurate and can provide information on hazardous materials.

Nondestructive assay techniques include field measurements of alpha particles, beta and gamma rays, neutrons, and X rays. They are generally known as nondestructive assays because the measured materials and the structures holding the materials are not destroyed. Although nondestructive assay methods are considered direct-contact, the characterization equipment would be used on the outside of the duct. The duct itself would act as a shield and containment for the radionuclides. Distance from the source can be increased by deploying the detectors at the end of a long extension.

The Internal Duct Characterization System is a remote control vehicle that is designed for maneuvering through ductwork systems 15 to 91 cm (6 to 36 in) in diameter. This system can visually inspect the interior condition of ducts using a video camera. The vehicle has a radiation sensor and is capable of collecting samples for laboratory analysis. The system is in the final stage of testing. It is expected to be available in 1996 or 1997 and may be used to assist in characterization.

#### Ductwork Segmentation

Segmenting ductwork would be accomplished using direct contact or remote methods.

Personnel performing direct-contact segmenting would wear appropriate protective equipment. ALARA principles (minimize time, maximize distance from the source, and shielding) would be used. By introducing a liquid foam into the duct and allowing the foam to cure into a solid, contaminants could be contained in a section of duct during and after segmentation. The cut is made through the middle of the foam such that both ends are capped during and after segmenting. An alternative method would be to carefully bag the duct during and after segmenting. Using a bag is not as effective as foam in isolating the contaminants, but it generates less waste.

Direct-contact segmenting would involve the use of cutting equipment, a crane or other means to support the ductwork while working, and a forklift or other means to move the resultant containment drum to a maintenance glovebox where the plutonium would be removed. Cutting would be performed using power nibblers or shears, conventional saws, or circular cutters.

Segmenting of ductwork could be performed remotely using robotics technology. Some robotics systems have been developed specifically for dismantling of equipment from nuclear facilities and are expected to be available within two years. Segmenting ducts with the remote equipment could be done with the same cutting tools as those used in the direct-contact mode.

## Removal of Plutonium from the Segmented Ducts

Removal of plutonium from duct segments would be conducted inside a maintenance glovebox. Foam caps or covering bags would be removed from the duct. Plutonium removal from duct segments could be accomplished using chemical or mechanical removal techniques. Chemical removal techniques involve the use of acidic solutions or chelating agents for removing plutonium from duct segments (DOE, 1994c; Allen, 1987; Jones and Wakefield, 1987).

Mechanical removal techniques include abrasive jetting, wiping, scrubbing, or vacuuming techniques with or without solvents, chemical degreasers, acids, detergents, surfactants, and acids. Several heavy-duty vacuum systems are available on the market with HEPA filters. Abrasive jetting uses a wide variety of abrasives, such as grit, sand, or carbon dioxide pellets to blast the target surface at high velocity. A good abrasive jetting technique is carbon dioxide (dry ice) blasting since no secondary solid or liquid waste products or waste streams are generated (DOE, 1994c; Allen, 1987; Jones and Wakefield, 1987; PNL, 1990).

## Decontamination and Disposal of Equipment and Duct Segments

Contaminated equipment and duct segments must be properly disposed of. One option is packaging the contaminated equipment and duct segments and disposing of them as transuranic or low-level radioactive wastes. Another option is decontaminating these materials to reduce the radiation levels prior to disposal or reuse.

Table 3-4 summarizes the direct-contact and remote technologies for removal of plutonium from contaminated ductwork.

### 3.2.2.2 Removal of Readily Retrievable Plutonium from Process Vacuum System Piping

Removal of the plutonium from the 10-cm (4-in) process vacuum pipe is similar to removal of the plutonium in the ductwork. The removal steps are expected to include:

- Characterization of process vacuum system piping contamination
- Segmentation of piping
- Removal of plutonium from the pipe segments
- Decontamination and disposal of equipment and pipe segments.

**Table 3-4 Technologies Available for Removal of Plutonium from Ductwork**

Operational Steps	Direct-contact Methods	Remote Technologies
Initial Characterization	Laboratory analyses  Nondestructive assays (gamma, neutron, and X ray measurements)	Internal Duct Characterization System
Disassembling/Segmenting	Power Nibblers and Shears  Mechanical Saws Circular Saws	Cutting tools deployed with a robotics system
Removal of Plutonium from Segmented Duct	Chemical Removal Techniques  Mechanical Removal Techniques including: <ul style="list-style-type: none"> <li>• washing</li> <li>• scrubbing</li> </ul>	Activity will take place in a glovebox

	<ul style="list-style-type: none"> <li>• vacuum cleaning</li> <li>• abrasive jetting</li> </ul>	
Decontamination	Washing Scrubbing Abrasive jetting	Activity will take place in a glovebox

**Decontamination and Disposal of Process Vacuum System Piping**

Contaminated process vacuum system piping must be properly disposed of. One option is packaging the contaminated piping segments and disposing of them as transuranic or low-level radioactive wastes. Another option is to decontaminate these materials to reduce the radiation levels prior to disposal or reuse.

**Characterization of Piping**

Characterization of plutonium and contaminants in the process vacuum system piping could be performed using direct-contact or remote methods.

The nondestructive assay methods described for the ductwork could also be used for the piping. These methods include gamma ray, neutron, and X ray measurements.

The Small Pipe Characterization System is a robotics system designed to characterize the internal surface of piping. The system can visually inspect the interior condition of a pipe using a video camera. Radiation sensors are mounted on the crawler to characterize plutonium distribution and radiological contaminants. The system is in the final stage of prototype testing. It could be available within a year and could be used to assist in characterization.

**Piping Segmentation**

Available segmentation technologies for the 10-cm (4-in) process vacuum system piping are equivalent to those for the ductwork. Direct-contact methods include power nibblers and shears and mechanical and circular saws. Remote operations could be achieved by deploying one or more of these cutting techniques using robotics systems.

**Removal of Plutonium from Segmented Pipes**

The approaches available for removing plutonium from the segmented piping are the same as those for the ductwork. Removal of plutonium from duct segments would be conducted inside a glovebox. Plutonium removal would involve chemical and/or mechanical removal techniques.

Table 3-5 summarizes technologies for removal of plutonium from contaminated process vacuum system piping.

**Table 3-5 Technologies Available for Removal of Plutonium from Process Vacuum System Piping**

Operational Steps	Direct-Contact Methods	Remote Technologies
Initial Characterization	Nondestructive assays (gamma, neutron, and X ray measurements)	Small pipe characterization system
Disassembling/	Power nibblers and shears	Cutting tools deployed with the robotics system

Segmenting	Mechanical saws Circular saws	
Removal of Plutonium from Segmented Piping	Chemical removal techniques Mechanical removal techniques <ul style="list-style-type: none"> <li>• Washing</li> <li>• Scrubbing</li> <li>• Vacuum Cleaning</li> <li>• Abrasive Jetting</li> </ul>	Activity would take place within a glovebox
Decontamination	Washing Scrubbing Abrasive Jetting	Activity would take place within a glovebox

### 3.2.2.3 Removal of Readily Retrievable Plutonium from Gloveboxes

Removal of readily retrievable plutonium held up in gloveboxes would include:

- Characterization of glovebox contamination
- Removal of equipment in gloveboxes, if necessary
- Removal of plutonium from the gloveboxes
- Decontamination and disposal of equipment used.

Gloveboxes are designed to provide shielding for the operators and at the same time provide the operators the capability to use a wide range of hand-tools. Remote technologies are not considered to be necessary in light of glovebox versatility.

#### Characterization of Gloveboxes

The characterization of plutonium and contaminants in the gloveboxes could be performed with the nondestructive assay methods (alpha, beta, gamma, neutron, and X ray measurements) or by taking samples for laboratory analysis.

#### Removal of Equipment from Gloveboxes

If equipment in a glovebox must be moved prior to plutonium removal, a number of cutting techniques could be used. These techniques include power nibblers and shears and mechanical and circular saws.

#### Removal of Plutonium from Gloveboxes

The plutonium hold-up in gloveboxes is in the form of a sludge or solid residue. Most of the plutonium is on the floors of the gloveboxes, with minor amounts on the equipment (small pipes, tubing, small tanks, etc.) and on the walls. The techniques which could be used to remove most of the plutonium include washing, scrubbing, vacuuming, or a combination of these (see Table 3-6).

#### Decontamination and Disposal of Equipment

Contaminated equipment used in the plutonium removal could be decontaminated directly in the glovebox. Decontamination techniques include washing and scrubbing.

### 3.2.2.4 Removal of Readily Retrievable Plutonium in PRF Canyon

The process for removal of plutonium hold-up in the PRF canyon involves a number of steps including:

- Characterization of PRF canyon contamination
- Movement or removal of equipment in the PRF canyon
- Removal of plutonium from the PRF canyon
- Decontamination and disposal of contaminated equipment used to remove the plutonium.

**Table 3-6 Summary of Methodologies for Removal of Plutonium Hold-up from Gloveboxes**

Operational Steps	Direct-Contact Methods	Remote Technologies
Initial Characterization	Laboratory Analysis Nondestructive assays (alpha, beta, gamma, neutron, and X ray measurements)	Gloveboxes are designed to provide shielding for the operators and at the same time provide the operators the capability to use a wide range of hand tools. This design eliminates any foreseeable need for remote technologies.
Equipment Removal	Power Nibblers and Shears Mechanical Saws Circular Saws	.
Removal of Plutonium Hold-up from Gloveboxes	Washing Scrubbing Vacuuming	.
Decontamination	Washing Scrubbing	.

#### Characterization of PRF Canyon Contamination

Characterization of plutonium and contaminants in the PRF canyon could be performed using direct-contact or remote methods. Direct-contact methods include nondestructive assays, organic-vapor analyzers, and taking samples for laboratory analysis. Nondestructive assay techniques and laboratory analysis have been discussed previously. Organic-vapor analyzers are portable instruments used to measure organic vapors in air. The Battery Operated Mobile Automated Characterization System is a mobile robotics system designed to perform floor characterization using radiation sensors. The system is in the final stage of testing. It is expected to be available in one to two years and could be used to assist in characterization.

#### Movement and Removal of Equipment in the PRF Canyon

Equipment (tanks, piping, etc.) in the PRF canyon was installed so that it rises several feet off the floor. Currently, there are two aluminum step ladders and a disassembled tank on the floor. These pieces of equipment may need to be moved during the plutonium removal step. In direct-contact mode, the ladders could be moved by operators without



any special tools. In remote mode, the ladders and tank could be moved using a robotics system or the existing crane.

### Removal of the Plutonium from the PRF Canyon

Direct-contact methods for the removal of plutonium from the PRF canyon floor include chemical and mechanical removal (washing, scrubbing, vacuuming, and abrasive jetting). Remote operations can be achieved by deploying one or more of these removal techniques using a robotics system. Another remote technology is to deploy a laser on a robotics platform. A laser uses high-energy light to raise surface temperatures and melt or vaporize the plutonium. A vacuum device is used simultaneously with the laser to collect the plutonium and filter the offgases.

### Decontamination and Disposal of Equipment

Direct-contact methods for decontamination of equipment include washing, scrubbing, and abrasive jetting. Remote technologies include deploying one or more of these decontamination techniques using a robotics system. A dual laser system mounted on a robotic platform has the capability of decontaminating other equipment as well as itself.

Table 3-7 summarizes the direct-contact and remote technologies for removal of readily retrievable plutonium from the PRF canyon floor.

**Table 3-7 Summary of Methodologies for Removal of Plutonium from the PRF Canyon Floor**

Operational Steps	Direct-Contact Methods	Remote Technologies
Initial Characterization	Nondestructive assays (alpha, beta, gamma, neutron, and X ray measurements)  Organic vapor analyzers	Mobile Automated Characterization System
Moving Equipment	Small crane for tank	Robotic System
Removal of Plutonium from Canyon Floor	Mechanical removal techniques including: <ul style="list-style-type: none"> <li>• Washing</li> <li>• Scrubbing</li> <li>• Vacuuming</li> <li>• Abrasive jetting</li> </ul>	Wet scrubbing and vacuuming deployed on a robotic platform  Laser and vacuuming deployed on a robotic platform
Decontamination	Washing  Scrubbing  Abrasive Jetting	Mechanical tools deployed using a robotic system  Laser (light-aided decontamination deployed on a robotic platform)

#### 3.2.2.5 Selection of a Reasonable Removal Approach for Impact Analysis

Reasonable methodologies that are currently available were selected for the removal of plutonium from ductwork, process vacuum system piping, gloveboxes, and PRF canyon floor. These technologies have been identified to support the potential impact analysis presented in this EIS. The selection of these methodologies is not intended to preclude future considerations of other technologies or combination of technologies. These technologies include:

- Initial characterization

- Disassembly/segmentation or equipment movement
- Plutonium removal
- Decontamination.

The reasonable technologies selected for analysis purposes are shown on Table 3-8.

**Table 3-8 Reasonable Technologies for the Removal of Hold-up Plutonium**

Operational Step	Ductwork	Process Vacuum System Piping	Glovebox	PRF Canyon Floor
Initial Characterization	Nondestructive assay	Nondestructive assay	Nondestructive assay	Mobile Automated Characterization System
Disassembly and/or Segmentation or Equipment Movement	Mechanical and circular saws	Mechanical and circular saws	Power nibblers and shears	Robotic equipment
Plutonium Removal	Scrubbing (scraping and wire brush with or without wet chemicals)	Scrubbing (scraping and wire brush with or without wet chemicals)	Scrubbing (scraping and brushing, with or without wet chemicals)	Laser and vacuum deployed on a robotic platform
Decontamination	Washing	Washing	Washing	Dual lasers and vacuum deployed on a robotic platform

### **Initial Characterization**

Nondestructive assays are reasonable methodologies for initial characterization. These techniques have been used extensively and effectively at the Facility. Exposure to PFP Facility workers using these detectors is expected to be minimal. For the PRF canyon, due to the high radiation levels, a robotic system was selected.

The degree to which the readily retrievable plutonium-bearing material would be removed would be determined following characterization of the material.

### **Disassembly/Segmentation or Equipment Movement**

Mechanical and/or circular saws are reasonable methodologies for segmenting the ductwork and vacuum system piping. These types of equipment are simple, effective, and easy to use. Power nibblers and shears are selected as reasonable techniques for segmenting equipment inside a glovebox. These techniques are effective because they are ideal for cutting intricate shapes, small bore piping and tubing, and for segmentation of small tanks.

A remote system is a reasonable method for moving equipment currently in the PRF canyon. The system is chosen because it also has the capability to perform both plutonium characterization, removal and decontamination.

### **Plutonium Removal**

Scrubbing is a reasonable methodology for plutonium removal in the ductwork and piping. Once a section of duct or

pipings has been placed in a glovebox, a scraper could be used to remove the plutonium on the inside surface. A potassium permanganate solution could be used in conjunction with the scraper or wire brush to enhance the efficiency of the removal. This method is simple and expected to be highly effective.

Scrubbing is a reasonable methodology for removal of plutonium hold-up in the gloveboxes. A scraper could be used to remove the plutonium on the floor of a glovebox. A wire brush or a scraper could be used to remove plutonium on the outside surfaces of equipment in the gloveboxes. A potassium permanganate solution could be used in conjunction (or as a presoak) with the scrubbing equipment to enhance efficiency. A vacuuming unit (wet or dry) could be used to collect the plutonium.

A laser deployed by a robotic platform is a reasonable method for removing the plutonium hold-up on the PRF canyon floor. Plutonium dispersed by the laser is immediately captured by a vacuum unit also mounted on a robotic platform.

## **Decontamination**

Washing is a reasonable methodology for decontamination of equipment, duct and pipe segments, and gloveboxes from which the plutonium has been removed. Water, a dilute acid, or other industrial cleaning agent would be used to rinse loose contaminants. This technique is simple and has proven to be effective.

In the PRF canyon, the use of dual-lasers and a vacuum unit mounted on the robotic platform is a reasonable method, because the platform-mounted equipment can decontaminate both itself and other equipment.

## **3.3 DESCRIPTION OF ALTERNATIVES**

Subsection 3.2.1 describes a reasonable method for stabilizing each of the inventory categories. These preferred methodologies were developed based on the technology screening and selection process described in Subsection 3.6. Several other viable alternatives to the preferred methodologies were identified during the technology screening process. These alternatives have been sorted by inventory type and are described in Subsections 3.3.1 through 3.3.4. Subsection 3.3.5 describes the alternative associated with immobilization.

### **3.3.1 Alternative Stabilization Process for Plutonium-bearing Solutions**

One viable alternative to ion exchange, vertical calcination, and thermal stabilization of the plutonium-bearing solutions was identified during the screening process. Hydroxide precipitation followed by thermal stabilization is discussed in Subsection 3.3.1.1. Subsection 3.3.1.2 describes a supplemental pretreatment process that may be beneficial in preparing the solutions for stabilization.

#### **3.3.1.1 Hydroxide Precipitation Followed by Thermal Stabilization of the Plutonium-bearing Solutions**

##### **Overview**

Under this alternative, plutonium-bearing solutions would be treated by a relatively simple precipitation process. The resultant plutonium precipitate would then be thermally stabilized to an oxide form capable of meeting the DOE storage standard.

Caustic or other hydroxide-forming reagents would be added to the solution, gradually increasing the pH until insoluble plutonium hydroxide is formed. The plutonium hydroxide and other metal impurities, such as nickel, chromium, and iron, would precipitate out and be filtered from solution. The filtered solids would then be thermally processed into a stable oxide form.

Approximately 4,800 l (1,268 gal) containing 338 kg (745 lb) (including the 3 kg [6.6 lbs] plutonium fluorides) of plutonium would be stabilized by this alternative. The resultant product, including americium and other impurities, would be packaged in accordance with the DOE storage standard and placed in the vault at the PFP Facility for storage.

### **Process Description**

Hydroxide precipitation has been used routinely in the metal-finishing and plating industry to remove metals from acidic solutions. It has been demonstrated at Rocky Flats and the Los Alamos National Laboratory for precipitating plutonium from solution (Sevigny, et al., 1995). Other similar precipitation methodologies (e.g., hydrogen peroxide precipitation) could be used to remove plutonium from nitric solutions. This alternative limits discussion to hydroxide precipitation since it has been demonstrated in the past for handling plutonium solutions and reducing plutonium to very low levels in the filtrates.

A block diagram describing the hydroxide precipitation process is shown in Figure 3-8. A more detailed block diagram and material balance of the hydroxide precipitation process is included in Appendix B.

#### [Figure 3-8. Hydroxide Precipitation and Thermal Stabilization of the Plutonium-bearing Solutions](#)

### **Inventory Retrieval and Feed Preparation**

The plutonium-bearing solutions to be stabilized under this alternative would be retrieved from their current storage location and transferred to an appropriate glovebox. Differing feeds could be blended prior to precipitation. It is also possible that the plutonium fluoride inventory could be dissolved and blended with other feed solutions. The plutonium-bearing solutions would then be transferred to another glovebox where the precipitation would be performed.

### **Precipitation and Filtration**

The process of precipitating metal hydroxides from acidic solutions would involve the use of solid magnesium oxide reagent to raise the pH and precipitate the metals. Magnesium hydroxide would be formed upon contact with the solution, and no additional liquid additives would be necessary. Magnesium oxide was selected as the reagent because magnesium hydroxide would form a granular solid that is easier to filter than precipitates formed from sodium or potassium hydroxide. Precipitates from sodium and potassium hydroxide tend to be gelatinous and sticky (Terino, 1987).

Filtration of the solids would be accomplished by centrifuging or allowing the precipitate to settle and then decanting the liquid. The remaining solids would be captured on filter paper, washed with water, and dried before undergoing thermal treatment in a muffle furnace.

### **Thermal Stabilization**

Thermal treatment in an air atmosphere would be used to convert the precipitated plutonium hydroxide to stabilized plutonium oxides. This could be performed in batches in muffle furnaces located nearby. Alternatively, the entire process could be operated in continuous mode as described in Subsection 3.2.1.2. Continuous operation would likely require new equipment in new gloveboxes.

### **Product Packaging and Transfer to Storage**

After cooling, a sample of the oxide product would be sent to the analytical laboratory to verify that the material meets storage specifications. Product failing to meet the storage specifications would be recycled through the thermal stabilization process. Nondestructive analyses would be performed on the packaged product to determine isotopic composition prior to transfer to the vault(s) at the PFP Facility. The product could be retrieved and repackaged to meet the DOE storage standard specifying organic-free containers once a bagless transfer system has been developed. A more detailed description of the repackaging process is given in Subsection 3.2.1.3.

## **Offgases and Effluents Offgases**

Gaseous effluents from thermal treatment would include air, water vapor, and small quantities of plutonium oxides. The product oxide would also likely contain small amounts of uranium oxides and manganese oxides. Solids entrained in the offgas would be significantly reduced by ceramic and HEPA filters in the PFP Facility ventilation control system.

The expected maximum release rate to the environment through the 291-Z-1 stack is estimated to be  $1.4 \times 10^{-8}$  g/sec ( $3.1 \times 10^{-11}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of 0.042 g ( $9.3 \times 10^{-5}$  lb) of plutonium oxides is assumed for this alternative.

## **Liquid Effluents**

The pH of the filtrate would be adjusted before transfer to the 200 Area Tank Farms. An estimated total of 5,060 l (1,338 gal) would be generated.

The plutonium concentration of the liquid filtrate solution is anticipated to be below 0.02 g/l ( $2 \times 10^{-4}$  lb/gal). The liquid effluent could be immobilized in cement and managed as transuranic or mixed transuranic waste. The total volume of solid waste would be approximately 7.6 m<sup>3</sup> (9.9 yd<sup>3</sup>). This would result in approximately 40 55-gallon drums of waste.

## **Solid Wastes**

Solid transuranic waste would be generated during glovebox operations. Solid transuranic wastes might include feed packaging material and plastic storage containers. This waste would be sent to Hanford Site solid waste management facilities.

## **Facilities and Equipment**

Hydroxide precipitation could be performed in new or existing gloveboxes in the PFP Facility. It is expected that a new batch precipitator would be used to do the precipitation. The filtration operation would be done with standard equipment in the same glovebox. Thermal treatment would be performed either in the same glovebox or an adjacent box. Alternatively, the dried filter cake could be transferred to another box in the PFP Facility glovebox system for thermal treatment in muffle furnaces. This may include furnaces currently installed.

A waste transfer line would be required in order to transfer filtrate liquid to waste tanks for subsequent neutralization and transfer to the 200 Area Tank Farms. If the waste were solidified, a transfer line or other means to transfer liquid waste to the solidification glovebox would be needed.

Assuming an average processing rate of one precipitation batch per shift, 24 hr/day, the estimated operational duration for precipitation would be 46 weeks. This estimate assumes a total operational efficiency of 70 percent. An additional 11 weeks would be required to thermally stabilize the precipitate, resulting in a total operational duration of approximately 57 weeks for this alternative.

### **3.3.1.2 Supplemental Pretreatment Process for Solutions**

The following describes a pretreatment process that could beneficially be used in conjunction with one or more of the stabilization alternatives for plutonium-bearing solutions described in this EIS.

## **Evaporation**

The process concentrates selected feed solutions into smaller volumes of residual aqueous solution through the use of steam pressure and moderate temperatures (up to 135°C or 275°F). Because the solute is generally non-volatile, the vapor/condensate is normally free of contamination. The final product would be an effluent with plutonium

concentrations up to 350 g/l (2.9 lb/gal) requiring further stabilization. The PRF currently has evaporation processes in a standby mode. Some additional equipment and controls may be necessary. This process could be operated semi-remotely to reduce exposure to PFP Facility workers. The primary effluent generated would be condensate from the evaporator containing low concentrations of plutonium. The effluent stream would likely be suitable for transfer to the high-level waste storage tanks.

### **3.3.2 Alternative Stabilization Process for Oxides, Fluorides and Process Residues**

A viable alternative to thermal stabilization of the oxides, fluorides, and process residues in a continuous furnace was identified during the technology screening process. Batch thermal stabilization using muffle furnaces is discussed in Subsection 3.3.2.1. Subsection 3.3.2.2 describes two supplemental pretreatment processes that may be beneficial in preparing the fluorides and process residues for subsequent stabilization steps.

#### **3.3.2.1 Batch Thermal Stabilization of Oxides, Fluorides, and Process Residues**

##### **Overview**

This alternative involves batch thermal stabilization of the plutonium-bearing oxides, fluorides, and process residues. The plutonium-bearing solids are fed into a muffle furnace which is elevated to a temperature of approximately 1,000°C (1,832°F). The high temperature air environment lowers the residual moisture level and facilitates conversion of incompletely oxidized plutonium to plutonium oxides.

Material that meets the DOE storage standard would not require any additional thermal stabilization and would be directly repackaged. The estimated 14-hour throughput would be approximately one 1,200-g (2.6-lb) batch per furnace.

The process would result in an offgas containing air, water vapor, and small quantities of entrained plutonium oxides. The offgas would be discharged to the environment after appropriate control measures such as HEPA filtration significantly reduced the quantity of entrained solids in the offgas.

Plutonium fluorides would pose problems in the muffle furnace due to the corrosive nature of fluoride-bearing gases that could be liberated. The plutonium fluorides could be pretreated using an acid dissolution process and blended with the plutonium-bearing solutions. The acid dissolution pretreatment process is discussed in Subsection 3.3.2.2. Alternately, a corrosion control program could be established and the fluorides sent through the muffle furnace.

This alternative could stabilize 2,417 kg (5,329 lb) of plutonium. The resultant plutonium oxides would be tested in accordance with the DOE storage standard. Product deemed acceptable would be packaged using existing capabilities at the Hanford Site and placed in the vault at the PFP Facility for storage. Product not meeting the DOE storage standard would be recycled through the muffle furnace. The product could be retrieved and repackaged at a later date to meet the DOE storage standard specifying organic-free containers when a bagless transfer system becomes available at the Hanford Site.

##### **Process Description**

A block diagram of the batch thermal stabilization process using a muffle furnace is shown in Figure 3-9. A more detailed block diagram and material balance of the batch thermal stabilization process is included in Appendix B.

##### **Inventory Retrieval and Feed Preparation**

Containers bearing oxides, fluorides, and process residues would be retrieved from the vault and transferred to a glovebox. Oxides, fluorides, and process residues not meeting the thermal stability requirements would be placed into a metal container. To facilitate an even spread over the bottom of the metal container, the feed materials may need to be ground up using a mortar and pestle. The metal container would then be reweighed and placed into the muffle furnace.

## Batch Thermal Stabilization

The muffle furnace process controls and operating procedures vary according to the type of feed being processed. The controls are designed to maintain pre-established, optimum oxidizing conditions and temperatures that ensure controlled reactions in the furnace. The plutonium-bearing materials considered under this alternative would follow one of several muffle furnace programs, each with unique ramp-up, thermal-soak, and cool-down rates. The thermal soaking would occur at approximately 1,000·C (1,832·F) for a minimum period of one hour. It is estimated that the furnaces would be capable of handling 1-l (0.26-gal) or 1,200-g (2.6-lb) batches of plutonium-bearing material depending on the density of material.

It is not likely that plutonium fluorides would be processed through the muffle furnaces due to the corrosive nature of fluoride-bearing gases. Oxides and the bulk of process residues at the PFP Facility are assumed to have very small organic content. Additional pretreatment measures may be necessary if process residues collected during removal actions and considered for stabilization are suspected to have high organic levels (greater than 2 weight percent organic). Hydrolysis is considered an appropriate pretreatment measure for process residues with high organic levels and is discussed further in Subsection 3.3.2.2.

### [Figure 3-9. Batch Thermal Stabilization of Oxides and Process Residues](#)

## Product Packaging and Transfer to Storage

After cooling, a sample of the product would be sent to the analytical laboratory to verify that the material meets storage specifications. Product failing to meet the storage specifications would be recycled through the muffle furnace. Nondestructive analyses would be performed on the packaged product to determine the isotopic composition prior to transfer to the vault(s) at the PFP Facility. The product would be retrieved and repackaged to meet the DOE storage standard specifying organic-free containers, once a bagless transfer system has been developed. A more detailed description of the repackaging process is described in Subsection 3.2.1.3.

## Offgases and Effluents Offgases

The offgas from the muffle furnace would consist of air, water vapor, and small amounts of entrained plutonium oxides and metal oxide. Solids entrained in the offgas would be significantly reduced by ceramic and HEPA filters in the PFP Facility ventilation control system. A maximum combined rate of plutonium oxides and metal oxide release to the environment through the 291-Z-1 stack is estimated to be  $2.4 \times 10^{-8}$  g/sec ( $5.3 \times 10^{-11}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of 0.3 g ( $6.8 \times 10^{-4}$  lb) of plutonium oxides is assumed for this alternative.

## Solid Waste

Solid transuranic waste will be generated during glovebox operations. Solid transuranic wastes might include feed packaging and material. Solid transuranic wastes would be sent to the Hanford Site solid waste management facilities for storage.

## Facilities and Equipment

Ongoing sludge stabilization activities involving batch thermal stabilization in muffle furnaces are currently being performed in Gloveboxes HC-21A and HC-21C. It is anticipated these and other gloveboxes would be used for this alternative.

Assuming an average processing rate of one 1,200-g (2.6-lb) batch per 14 hours per muffle furnace, 24 hr/day, and operating 10 muffle furnaces simultaneously, the estimated operational duration for this alternative is 1.6 years. This estimate assumes a 70 percent total operational efficiency and 10 percent recycle for failure to meet the DOE storage standard.

### **3.3.2.2 Supplementary Pretreatment Processes for Oxides, Fluorides, and Process Residues**

The following describes two pretreatment processes that may be necessary in conjunction with one or more of the stabilization alternatives for the oxides, fluorides, and process residues described in this EIS.

#### **Acid Dissolution**

This pretreatment process would apply to the fluorides and, potentially other low-grade material. The process consists of dissolving the plutonium-bearing material in a mixed solution of nitric and hydrofluoric acid. Aluminum nitrate is also added to complex the fluorides and minimize corrosion problems. The final product, an acid solution containing concentrated plutonium, would be blended with the plutonium-bearing solutions and would be further stabilized. This process could be run with existing equipment in any suitable location at the PFP Facility. This process would result in added PFP Facility worker dose, as this is a hands-on, glovebox process. The effluents from this pretreatment operation would be nitrogen oxides that could be vented to the atmosphere and low plutonium-content solids that would be processed with other waste residues.

#### **Hydrolysis**

Hydrolysis is a chemical decomposition process involving water. This pretreatment process would apply to high organic-bearing process residues (solvents, sludges, etc., containing greater than 2.0 weight percent organic content) that may be generated during future plutonium retrieval operations. Hydrolysis avoids the formation of nitrated organic compounds that could become explosive during subsequent processing. Soluble and insoluble solids, along with plutonium hydroxide and other metal hydroxides, are the final products and would require further stabilization. Existing facilities and equipment could be used to accomplish the hydrolysis process.

### **3.3.3 Alternative Stabilization Process for Metals and Alloys**

A viable alternative to repackaging the metals and alloys was identified during the technology screening process. Batch thermal stabilization using muffle furnaces is discussed in Subsection 3.3.3.1.

#### **3.3.3.1 Batch Thermal Stabilization of the Metals and Alloys**

##### **Overview**

This alternative involves batch thermal stabilization of the plutonium metals and alloys. The plutonium-bearing solids are fed into a muffle furnace and elevated to a temperature of approximately 1,000·C (1,832·F). The high temperature air environment facilitates conversion of the metal and alloys to metal oxides (i.e., plutonium oxides). The estimated throughput would be approximately one 1,200-g (2.6-lb) batch every 12 hours.

The process would result in an offgas containing air and small quantities of entrained plutonium dioxide. The offgas would be discharged to the environment after appropriate control measures such as HEPA filtration significantly reduced the quantity of entrained solids in the offgas.

A total of 770 kg (1,698 lb) of plutonium would be stabilized by this alternative. The resultant product would be tested in accordance with the DOE storage standard. Product deemed acceptable would be packaged using existing capabilities at the Hanford Site and placed in the vault(s) at the PFP Facility for storage. It is assumed that the metals and alloys would require two thermal processing cycles to achieve the desired oxide product. Product not meeting the DOE storage standard would be cycled through the muffle furnace a third time. The product could be retrieved and repackaged at a later date to meet the DOE storage standard specifying organic-free containers once a bagless transfer system becomes available at the Hanford Site.

##### **Process Description**



A block diagram of the batch thermal stabilization using a muffle furnace is shown in Figure 3-10. A more detailed block diagram and material balance of the batch thermal stabilization process is included in Appendix B.

### **Inventory Retrieved and Feed Preparation**

Containers bearing metals and alloys would be retrieved from the vault and transferred to a glovebox. The metals and alloys would be placed into a feed container, preweighed and placed into the muffle furnace.

### **Batch Thermal Stabilization**

The muffle furnace process controls and operating procedures vary according to the type of feed being processed. The controls are designed to maintain pre-established, optimum oxidizing conditions and temperatures that ensure controlled reactions in the furnace. The plutonium-bearing materials considered under this alternative would follow one of several muffle furnace programs, each with unique ramp-up, thermal-soak, and cool-down rates. The thermal soaking would occur at approximately 1,000·C (1,832·F) for a minimum period of one hour.

It is estimated that the furnaces would be capable of handling 1,200-g (2.6-lb) batches of plutonium-bearing material. The product would undergo loose oxide separation to ensure exposure of the core material during the second run. Metal and alloys at the PFP Facility are assumed to have negligible moisture and organic content. During firing of the plutonium-bearing material, air would be fed continuously to the muffle furnace in order to facilitate oxidation of this material.

### **Product Packaging and Transfer to Storage**

After cooling, a sample of the product would be sent to the analytical laboratory to verify that the material meets the DOE storage standard. Product not meeting the DOE storage standard would be cycled through the muffle furnace a third time. Nondestructive analyses would be performed on the packaged product to determine isotopic composition prior to transfer to the vault(s) at the PFP Facility. The product could be retrieved and repackaged to meet the DOE storage standard specifying organic-free containers, once a bagless transfer system has been developed. A more detailed description of the repackaging process is described in Subsection 3.2.1.3.

### [Figure 3-10. Batch Thermal Stabilization of Metals and Alloys](#)

### **Offgases and Effluents Offgases**

The offgas from the muffle furnace would consist of air and very small amounts of entrained plutonium oxides. Solids entrained in the offgas would be significantly reduced by ceramic and HEPA filters in the PFP Facility ventilation control system. A maximum combined rate of plutonium oxides and metal oxide release to the environment through the 291-Z-1 stack is estimated to be  $3.7 \times 10^{-8}$  g/sec ( $8.2 \times 10^{-11}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of 0.19 g ( $4.2 \times 10^{-4}$  lb) of plutonium oxides is assumed for this alternative.

### **Solid Waste**

Solid transuranic waste will be generated during glovebox operations. Solid transuranic wastes might include feed packaging material. Solid transuranic wastes would be sent to Hanford Site solid waste management facilities for storage.

### **Facilities and Equipment**

Ongoing sludge stabilization activities involving batch thermal stabilization in muffle furnaces are currently being performed in Gloveboxes HC-21A and HC-21C. It is anticipated these and other gloveboxes would be used for this alternative.

Assuming an average processing rate of one 1,200-g (2.6-lb) batch per 12 hours per muffle furnace, 24 hr/day, and operating 10 muffle furnaces simultaneously, the estimated operational duration for this alternative is 27 weeks. This

estimate assumes a 70 percent total operational efficiency and 10 percent recycle for failure to meet the DOE storage standard.

### **3.3.4 Alternative Stabilization Processes for Polycubes and Combustibles**

Two viable alternatives to pyrolysis were identified during the technology screening process for stabilizing the polycubes and combustibles. A batch thermal stabilization method is discussed in Subsection 3.3.4.1 and a molten salt oxidation method is discussed in Subsection 3.3.4.2.

#### **3.3.4.1 Batch Thermal Stabilization with Secondary Combustion of Polycubes and Combustibles**

##### **Overview**

This alternative involves batch thermal stabilization of the plutonium-bearing polycubes and combustibles. Although the thermal stabilization method used for the two types of materials is the same, each type of material would be processed separately. The polycubes or combustibles are fed into a muffle furnace, which is elevated to a temperature of approximately 300·C (572·F). Initially, the furnace is purged with nitrogen gas to maintain an inert environment and prevent combustion of the organic component. At 300·C (572·F), the organic component of the feed is driven off into a secondary combustion chamber. The plutonium-bearing material remaining in the muffle furnace is exposed to air and elevated to approximately 1,000·C (1,832·F). The high temperature environment facilitates conversion of incompletely oxidized plutonium to plutonium oxides. The estimated 14-hour throughput would be approximately one 500-g (1.1-lb) batch per furnace.

The process would result in an offgas containing water vapor, organic combustion products (carbon dioxide and carbon monoxide), residual organic material (styrene monomer), and small quantities of entrained plutonium dioxide. The offgas would be discharged to the environment after appropriate control measures such as HEPA filtration significantly reduced the quantity of entrained solids in the offgas.

A total of 35 kg (77 lb) of plutonium would be stabilized by this alternative. The resultant product would be tested in accordance with the DOE storage standard. Product deemed acceptable would be packaged using existing capabilities at Hanford and placed in the vault(s) at the PFP Facility until future DOE disposition decisions are made. Product not meeting the DOE storage standard would be recycled through muffle furnaces. The product could be retrieved and repackaged at a later date to meet the DOE storage standard specifying organic-free containers when a bagless transfer system has been developed.

##### **Process Description**

A block diagram of the batch thermal stabilization with secondary combustion process is shown in Figure 3-11. A more detailed block diagram and material balance of this process is included in Appendix B.

##### **Inventory Retrieval and Feed Preparation**

Containers bearing polycubes would be retrieved from the vault and transferred to a glovebox. The polycubes would be first stripped of their aluminum coating, if required. Aluminum coating removal is a two-step process in which the outer coating of the polycubes is loosened by placing the polycube into a hot water bath for 5 to 10 minutes. The outer coating is then removed by hand (in a glovebox), exposing the aluminum underneath. The aluminum is removed by placing the cube into a hot solution of sodium hydroxide and sodium nitrate. The dejacketed cubes are then rinsed with water and placed into a previously weighed feed container. To facilitate an even spread over the bottom of the weighed feed container, the polycubes may need to be broken into smaller pieces. The feed container would then be reweighed and placed into the muffle furnace.

[Figure 3-11. Batch Thermal Stabilization with Secondary Combustion of Polycubes and Combustibles](#)

## Batch Thermal Stabilization

The muffle furnace process controls and operating procedures vary according to the type of feed being processed. The controls are designed to maintain pre-established, optimum oxidizing conditions and temperatures that ensure controlled reactions in the furnace. The plutonium-bearing materials considered under this alternative would follow one of several muffle furnace programs, each with unique ramp-up, thermal-soak, and cool-down rates. The initial soaking temperature would be limited to 300·C (572·F) and would drive the organic material (i.e., styrene monomer) into the combustion chamber under nitrogen inert conditions. Afterwards, the nitrogen gas would be discontinued and air would be fed into the muffle furnace to facilitate the oxidation of the plutonium-bearing material. The thermal soak would occur at approximately 1,000·C (1,832·F) for a minimum of one hour. The combustion chamber, containing a thermal oxidation catalyst to ensure complete combustion, would be used to burn the organic material without an open flame. It is estimated that the furnaces would be capable of handling 500-g (1.1-lb) batches of plutonium-bearing material.

## Product Packaging and Transfer to Storage

After cooling, a sample of the product would be sent to the analytical laboratory to verify the material meets the DOE storage standard. Product not meeting the storage specifications would be recycled through the muffle furnace. Following this verification, the plutonium product would be packaged in accordance with existing procedures and transferred to the vault(s) at the PFP Facility for storage. The product could be retrieved and repackaged to meet the DOE storage standard specifying organic-free containers once a bagless transfer system has been developed. A more detailed description of this repackaging process is described in Subsection 3.2.1.3.

## Offgases and Effluents Offgases

Offgas from the muffle furnace would consist of air, water vapor, combustion products of polystyrene including carbon dioxide, carbon monoxide, residual styrene monomer, and small amounts of entrained plutonium dioxide. Solids entrained in the offgas would be significantly reduced by ceramic and HEPA filters in the PFP Facility ventilation control system. Maximum release rates to the environment through the 291-Z-1 stack are estimated to be: plutonium oxides,  $2 \times 10^{-10}$  g/sec ( $4.4 \times 10^{-13}$  lb/sec); carbon monoxide,  $1.7 \times 10^{-3}$  g/sec ( $3.8 \times 10^{-6}$  lb/sec); and styrene,  $7.9 \times 10^{-4}$  g/sec ( $1.8 \times 10^{-6}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of  $4.3 \times 10^{-3}$  g ( $1.0 \times 10^{-5}$  lb) of plutonium dioxide, 37 kg (81 lb) of carbon monoxide, and 17 kg (37.7 lb) of styrene is assumed for thermal stabilization.

## Solid Waste

Solid transuranic waste would be generated during glovebox operations. Solid transuranic wastes might include feed packaging material, and small quantities of latex and krylon tape. Solid transuranic wastes would be sent to Hanford Site solid waste management facilities for storage.

## Liquid Effluent

Coating removal, if required for aluminum-coated polycubes, would produce a caustic solution that would be pH adjusted, if necessary, sampled for plutonium content, and sent to the 200 Area Tank Farms. The total volume of caustic liquid that would be stabilized or disposed of is estimated to be 20 l (5.3 gal) containing 100 g (0.2 lb) of plutonium.

## Facilities and Equipment

Ongoing sludge stabilization activities involving batch thermal stabilization in muffle furnaces are currently being performed in Gloveboxes HC-21A and HC-21C. It is anticipated these and other gloveboxes would be used for this alternative.

Assuming an average processing rate of one 500-g (1.1-lb) batch 14 hours per muffle furnace, 24 hr/day, and operating

one muffle furnace, the estimated operational duration for this alternative is 72 weeks. This estimate assumes a 70 percent total operational efficiency and 10 percent recycle for failure to meet the DOE storage criteria.

### **3.3.4.2 Molten Salt Oxidation of Polycubes and Combustibles**

#### **Overview**

This alternative is intended to stabilize the inventory of polycubes and combustibles currently stored in the vaults and gloveboxes at the PFP Facility.

A description of the polycube inventory is contained in Subsection 3.1.1.4. Molten salt oxidation is a thermal process in which polycubes and combustibles are oxidized in a bed of molten salt. The product would be an ash containing the plutonium oxides.

Molten salt oxidation technology could potentially be used to process a broad range of materials, including organic liquids, oils, combustible solids (paper products, rubber, plastics), aqueous solutions, slurries (process residues), noncombustibles, metals, alloys, and polycubes. As discussed in previous sections, other technologies are preferable for processing liquids, metals, alloys, and oxides. Molten salt oxidation is being considered only for processing polycubes and combustibles at the PFP Facility.

A total of 35 kg (77 lb) of plutonium would be stabilized using this alternative. The resultant ash would be thermally stabilized and subsequently tested in accordance with the DOE storage standard. Product determined to be acceptable would be packaged using existing packaging capabilities and placed in the vaults at the PFP Facility for storage.

#### **Process Description**

Molten salt oxidation is a thermal process where feed and oxygen are introduced under the surface of a bed of molten salt maintained at a temperature of between 500 and 1,000·C (932 and 1,832·F). Figure 3-12 provides a simplified block diagram of the molten salt oxidation process. A more detailed block diagram and material balance of this process are included in Appendix B.

#### **Inventory Retrieval and Feed Preparation**

The containers holding polycubes and combustibles would be retrieved from storage and transferred to a glovebox at the PFP Facility dedicated to molten salt oxidation. Differing feed systems may be required to accommodate the differing inventory forms. An in-line shredder could be used for reducing the size of plastics and rags, while a heated hopper could be used to soften the polycubes for pneumatic injection. Polycubes with aluminum coatings may require crushing in lieu of the heated hopper injection process.

#### **Molten Salt Oxidation**

The molten salt oxidation process involves two molten salt units. Each unit contains a bed of molten salt comprised of a suitable mixture of carbonates, chlorides, or sulfates of sodium, potassium, lithium, or calcium.

The prepared feed would be fed into the first unit along with nitrogen gas. The salts would provide a heat transfer zone to melt and volatilize the polystyrene to styrene monomer. The styrene would then be conveyed to a second reactor where the remaining organic components would be oxidized in the presence of air and a catalyst. The offgas from this reactor would be pre-filtered, then HEPA filtered and vented. Inorganic components (such as radioactive actinides and metallic impurities in the form of ash) would be retained in the molten salt bed.

The molten salt oxidation process would be operated at atmospheric pressure with a predetermined unit residence time. The total heat of reaction for organics is often sufficient to maintain the operating temperature of the molten salt bed without supplemental heat.

#### **Dissolve and Filter**

Ash would build up in the molten salt bed as either a dissolved substance or slurry. This ash would be withdrawn and dissolved in water. The insoluble oxides and salts of actinides would precipitate and be filtered out.

### **Thermal Stabilization**

The solid ash product from filtering would require additional thermal treatment to reduce the moisture content and meet the safe storage stability requirements. Thermal treatment could be accomplished in a batch or continuous furnace. Following thermal stabilization, a sample of the product would be taken and sent to the analytical laboratory to verify the material meets the DOE storage standard.

### [Figure 3-12. Molten Salt Oxidation of Polycubes and Combustibles](#)

### **Product Packaging and Transfer to Storage**

Acceptable plutonium oxide product would be transferred to a container, weighed, sealed out of the glovebox, and packaged in containers in accordance with existing procedures. Product not meeting the DOE storage standard would be thermally stabilized a second time. A nondestructive analysis would be performed on the packaged product to determine the isotopic composition prior to transfer to the vault(s) at the PFP Facility for storage. The product could be retrieved and repackaged to meet the DOE storage standard when a bagless transfer system has been developed. A more detailed description of the repackaging process is found in Subsection 3.2.1.3.

### **Offgases and Effluents Offgases**

Gaseous effluent from the molten salt oxidation process would include air, water vapor, carbon monoxide, styrene, and entrained plutonium oxides. The offgas from this reactor would be pre-filtered, then HEPA-filtered in the PFP Facility ventilation control system. Maximum release rates to the environment through the 291-Z-1 stack are estimated to be: styrene,  $7.8 \times 10^{-3}$  g/sec ( $1.7 \times 10^{-5}$  lb/sec); carbon monoxide, 0.017 g/sec ( $3.7 \times 10^{-5}$  lb/sec); plutonium oxides,  $2.3 \times 10^{-8}$  g/sec ( $5.1 \times 10^{-11}$  lb/sec). For the purposes of this EIS, a theoretical maximum release to the environment of  $6 \times 10^{-3}$  g ( $1.3 \times 10^{-5}$  lb) of plutonium dioxide, 33.3 kg (73 lb) of carbon monoxide, and 16 kg (34 lb) of styrene is assumed for this alternative.

### **Solid Waste**

Solid transuranic waste will be generated during glovebox operations. Solid transuranic waste might include feed packaging material and would be sent to Hanford Site solid waste management facilities for storage.

### **Liquid Effluent**

The liquid effluent stream from aluminum coating removal has an estimated volume of 20 l (5.3 gal) containing 100 g (0.2 lb) of plutonium. This material would be stabilized or disposed of.

The filtered alkaline solution from the ash dissolver generates a liquid waste stream containing dissolved salts. A total of about 2,040 l (538 gal) of sodium carbonate solution would be generated containing a total of about 39 g (0.09 lb) of plutonium oxides. The solution would be discharged to the 200 Area Tank Farms or cemented and immobilized for storage at the Hanford Site solid waste management facilities.

### **Facilities and Equipment**

The molten salt oxidation process would require that some new equipment be installed at the PFP Facility. A typical molten salt oxidation system consists of molten salt units, a feed system, and dissolution/filtration equipment. Modifications to the PFP Facility would be required to accommodate the system. Roughly 90 square meters (m<sup>2</sup>) (107 square yards [yd<sup>2</sup>]) of floor space and 15 m<sup>3</sup> (19.6 yd<sup>3</sup>) of glovebox space would be needed. A new glovebox may be required to house the molten salt oxidation system. The molten salt oxidation process could use existing utilities, materials, supplies, and personnel at the PFP Facility.

Assuming a processing rate of 350 g/hr (0.77 lb/hr), and 24 hr/day, the estimated operational duration for this alternative is 24 weeks. This estimate assumes a 70 percent total operational efficiency and considers the contribution of handling and thermally stabilizing the polycubes and combustibles.

### 3.3.5 Immobilization Alternative

#### Overview

This alternative involves cementing candidate plutonium-bearing materials, packaging the cemented materials in appropriate shipping containers, and transporting the containers to a Hanford Site solid waste management facility. Currently, decisions to immobilize plutonium-bearing materials at the PFP Facility are made in accordance with criteria and provisions contained in the April 1994 version of the *Plutonium Disposition Plans* (Halsted, 1994). This plan and its criteria are discussed in more detail in Appendix E.

DOE has recently proposed a new policy for the disposition of plutonium-bearing materials. Under this draft policy entitled, *Department of Energy Policy for the Treatment and Disposition of Excess Plutonium-bearing Residues* (Lytle, 1996), excess plutonium-bearing residues would be processed to one of two end-states: 1) plutonium separated from its residue matrix (not necessarily refined) and packaged for storage in accordance with the DOE's storage standard; or 2) waste suitable for disposal at the Waste Isolation Pilot Plant. The draft policy further states:

For each quantity, batch, or category of residues, a determination of which end-state is more cost-effective must be made by the responsible field office and approved by the appropriate Secretarial Officer. The performance factors for cost-effectiveness must include worker exposure, waste generation, and cost.

This draft policy has been considered in the development of the immobilization alternative. Prior to any DOE decision to immobilize plutonium-bearing materials at the PFP Facility, the candidate materials would be further screened using cost-effectiveness performance factors. The draft policy and a complete list of the performance factors are described in more detail in Appendix E.

#### Process Description

A Portland cement system has been selected as a reasonable immobilization method to analyze further because: 1) the ingredients are inexpensive, safe, and readily available; 2) the equipment needs are simple; 3) the final waste form has proven stability; and 4) it meets the Hanford Site solid waste acceptance criteria and has been used extensively at the Hanford Site for immobilizing wastes.

Prior to cementation, the compatibility of the plutonium-bearing materials and cementitious materials would be evaluated. The cementation would take place inside a glovebox in the PFP Facility. Plutonium-bearing materials would be cemented in batches. The final volume of each batch would be approximately 3.40 l (0.9 gallon).

A schematic for the proposed cementation process is shown in Figure 3-13. Plutonium-bearing material would be fed into a mixing container using an auger feeder for accurate control. An appropriate amount of water would be added, followed by a measured amount of cement and other additives as needed. After all the cement had been added and mixed, the mixer would be shut off and the container removed from the mixer.

The container would then be moved to an out-of-the way location within the glovebox and allowed to set up. Once the materials inside three containers were sufficiently set up, the containers would be transferred out of the glovebox and packaged into a pipe-container-in-drum. A diagram of the pipe-container-in-drum is shown in Figure 3-14. This package consists of a stainless steel pipe-container placed vertically in the middle of a 55-gallon drum. The void space between the pipe-container and the wall of the drum would be filled with packing material. Both the pipe-container and the drum would be vented through a filter to prevent gas build-up.

The maximum allowable limit for plutonium in each pipe-container-in-drum is 200 g (0.44 lb) (DOE, 1996a). To

ensure that the drums would be accepted at a Hanford Site solid waste management facility, the plutonium content for each drum would likely be targeted at 170 g (0.37 lb). Since up to 272 kg (599 lb) of plutonium may be processed under this alternative, approximately 1,600 drums would be generated. The drums would be transported by truck to a Hanford Site solid waste management facility for storage. Additional details regarding the above process description are presented in Appendix E.

The offgas from the immobilization process would consist of small amounts of entrained particulates, including plutonium oxide. Solids entrained in the offgas would be significantly reduced by a ceramic filter and HEPA filters in the PFP Facility ventilation control system. The maximum rate of gross particulate and plutonium oxide release to the environment through the 291-Z-1 stack is estimated to be  $2.6 \times 10^{-9}$  g/sec ( $5.7 \times 10^{-12}$  lb/sec) and  $1.9 \times 10^{-11}$  g/sec ( $4.2 \times 10^{-14}$  lb/sec), respectively. For the purposes of this EIS, a theoretical maximum release to the environment of 0.74 g ( $1.6 \times 10^{-3}$  lb) of gross particulates and  $5.4 \times 10^{-4}$  g ( $1.2 \times 10^{-6}$  lb) of plutonium oxide is assumed for this alternative.

Assuming a processing rate of 15.3 kg/hr (34 lb/hr), 24 hr/day, the estimated operational duration of this alternative is 29 weeks. This estimate assumes a total operational efficiency of 70 percent

[Figure 3-13. Proposed Cementation Process](#)

[Figure 3-14. Pipe-container-in-drum](#)

## 3.4 DESCRIPTION OF THE NO ACTION ALTERNATIVE

Under the no action alternative, actions would be limited to ongoing maintenance and security activities necessary for safe and secure management of the PFP Facility. Following completion of ongoing actions, identified in Subsection 1.1, the no action alternative would not include additional actions for stabilization, or immobilization of sludges or ductwork cleanout.

### 3.4.1 Overview of the No Action Alternative

Under this alternative, reactive plutonium-bearing material currently in vault storage at the PFP Facility would not be stabilized or immobilized. Hold-up material in PFP Facility process piping, gloveboxes, process canyon areas, and ductwork would not be removed. Vault storage would continue as an ongoing action. The material in the vaults would continue to be inventoried, repackaged, and when an immediate safety hazard exists, stabilized as necessary. Surveillance and maintenance would continue at present required levels.

In order to minimize risk to PFP Facility and Hanford Site workers, the public, and the environment, measures currently in progress at the PFP Facility would continue. These measures would include existing monitoring and surveillance programs, materials accountability, and performing routine housekeeping and preventive maintenance. Overpressurization of storage containers would continue to require repackaging.

The activities that would continue to occur under the no action alternative for each of the plutonium inventory types are described in the following subsections.

#### 3.4.1.1 Plutonium-bearing Solutions

Plutonium-bearing solutions would be stored in storage rooms restricting unnecessary PFP Facility worker access. Some of the solutions are currently in plastic bottles inside stainless steel containers. Other solutions have been placed directly in stainless steel containers. None of these containers were designed for extended storage. No regular inspections are performed on the inner bottles, and the outer containers are only inspected for inventory considerations.

The plastic inner bottles are susceptible to failure from gas pressure and radiation embrittlement. Some of the solutions contain chlorides or fluorides that would damage the stainless steel outer container if the inner bottle leaked. Some of the bottles also are suspected of not being vented. Lack of venting could cause hydrogen gas, from radiolysis, to build up pressure, resulting in bottle failure. Cleanup actions would then be required.

#### **3.4.1.2 Oxides, Fluorides, and Process Residues**

The primary purpose of the current program is to ensure material accountability. The program monitors temperature and pressure by indirect methods. While temperature is based on the system ventilation, pressure is determined by inspecting the containers for bulging. There are no means to directly measure the temperature and pressure for individual containers.

These inspections have been successful in identifying packages that are suspected of hydrogen gas pressurization. Under the no action alternative, containers suspected of pressurization (typically three to seven per year at the PFP Facility for all inventory types) would be repackaged to pre-1995 requirements.

#### **3.4.1.3 Metals and Alloys**

The primary purpose of the current program is to ensure material accountability. The program monitors temperature and pressure by indirect methods. While temperature of the metals and alloys is based on the system ventilation, pressure is determined by inspecting the containers for bulging. Temperature and pressure of individual containers is not directly measured.

These inspections have been successful in identifying packages that are suspected of hydrogen gas pressurization. Under the no action alternative, containers suspected of pressurization (typically three to seven per year at the PFP Facility for all inventory types) would be repackaged to pre-1995 requirements.

#### **3.4.1.4 Polycubes and Combustibles**

The polycubes in the vaults are in containers and are not considered to pose significant pressurization risks. The combustibles include paper, rags, chemical wipes, graphite, wood, and plastics.

The proximity of the plutonium to the organic constituents of the polycubes and combustibles could cause radiolysis and hydrogen gas generation. The resultant potential for fire or explosion leaves the polycubes and combustibles in a condition unacceptable for extended storage.

#### **3.4.1.5 No Removal of Hold-up**

In this no action alternative, the plutonium that is readily accessible would not be removed and stabilized. This plutonium is held up in process piping, ducts, gloveboxes and on the PRF canyon floor.

### **3.4.2 Description of Routine Tasks by Functional Areas**

Approximately 592 people support the PFP Facility. Approximately 100 of these people are currently involved in ongoing material removal and stabilization activities. Therefore, it is anticipated that a labor force of approximately 492 would be required to support the Facility under the no action alternative. Some of the ongoing routine tasks being currently performed include:

- Maintenance of the Safety Boundary for the PFP Facility - includes all safety boundary maintenance, operation surveillances, and environmental compliance tasks. It maintains the Facility structure, qualified staff, safe and



- compliant equipment, and documentation, and provides all necessary resources for safe and compliant operation and assessment in accordance with governing safety codes and regulations.
- Corrective Maintenance - provides all corrective maintenance that restores systems and equipment to their operational states after failure. These tasks include the replacement or repair of failed building equipment or systems such as pumps, fans, or electrical equipment.
  - Preventive Maintenance - provides all preventive maintenance activities necessary to minimize unplanned events and premature equipment failures. These tasks include scheduled replacement or cleaning of filters and pump oil changes.
  - Operational Safety Requirements Surveillance - provides preventive maintenance to all Facility operational safety requirements equipment, systems, or instrumentation.
  - Nuclear Process/Radiation Surveillances - provides all nuclear process and radiation surveillances of Facility operations and operating systems (i.e., approximately 15,000 surveillances/week).
  - Nuclear Process Surveillances - provides for surveillance of all nuclear processes in the PFP Facility such as the dangerous waste tanks in Building 241-Z, the PRF and RMC line process areas, and surveillances of chemical satellite areas and dangerous waste temporary storage areas.
  - Health Physics Surveillances - provides for all Health Physics surveillances in the PFP Facility.
  - Power Operator Surveillances - provides for surveillance of all ventilation and power-related systems in the PFP Facility as required by operating procedures.
  - Environmental Compliance - provides all environmental surveillances of Facility operations and systems.
  - Environmental Surveillances - provides for the surveillance of Facility environmental equipment, systems, or instrumentation.
  - General Laboratory Support - provides all laboratory support necessary to maintain laboratory process control and research measurement capabilities.
  - Engineering Support - provides support to several ongoing PFP Facility projects related to modifications and upgrades not associated with preventive or corrective maintenance.
  - Management of Special Nuclear Materials, Nuclear Materials, and Nuclear Fuels - ensures that this material is received, handled, stored, and transferred for ultimate disposition in a safe and efficient way.
  - Safeguards and Security Resources - provides direction and oversight to ensure safe, and secure storage of special nuclear materials, nuclear materials, and nuclear fuel until final disposition of the material is accomplished. It includes physical security, safeguards accounting and material control, record keeping, studies, evaluations, and assessments.

In addition to the baseline security for stabilized and safely stored plutonium, additional security is required for the nonstabilized material in gloveboxes, and liquids (WHC, 1995c).

### **3.4.3 PFP Effluents**

For the no action alternative, there are three main PFP Facility effluent streams: one gaseous, one liquid, and one solid. The treated liquid effluent is discharged to the Treated Effluent Disposal Facility located in the 200 East Area. The gaseous stream is discharged to the 291-Z-1 stack. Solid wastes are handled according to type.

#### **3.4.3.1 Gaseous Effluents**

Of the four monitored gaseous effluent streams at the PFP Facility, the major portion of the volume and radioactivity is associated with the 291-Z-1 main stack. Recent releases through the 291-Z-1 stack, with the plant shut down, are considered representative of the no action alternative. Averages of the 1991 through 1994 releases rates would be projected to continue for the no action alternative. These are shown in Table 3-9.

**Table 3-9 Average Annual Release Rates through the 291-Z-1 Stack (Based on 1991-1994)**

**Emissions)**

Isotopes	Atmospheric Emissions Projected Future Emissions (Ci/yr)
<sup>239</sup> Pu and <sup>240</sup> Pu	3.7 x 10 <sup>-4</sup>
<sup>238</sup> Pu	1.5 x 10 <sup>-5</sup>
<sup>241</sup> Pu	2.5 x 10 <sup>-3</sup>
<sup>241</sup> Am	6.9 x 10 <sup>-5</sup>

**Source:** DOE, 1991; DOE, 1992; DOE, 1993; DOE, 1994d; DOE, 1995a; WHC, 1992a; WHC, 1992b; WHC, 1993; WHC, 1994; WHC, 1995d

**Notes:** Pu = Plutonium

Am = Americium

**3.4.3.2 Liquid Effluents**

The PFP Facility currently generates two radioactive liquid waste streams. The first is composed of wastes produced in the development laboratories as a result of testing for various stabilization alternatives (e.g., the vertical calciner, magnesium hydroxide precipitation). The liquid wastes contain plutonium, uranium, and potassium hydroxide. They are held in the 241-Z Building before being sent to the 200 Area Tank Farms. For the no action alternative, these tests will cease and this radioactive liquid waste stream will cease.

The second radioactive PFP liquid waste stream contains very low levels of radioactivity. This stream consists of cooling water, floor drains, condensates, air conditioning streams and various other building service wastes. Historically, this stream was discharged to the 216-Z-20 crib. This stream is now treated in the 243-Z low-level waste treatment facility prior to being discharged to the 200 Area Treated Effluent Disposal Facility (Ecology, 1995). Actual concentrations of radioactivity in the PFP liquid waste stream to the 200 Area Treated Effluent Disposal Facility in 1995 averaged one-third of the 200 Area Treated Effluent Disposal Facility allowables and the stream is no longer considered to be radioactive. This level is expected to continue for the future in the no action alternative. This projection is shown in Table 3-10.

The PFP Facility discharged 2.7 x 10<sup>8</sup> l (7.1 x 10<sup>7</sup> gal) of liquid effluents in 1991, 9.0 x 10<sup>7</sup> l (2.4 x 10<sup>7</sup> gal) in 1992, 1.0 x 10<sup>8</sup> l (2.6 x 10<sup>7</sup> gal) in 1993 and 2.8 x 10<sup>7</sup> l (7.4 x 10<sup>6</sup> gal) in 1994 (WHC, 1992b; WHC, 1993; WHC, 1994; WHC, 1995d). Based on these values, an assumption of 3.0 x 10<sup>7</sup> liters per year (7.9 x 10<sup>6</sup> gallons per year) total water discharge from the PFP Facility was made for the no action alternative.

**Table 3-10 Annual Liquid Radionuclides Discharged to 200 Area Treated Effluent Disposal Facility**

Radionuclides	Annual Release <sup>a</sup> (Curies)
<sup>238</sup> Pu	1.6 x 10 <sup>-5</sup>
<sup>239</sup> Pu	1.2 x 10 <sup>-5</sup>

240 Pu	1.2 x 10 <sup>-5</sup>
241 Pu	0.8 x 10 <sup>-3</sup>
241 Am	1.2 x 10 <sup>-5</sup>

**Source:** WHC, 1995e

**Notes:** a. Assumes flow of 3.0 x 10<sup>7</sup> l/yr.

Pu =Plutonium

Am =Americium

### 3.4.3.3 Solid Waste

The average amount of solid wastes being generated at the PFP Facility is provided in Table 3-11. This is representative of the solid wastes that would be generated for the no action alternative.

**Table 3-11 Annual Solid Waste Generation**

Waste Type	Weight (kg)	Volume (m3)
Hazardous	1,360	3.52
Mixed Low-level Radioactive	16,600	106
Mixed Transuranic	1,088	6.6
Mixed PCB Low-level	1,860	9.2
Nonregulated	2,720	5.6
PCB	78	0.74
Low-level Radioactive	26,640	205
Transuranic	9,600	75

**Source:** SWIR106, 1995

**Note:** PCB = polychlorinated biphenyl

### 3.4.4 Radiation Doses to PFP Facility Workers

The major portion of personnel dose exposure results from the routine inspections performed in order to ensure the safety and security of the stored material. In 1992, the PFP Facility total worker dose exposure was 68 person-rem. In 1993, exposure was 45 person-rem, and 1994 exposure was 46 person-rem. Failure of the storage containers would escalate these exposures. It is expected that for the no action alternative the PFP Facility worker dose exposure will

continue at the 1992 to 1994 average level of 53 person-rem per year. Even though the plutonium in the PFP Facility is aging (which results in higher americium levels), this is not expected to affect PFP Facility worker dose for the no action alternative. This is because there is limited handling of plutonium in this alternative. When handling is required, shielding for radiation from americium is readily accomplished (WHC, 1995f).

### **3.5 COMPARISON OF THE ANTICIPATED ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES**

This section provides a comparison of potential impacts of the alternatives, including the no action alternative, for two periods of time: Operational and interim storage.

The operational comparison, Subsection 3.5.1, covers the period from October 1996 through September 2002. This is the estimated length of time needed to implement and complete stabilization, removal, and immobilization activities. This corresponds with the DNFSB Recommendation 94-1 that "within a reasonable period of time (such as eight years), all storage of plutonium metal and oxide should be in conformance with the draft Standard on storage of plutonium" (DNFSB, 1994).

The interim storage comparison, Subsection 3.5.2, covers the time period from October 1996 through 2046. This 50-year timeframe provides a comparison basis for a period corresponding to that defined for interim storage (i.e., approximately 50 years) (DOE, 1994b).

In some areas there is no measurable difference in the impacts among the alternatives. A comparison could not be made of:

- Geology, seismology, and soils
- Water resources and hydrology
- Noise and sound levels
- Ecosystems
- Environmental Justice and Equity
- Transportation
- Land use
- Cultural resources.

Therefore, this section focuses on health effects, financial considerations, and on population and socioeconomic impacts. Analysis has shown these to be the parameters for which meaningful comparisons can be made.

#### **3.5.1 Operational Comparison**

For operational comparisons of alternatives, it is assumed that stabilization and removal activities described in this EIS would begin in October 1996 and be completed approximately six years later in September 2002 (WHC, 1995a).

The no action alternative is based on operations continuing as they are and the accompanying radiation exposures associated with that routine work. The preferred alternative (stabilization and removal) also includes the routine work that will be conducted at the PFP Facility during the six-year stabilization process. Therefore, estimated exposures in the preferred alternative include those from ongoing operations. The exposure to PFP Facility workers from routine activities decreases from 53 person-rem per year to 24 person-rem per year once the plutonium is stabilized and stored (WHC, 1996b). These exposures to PFP Facility workers should be considered in comparing the alternatives.

Table 3-12 provides a summary comparison of the impacts associated with the preferred alternative and the no action alternative.

Table 3-13 summarizes the health effects associated with the preferred alternative for stabilization only.

Table 3-14 summarizes the impacts of effluent generation associated with the preferred alternative for stabilization only.

Table 3-15 provides a summary of the impacts associated with the preferred alternative for removal.

Table 3-16 describes the health effects associated with the stabilization alternatives for the four inventory groups.

Table 3-17 describes the impacts associated with the immobilization of materials containing up to 272 kg (599 lb) of plutonium.

### 3.5.2 Interim Storage Comparison

#### Health Effects

Table 3-12 compares the radiation dose incurred by PFP Facility workers for the preferred alternative with the no action alternative. Figures 3-15 and 3-16 provide this information in a graphic form over a number of years to more clearly compare the relative annual and cumulative PFP Facility worker dose for these alternatives.

Figure 3-15 compares the estimated annual radiation exposure from the preferred alternative and the no-action alternative over a period of approximately 20 years. During the six years required to implement the preferred alternative, the radiation dose to the PFP Facility workers would exceed the radiation exposure when compared to the no action alternative. After the year 2002, following completion of all actions under the preferred alternative, the radiation dose to PFP Facility workers would drop to less than half of the no action dose.

The preferred alternative includes PFP Facility worker radiation dose resulting from stabilization and removal activities, as well as routine PFP operations. The actual timing and sequencing of stabilization and removal activities will depend on engineering judgement at the time workplans are made. However, total PFP Facility worker radiation dose will be the same regardless of timing and sequencing.

Figure 3-16 provides a summation of the radiation dose to PFP Facility workers for the preferred alternative and the no-action alternative over a 50 year period. The point in time where these lines cross, in the year 2028, is where the exposure of the no action alternative would begin to exceed the exposure of the PFP Facility worker dose for the preferred alternative. This comparison emphasizes that the no action alternative, although presenting a lower health risk in the short-term, would result in greater health risk after 32 years. Continuing ALARA improvements in Facility operations may increase the payback period beyond the currently estimated 32 years.

#### Financial considerations

A comparison of the monies expended in the preferred alternative compared to those expended in the no action alternative is shown in Figure 3-17. Costs are depicted in cumulative dollars using constant (unescalated) 1995 dollars.

**Table 3-12 A Comparison of the Impacts of the Preferred Alternative with the No Action Alternative (Based on a six year operation)**

Impact	Preferred Alternative (including stabilization and removal)	No Action Alternative
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Health effects - Routinea PFP Facility workers Hanford Site workers Public	930 person-rem, 0.37 LCF 3.9 x 10 <sup>-3</sup> person-rem, 1.6 x 10 <sup>-6</sup> LCF 14 person-rem, 7.0 x 10 <sup>-3</sup> LCF	320 person-rem, 0.13 LCF 7.4 x 10 <sup>-5</sup> person-rem, 2.9 x 10 <sup>-8</sup> LCF 0.26 person-rem, 1.3 x 10 <sup>-4</sup> LCF
Health effects - Accident PFP Facility worker (MEI) Hanford Site worker (MEI) Public (MEI)	250 rem; 0.1 LCF 1.9 x 10 <sup>-4</sup> rem; 7.8 x 10 <sup>-8</sup> LCF 6.9 x 10 <sup>-5</sup> rem; 3.4 x 10 <sup>-8</sup> LCF	b 15 rem, 6.1 x 10 <sup>-3</sup> LCF 0.31 rem; 1.6 x 10 <sup>-4</sup> LCF
Effluent Generationa Airborne Liquids Solids	0.36 g Pu-oxide, 84 kg NO <sub>x</sub> , 1.7 kg styrene, 3.9 kg CO 40,000 l caustic containing 640 g Pu Feed packing materials, 60 l ion exchange resin containing 55 g Pu, granulated activated carbon canister containing 54 kg carbon, 14 kg styrene and 200 g Pu	0.02 g Pu-oxide, zero NO <sub>x</sub> , zero styrene, zero CO Zero caustic solutions. 1.8 x 10 <sup>8</sup> l water with lower than allowable levels for drinking standards. 360,000 kg of various solids.
Population and Socioeconomics  Workforce requirements Population change Economic change	Increase from 592 to an average of 640 until 2002 when it decreases to 254. Less than 1 percent Less than 1 percent	Decrease from 592 to 492. Less than 1 percent Less than 1 percent

**Notes:** a. Potential routine health effects and effluents generated in the preferred alternative would also include those from on-going facility operations (no action alternative).

b. Not calculated since this accident involves an earthquake and PFP Facility worker doses are incidental to other consequences.

LCF = Latent cancer fatalities

CO = Carbon monoxide

Pu = Plutonium

NO<sub>x</sub> = Nitrogen Oxides

**Table 3-13 Summary of the Health Effects Associated with the Preferred Alternative for Stabilization Only**

Impact	Inventory Group/Stabilization Process				Stabilization Impacts
	Plutonium-bearing Solutions	Oxides, Fluorides, and Process Residues	Metals and Alloys	Polycubes and Combustibles	
	Ion Exchange, Vertical Calciner, Thermal Stabilization	Continuous Thermal Stabilization	Repackaging	Pyrolysis	
Health Effects - Routine					Summed Routine Health Effects
PFP Facility Workers	86 person-rem; 0.034 LCF	450 person-rem; 0.18 LCF	180 person-rem; 0.072 LCF	15 person-rem; 6.0 x 10 <sup>-3</sup> LCF	730 person-rem; 0.29 LCF
Hanford Site Workers	2.0 x 10 <sup>-4</sup> person-rem; 7.9 x 10 <sup>-8</sup> LCF	3.6 x 10 <sup>-3</sup> person-rem; 1.4 x 10 <sup>-6</sup> LCF	4.6 x 10 <sup>-5</sup> person-rem; 1.9 x 10 <sup>-8</sup> LCF	4.6 x 10 <sup>-5</sup> person-rem; 1.8 x 10 <sup>-8</sup> LCF	3.9 x 10 <sup>-3</sup> person-rem; 1.6 x 10 <sup>-6</sup> LCF
Public	0.70 person-rem; 3.5 x 10 <sup>-4</sup> LCF	13 person-rem; 6.4 x 10 <sup>-3</sup> LCF	0.16 person-rem; 8.2 x 10 <sup>-5</sup> LCF	0.16 person-rem; 8.1 x 10 <sup>-5</sup> LCF	14 person-rem; 7.0 x 10 <sup>-3</sup> LCF
MEI	7.4 x 10 <sup>-6</sup> rem 3.7 x 10 <sup>-9</sup> LCF	1.3 x 10 <sup>-4</sup> rem 6.5 x 10 <sup>-8</sup> LCF	1.7 x 10 <sup>-6</sup> rem 8.5 x 10 <sup>-10</sup> LCF	1.7 x 10 <sup>-6</sup> rem 8.5 x 10 <sup>-10</sup> LCF	1.5 x 10 <sup>-4</sup> rem 7.5 x 10 <sup>-8</sup> LCF
Health Effects -Accident					Accident with Most Severe Consequences
PFP Facility Worker (MEI)	100 rem; 0.04 LCF	250 rem; 0.1 LCF	52 rem; 2.1 x 10 <sup>-2</sup> LCF	0.74 rem; 3.0 x 10 <sup>-4</sup> LCF	250 rem; 0.1 LCF
Hanford Site Worker (MEI)	7.8 x 10 <sup>-5</sup> rem 3.1 x 10 <sup>-8</sup> LCF	1.9 x 10 <sup>-4</sup> rem 7.8 x 10 <sup>-8</sup> LCF	4.0 x 10 <sup>-5</sup> rem; 1.6 x 10 <sup>-8</sup> LCF	5.7 x 10 <sup>-7</sup> rem; 2.3 x 10 <sup>-10</sup> LCF	1.9 x 10 <sup>-4</sup> rem; 7.8 x 10 <sup>-8</sup> LCF
Public (MEI)	2.8 x 10 <sup>-5</sup> rem;	6.9 x 10 <sup>-5</sup> rem;	1.4 x 10 <sup>-5</sup> rem;	2.0 x 10 <sup>-7</sup> rem;	6.9 x 10 <sup>-5</sup> rem

	1.4 x 10 <sup>-8</sup> LCF	3.4 x 10 <sup>-8</sup> LCF	7.1 x 10 <sup>-9</sup> LCF	1.0 x 10 <sup>-10</sup> LCF	3.4 x 10 <sup>-8</sup> LCF
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**Notes:** CO = Carbon monoxide

NO<sub>x</sub> = Nitrogen oxides

MEI = Maximally exposed individual

LCF = Latent cancer fatalities

GAC = Granular activated carbon

Pu = Plutonium

**Table 3-14 Summary of Effluent Generation Associated with the Preferred Alternative for Stabilization Only**

Impact	Inventory Group/Stabilization Process				Stabilization Impacts
	Plutonium-bearing Solutions	Oxides, Fluorides, and Process Residues	Metals and Alloys	Polycubes and Combustibles	
	Ion Exchange, Vertical Calciner, Thermal Stabilization	Continuous Thermal Stabilization	Repackaging	Pyrolysis	
<b>Effluent Generation</b>					
Airborne	Pu-oxide 0.042 g; NO <sub>x</sub> 84 kg	0.31 g of Pu-oxide	5.6 x 10 <sup>-3</sup> g of Pu-oxide	Totals: styrene 1.7 kg, CO 3.9 kg, and Pu-oxide 6 x 10 <sup>-3</sup> g	0.36 g Pu-oxide, 84 kg NO <sub>x</sub> , 1.7 kg styrene, 3.9 kg CO
Liquids	Two streams: One of 8,300 l caustic containing a total of 108 g of Pu; and a second of 32,000 l caustic scrubber bottoms containing 28 g Pu.	NA	NA	A total of 20 l aluminum coating removal caustic solution containing 100 g Pu-oxide, 143 l of condensate styrene containing 400 g Pu-oxide	40,000 l caustic containing 640 g Pu.
Solid	Feed packaging material including plastic storage containers. 60 l spent ion exchange resin	Feed packaging material	Feed packaging material	Feed packaging material GAC canister (55-gallon drum), 54 kg	Feed packaging material including plastic storage containers. GAC canister containing 54



	containing 55 g Pu.			carbon; 14 kg styrene, and 200 g Pu.	kg carbon, 14 kg styrene and 200 g Pu. 60 l spent ion exchange resin containing 55 g Pu.
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**Notes:** CO = Carbon monoxide

NO<sub>x</sub> = Nitrogen oxides

MEI = Maximally exposed individual

LCF = Latent cancer fatalities

GAC = Granular activated carbon

Pu = Plutonium

**Table 3-15 Summary of Health Effects Associated with the Preferred Alternative for Removal**

Impact	Hold-up Area				Totals
	Ductwork	Drains and Piping	Gloveboxes	Canyon Floor	
Health Effects					
- Routine					
PFP Facility Workers	130 person-rem, 0.052 LCF	56 person-rem; 0.022 LCF	5.1 person-rem; 2 x 10 <sup>-3</sup> LCF	1.0 person-rem; 4 x 10 <sup>-4</sup> LCF	200 person-rem; 0.079 LCFa
Hanford Site Workers	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect
Public	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect	No measurable incremental effect
Health Effects					
- Accident					
PFP Facility Workers (MEI)	150 rem; 0.060 LCF	Bounded by ductwork accident			150 rem; 0.060 LCF
Hanford Site Workers (MEI)	1.1 x 10 <sup>-5</sup> rem; 4.4 x 10 <sup>-9</sup> LCF				1.1 x 10 <sup>-5</sup> rem; 4.4 x 10 <sup>-9</sup> LCF

Public (MEI)	4.0 x 10 <sup>-6</sup> rem; 2.0 x 10 <sup>-9</sup> LCF	4.0 x 10 <sup>-6</sup> rem; 2.0 x 10 <sup>-9</sup> LCF
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**Notes:**a. Total includes an additional 7.9 person-rem and 3.2 x 10<sup>-3</sup> LCF from thermal stabilization of the removed plutonium

LCF = Latent cancer fatalities

MEI =Maximally exposed individual

Pu =Plutonium

**Table 3-16 Summary of Impacts Associated with the Alternatives for Stabilization of each of the Inventory Groups**

Impact	Solutions	Oxides	Metals	Polycubes	
	Hydroxide Precipitation and Thermal Stabilization	Batch Thermal Stabilization Using Ten Muffle Furnaces	Batch Thermal Stabilization Using Ten Muffle Furnaces	Batch Thermal Stabilization with Secondary Combustion Chamber	Molten Salt Oxidation
Health Effects - Routine	85 person-rem; 0.034 LCF	640 person-rem; 0.26 LCF	320 person-rem; 0.13 LCF	29 person-rem; 1.2 x 10 <sup>-2</sup> LCF	19 person-rem; 7.6 x 10 <sup>-3</sup> LCF
PFP Facility Workers	2.0 x 10 <sup>-4</sup> person-rem; 7.9 x 10 <sup>-8</sup> LCF	3.6 x 10 <sup>-3</sup> person-rem; 1.4 x 10 <sup>-6</sup> LCF	1.6 x 10 <sup>-3</sup> person-rem; 6.4 x 10 <sup>-7</sup> LCF	3.3 x 10 <sup>-5</sup> person-rem; 1.3 x 10 <sup>-8</sup> LCF	5.5 x 10 <sup>-5</sup> person-rem; 2.2 x 10 <sup>-8</sup> LCF
Hanford Site Workers					
Public	7.0 x 10 <sup>-1</sup> person-rem; 3.5 x 10 <sup>-4</sup> LCF	13 person-rem; 6.4 x 10 <sup>-3</sup> LCF	5.6 person-rem; 2.8 x 10 <sup>-3</sup> LCF	1.2 x 10 <sup>-1</sup> person-rem; 5.8 x 10 <sup>-5</sup> LCF	1.9 x 10 <sup>-1</sup> person-rem; 9.7 x 10 <sup>-5</sup> LCF
<b>Health Effects - Accident</b>					
PFP Facility Workers (MEI)	100 rem; 4.0 x 10 <sup>-2</sup> LCF	250 rem; 0.1 LCF	31 rem; 1.3 x 10 <sup>-2</sup> LCF	0.74 rem; 3.0 x 10 <sup>-4</sup> LCF	0.52 rem; 2.1 x 10 <sup>-4</sup> LCF
Hanford	7.8 x 10 <sup>-5</sup> rem;	1.9 x 10 <sup>-4</sup>	2.4 x 10 <sup>-5</sup>	5.7 x 10 <sup>-7</sup> rem;	4.0 x 10 <sup>-7</sup> rem;

Site Workers (MEI)	3.1 x 10 <sup>-8</sup> LCF	rem; 7.8 x 10 <sup>-8</sup> LCF	rem; 9.6 x 10 <sup>-9</sup> LCF	2.3 x 10 <sup>-10</sup> LCF	1.6 x 10 <sup>-10</sup> LCF
Public (MEI)	2.8 x 10 <sup>-5</sup> rem; 1.4 x 10 <sup>-8</sup> LCF	6.9 x 10 <sup>-5</sup> rem; 3.4 x 10 <sup>-8</sup> LCF	8.5 x 10 <sup>-6</sup> rem; 4.3 x 10 <sup>-9</sup> LCF	2.0 x 10 <sup>-7</sup> rem; 1.0 x 10 <sup>-10</sup> LCF	1.4 x 10 <sup>-7</sup> rem; 7.1 x 10 <sup>-11</sup> LCF
<b>Effluent Generation</b>					
Airborne	0.042 g Pu-oxide	0.3 g of Pu-oxide	0.2 g of Pu-oxide	Styrene 17.1 kg, CO 37 kg, and Pu-oxide 4.3 x 10 <sup>-3</sup> g	Styrene 16 kg, CO 33 kg Pu-oxide 6 x 10 <sup>-3</sup> g
Liquids	A total of 5,060 l of caustic solutions containing a total of 101 g of Pu.	None	None	A total of 20 l aluminum coating removal caustic solution containing 100 g Pu-oxide.	A total of 20 l aluminum coating removal caustic solution containing 100 g Pu-oxide. A total of 2,040 l liquid salt waste stream containing 39 g Pu.
Solid	Feed packaging material including plastic storage containers.	Feed packaging material	Feed packaging material	Feed packaging material and small quantities of latex and krylon tape	Feed packaging material

**Notes:** LCF = Latent cancer fatalities

MEI = Maximally exposed individual

CO = Carbon monoxide

**Table 3-17 Summary of the Impacts Associated with the Immobilization Alternative**

Impact	Immobilization Alternative
Health Effects - Routine	74 person-rem, 0.03 LCF 6.2 x 10 <sup>-4</sup> person-rem, 2.5 x 10 <sup>-7</sup> LCF
PFP Facility workers	2.2 person-rem, 1.1 x 10 <sup>-3</sup> LCF
Hanford Site	

workers	
Public	
Health Effects - Accident	210 rem; 0.084 LCF 1.6 x 10 <sup>-4</sup> rem; 6.4 x 10 <sup>-8</sup> LCF
PFP Facility worker (MEI)	5.7 x 10 <sup>-5</sup> rem; 2.8 x 10 <sup>-8</sup> LCF
Hanford Site worker (MEI)	
Public (MEI)	
Effluent Generationa	5.4 x 10 <sup>-3</sup> g Pu-oxide
Airborne	No liquid wastes
Liquids	Approximately 1,600 drums of transuranic waste. The approximately 1,500 containers currently holding the plutonium for immobilization would be crushed and placed in 55-gallon drums and disposed of as low-level waste.
Solids	

**Notes:** a. Potential routine health effects and effluents generated in the immobilization alternative would also include those from ongoing facility operations.

MEI = Maximally exposed individual

LCF = Latent cancer fatalities

Pu = Plutonium

[Figure 3-15.A Comparison of Annual PFP Facility Worker Radiation Dose from the Preferred Alternative versus No Action \(Preferred Alternative Includes Dose from Routine Facility Operations\)](#)

[Figure 3-16. A Comparison of Cumulative PFP Facility Worker Radiation Dose Incurred from the Preferred Alternative versus No Action](#)

[Figure 3-17.A Comparison of Costs for the Preferred Alternative versus No Action](#)

### 3.6 ALTERNATIVE SELECTION METHODOLOGY AND ALTERNATIVES DISMISSED

Council on Environmental Quality regulations direct all agencies to use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment (40 CFR 1500.2(e)). Council on Environmental Quality regulations also require that EISs identify those alternatives that have been eliminated from detailed study because they are unreasonable and briefly discuss why they have been eliminated (40 CFR 1502.14(a)). The following subsections describe the process used to

identify reasonable alternatives for removing and stabilizing plutonium-bearing materials in the PFP Facility.

In applying this selection process, alternatives that would require declaring the PFP Facility plutonium-bearing materials waste potentially foreclose on alternatives considered for the *Storage and Disposition of Weapons-Usable Fissile Material Draft Programmatic Environmental Impact Statement* (DOE, 1996b). Waste disposal alternatives are therefore not considered in this EIS.

Subsection 3.6.1 discusses the selection process for the stabilization alternatives. Subsection 3.6.2 discusses the selection process for the removal alternatives.

### 3.6.1 Stabilization Alternatives Selection Process

The approach used in the selection of alternatives consisted of the following:

1. Identify candidate technologies that may be suitable for stabilization
2. Determine the applicability of technologies to inventory groups
3. Apply criteria based on the purpose and need to evaluate and compare these candidate technologies
4. Develop alternatives based on selected technologies.

The term alternative is used here to mean a major choice or strategy as opposed to a technology or engineering option available to achieve the purpose and need. An alternative may consist of several component technologies or engineering steps.

#### 3.6.1.1 Candidate Technologies for Stabilizing Plutonium

The following sources were used to identify a broad range of candidate technologies for the stabilization of plutonium.

- *Plutonium Finishing Plant Interim Plutonium Stabilization Engineering Study*, (Sevigny, et al., 1995)
- The results of the Environmental Assessment and EIS Scoping Processes (DOE, 1995b)
- Meetings with knowledgeable personnel at Westinghouse Hanford Company and the Pacific Northwest National Laboratory
- DNFSB Recommendation 94-1 (DNFSB, 1994)
- *DNFSB Recommendation 94-1 Hanford Site Integrated Stabilization Management Plan* (WHC, 1995a)
- Consultation with staff at other DOE facilities who are managing and/or conducting research on the management of plutonium.

These sources resulted in the identification of a lengthy list of candidate stabilization technologies and options (see Table 3-18).

**Table 3-18 Candidate Stabilization Technologies**

Absorption	Hydroxide Precipitation
Acid dissolution	Ion Exchange
ACT*DE*CON Soil and Sludge Washing	Membrane Separation
Alumina-hydroxy-ligand Gel	Microwave Drying

Ammonium Hydroxide Precipitation	Molten Salt Oxidation
Catalyzed Electrochemical Plutonium	Oxalic Acid Precipitation
Oxide Dissolution (CEPOD)	Ozone Treatment
Cementation	Phase Separation (by Adduct Formation)
Cold Glass Processing (Sol-gel)	Pyrolysis
Direct Denitration via Fluid Bed	Screening
Direct Denitration via Horizontal Screw Calcination	Seeded Magnetic Filtration (MAG'SEP)
Direct Denitration via Vertical Calcination	Silver Chloride Precipitation
Evaporation	Silver Persulfate
Freeze Crystallization	Solvent Extraction
Grind and Leach	Sugar Denitration
High Gradient Magnetic Separation	Thermal Treatment (Batch and Continuous)
High Temperature Plasma	Vitrification
Hydrogen Peroxide Precipitation	Wet Oxidation
Hydrolysis	Zone Melting

Options evaluated in addition to the above list of candidate stabilization technologies included:

### **Repackaging**

DOE *Criteria for Safe Storage of Plutonium Metals and Oxides* (DOE, 1994b), requires the use of a packaging system that does not rely on organic seals or plastic bags. Repackaging of plutonium-metals and oxides using a so-called bagless system reduces the generation of hydrogen gas and the possibility of bulging containers.

### **Shipment Offsite for Stabilization**

This would involve shipping material such as polycubes or plutonium-bearing solutions to other DOE sites for processing and stabilization. For example, DOE's Savannah River Site, where local plutonium-bearing solutions will be processed, could be considered a likely destination for plutonium-bearing solutions.

### **Restart of the PRF and/or RMC Line**

This would involve restarting major portions of the former PFP Facility process facilities.

#### **3.6.1.2 Evaluation of Candidate Technologies**

Two types of screening criteria were defined to evaluate and compare candidate technologies: 1) disqualification criteria; and 2) selection criteria. The disqualification criteria eliminated those candidate technologies that could not be used to stabilize the plutonium-bearing materials at the PFP Facility. The selection criteria were used to compare the remaining candidate technologies and select the more favorable technologies for detailed evaluation in the EIS.

## Disqualification Criteria and Their Application

There were two disqualification criteria. Each candidate technology was evaluated against these criteria and failure of a candidate to pass either of the criteria resulted in its disqualification from any further consideration. Table 3-19 identifies potentially applicable stabilization technologies that passed both of the disqualification criteria.

**Disqualification Criterion 1** - The technology must be compatible with one of the plutonium inventory groups and contribute to the stabilization of these materials. That is, the technology must be a step in the direction of stabilization.

**Disqualification Criterion 2** - It must be possible to implement the technology in a timely manner in order to support the schedule for completion of stabilization and storage within the timeframe recommended in DNFSB Recommendation 94-1 (DNFSB, 1994). Therefore, compatibility with the existing DOE plutonium processing facility was required. Demonstration of the technology in at least pilot-scale operation for material similar to plutonium would provide confidence that full-scale design and operation could be achieved in a timely manner.

**Table 3-19 Potentially Applicable Stabilization Technologies**

Plutonium Inventory Groups	Potentially Applicable Technology	
Plutonium-bearing Solutions	Ammonium Hydroxide Precipitation Direct Denitration via Fluid Bed Direct Denitration via Vertical Calciner Evaporation Freeze Crystallization Hydroxide Precipitation	Ion Exchange Microwave Drying Oxalic Acid Precipitation Hydrogen Peroxide Precipitation Solvent Extraction Sugar Denitration
Oxides, Fluorides, and Process Residues	Acid Dissolution Horizontal Screw Calciner Hydrolysis	Continuous Thermal Stabilization Batch Thermal Stabilization
Metals and Alloys	Molten Salt Oxidation	Batch Thermal Stabilization
Polycubes and Combustibles	Acid Dissolution Hydrolysis Molten Salt Oxidation	Batch Thermal Stabilization Pyrolysis

## Selection Criteria and Their Application

Selection criteria were identified and used to qualitatively compare technologies that were not eliminated by the disqualification criteria. Program objectives identified in the statement of purpose and need for agency action are: reduction of risks to PFP Facility and Hanford Site workers, the public, and the environment. As a result, the following were identified as relevant selection criteria:

- Potential for routine and accident risks that could adversely affect the public, PFP Facility and Hanford Site workers, and/or the environment
- Consideration of applicable regulatory requirements
- Volume and hazards of the effluents produced
- Public and PFP Facility and Hanford Site worker radiation dose considerations.

In order to facilitate this comparison, the candidate technologies (those not disqualified) were grouped according to their applicability to one or more of the plutonium inventory groups described in Subsection 3.1. The resulting groups are shown in Table 3-19.

Table 3-19 contains technologies that could stabilize plutonium-bearing materials in chemically or physically comparable manners. For example, the precipitation technologies all involved the adjustment of the pH (acidity or alkalinity) of the solution in order to separate the plutonium. Therefore, in order to evaluate and compare these candidate technologies against one another, they were further grouped according to the similarity of the process (for example, all denitration technologies were grouped together). Each similar candidate technology was compared against the others in its group to determine if any was qualitatively superior. For example, if one technology in the group presented a relatively smaller potential for risk to PFP Facility and Hanford Site workers, it would be judged more favorable for this criterion than the others in the group for that selection criterion. These groupings are:

### **Plutonium-bearing Solutions**

- Precipitation Processes - Through pH adjustment of the solution, the dissolved plutonium is chemically separated from the solution so it can be collected and removed (i.e., ammonium hydroxide, oxalate, hydrogen peroxide, and hydroxide precipitation).
- Liquid Reduction Technologies - Techniques used to decrease the solution volume (i.e., evaporation, freeze crystallization, microwave drying).
- Denitration Technologies - The conversion of the nitrate or nitrite portions of plutonium nitrate solutions into nitrogen or oxides of nitrogen (i.e., fluid bed, vertical calciner, sugar denitration). This leaves a residue of plutonium-bearing material.
- Conditioning Technologies - These techniques prepare and/or enhance the suitability of the plutonium-bearing material for the next stage of the stabilization process (i.e., ion exchange, solvent extraction).

### **Oxides, Fluorides, and Process Residues**

- Thermal Stabilization Technologies - Plutonium-bearing materials are exposed to a high-temperature atmosphere to convert reactive constituents to oxides (i.e., molten salt oxidation, horizontal screw calciner, continuous thermal stabilization, batch thermal stabilization).

### **Metals and Alloys**

- Thermal Stabilization Technologies - This includes molten salt oxidation and batch thermal stabilization.

### **Polycubes and Combustibles**

- Molten salt oxidation
- Batch thermal treatment
- Pyrolysis.

#### **3.6.1.3 Alternatives Development**

Table 3-20 shows the candidate technologies that were disqualified or eliminated, as well as those that passed both disqualification criteria and were considered preferable in the selection criteria.



**Table 3-20 Alternatives Identification Alternatives Identification**

<b>Initial Candidate Technologies</b>	<b>Disqualified</b>	<b>Selected</b>
Absorption	Disqualified	.
Acid Dissolution	Qualified-->	Selected
ACT*DE*CON Soil and Sludge Washing	Disqualified	.
Alumina-hydroxy-ligand Gel	Disqualified	.
Ammonium Hydroxide Precipitation	Qualified-->	Selected
Catalyzed Electrochemical Plutonium Oxide Dissolution (CEPOD)	Disqualified	.
Cementation	Disqualified	.
Cold Glass Processing (Sol-gel)	Disqualified	.
Direct Denitration via Fluid Bed	Qualified-->	Selected
Direct Denitration via Horizontal Screw Calcination	Qualified-->	Selected
Direct Denitration via Vertical Calcination	Qualified-->	Selected
Evaporation	Qualified-->	Selected
Freeze Crystallization	Qualified-->	Not Selected
Grind and Leach	Disqualified	.
High Gradient Magnetic Separation	Disqualified	.
High Temperature Plasma	Disqualified	.
Hydrogen Peroxide Precipitation	Qualified-->	Selected
Hydrolysis	Qualified-->	Selected
Hydroxide Precipitation	Qualified-->	Selected
Ion Exchange	Qualified-->	Selected
Membrane Separation	Disqualified	.
Microwave Drying	Qualified-->	Not Selected
Molten Salt Oxidation	Qualified-->	Selected
Oxalic Acid Precipitation	Qualified-->	Not Selected
Ozone Treatment	Disqualified	.
Phase Separation (by adduct formation)	Disqualified	.

Pyrolysis	Qualified-->	Selected
Screening	Disqualified	.
Seeded Magnetic Filtration (MAG'SEP)	Disqualified	.
Silver Chloride Precipitation	Disqualified	.
Silver Persulfate	Disqualified	.
Solvent Extraction	Qualified-->	Not Selected
Sugar Denitration	Qualified-->	Not Selected
Thermal Treatment (batch and continuous)	Qualified-->	Selected
Vitrification	Disqualified	.
Wet Oxidation	Disqualified	.
Zone Melting	Disqualified	.

Shipping polycubes or plutonium-bearing nitrate solutions to another DOE site was not considered reasonable. There was no technology or facility at any other DOE location for stabilizing polycubes available within a reasonable time frame.

Shipping plutonium-bearing solutions by rail or truck to other DOE sites is restricted by U.S. Department of Transportation regulations. Given highway route-controlled shipping quantities (49 CFR 173.403(l)), the number of containers required to ship the plutonium-bearing solutions would exceed 23,000. The extraordinary number of containers required to ship the plutonium-bearing materials, coupled with the risks to the inhabitants along the transportation route, resulted in this option being disqualified.

Although restart of the PFP Facility would achieve the purpose and need for the proposed action, it is no longer considered reasonable because of environmental and PFP Facility and Hanford Site worker health risks, facility upgrades required, and limited availability of material (carbon tetrachloride) needed to operate the PRF.

Vitrification of the plutonium into glass logs was not considered a reasonable alternative for several reasons:

- At most only 9 percent of the weight of the logs could be plutonium. This would result in a volume of material for storage that would exceed the existing capacity of the vaults.
- Some of the plutonium-bearing materials are incompatible with the glass matrix of the logs. This would result in the need for pretreatment in order to stabilize materials.
- Operation of a vitrification facility is not compatible with the current configuration of the PFP Facility.

The two-step evaluation process resulted in identifying reasonable candidate technologies for analysis in this EIS (see Table 3-21). Evaluation of these candidate technologies indicated that they often needed to be combined into two- or three-step processes to stabilize the variable forms of the plutonium-bearing materials at PFP Facility and to meet the DOE storage standard (DOE, 1994b). The combinations are shown in Table 3-22.

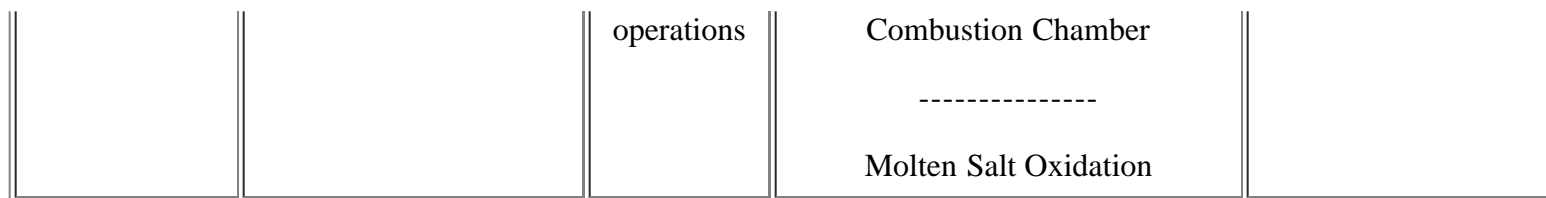
**Table 3-21 Selected Stabilization Technologies**

Inventory Group	Pretreatment	Solution	Final Stabilization Technology
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	Technologies	Separation Technologies	
Plutonium-bearing Solutions	Ion Exchange Evaporation	Vertical Calciner Precipitation Direct Denitration	Thermal (Batch or Continuous)
Oxides, Fluorides, and Process residues	Acid Dissolution Hydrolysis	.	Thermal (Batch or Continuous) Repackaging
Metals and Alloys	.	.	Repackaging Thermal (Batch)
Polycubes and Combustibles	.	.	Pyrolysis Thermal (Batch) (with Secondary Combustion Chamber) Molten Salt Oxidation

**Table 3-22 Description of Alternatives for Plutonium Stabilization**

Plutonium Inventory Group	Preferred Alternative	No Action Alternative	Alternative	Applicable Pretreatment Technologies
Plutonium-bearing Solutions	Ion Exchange, Vertical Calcination and Thermal Stabilization	No change in facility operations	Hydroxide Precipitation followed by Thermal Stabilization	Liquid Reduction using Evaporation
Oxides, Fluorides and Process Residues	Continuous Thermal Stabilization	No change in facility operations	Batch Thermal Stabilization in a Muffle Furnace	Hydrolysis of High Organic-bearing Process Residues ----- Acid Dissolution of Fluorides
Metals and Alloys	Repackaging	No change in facility operations	Batch Thermal Stabilization in a Muffle Furnace	.
Polycubes and Combustibles	Pyrolysis	No change in facility	Batch Thermal Stabilization in Muffle Furnace with secondary	.



Two candidate technologies were judged to be preliminary steps that would be used only in conjunction with other technologies. Acid dissolution is a preliminary step that may be used in the treatment of fluorides or polycubes. Hydrolysis is a preliminary step that may be used in the treatment of organics.

Acid dissolution and hydrolysis are both preliminary steps that may be used in the stabilization of polycubes. Because of the uncertainties associated with the handling of polycubes, the three candidate technologies, molten salt oxidation, batch thermal treatment with secondary combustion chamber, and pyrolysis, were retained for further evaluation in the EIS.

Packaging or repackaging of the stabilized material using the existing capabilities of the PFP Facility or repackaging to the DOE storage standard using a nonorganic or bagless system in accordance with DOE *Criteria for Safe Storage of Plutonium Metals and Oxides* (DOE, 1994b) would be considered as candidate technologies.

### 3.6.2 Removal Alternatives Selection Process

Readily retrievable hold-up material is contained in various PFP systems, structures, and components. These include gloveboxes, hoods, exhaust and ventilation systems, process equipment, piping, building structures, and canyon facilities. This material is the result of many years of processing plutonium-containing material at Hanford and is commonly referred to as hold-up material. This hold-up material poses radiation exposure risks to PFP Facility and Hanford Site workers and to the public, and it could include unstable forms of plutonium.

#### 3.6.2.1 Candidate Technologies for Hold-up Material Removal

The following sources were used to identify a broad range of candidate technologies for the removal of hold-up material:

- Results of the public scoping process (DOE, 1995b)
- Ongoing discussions with DOE contractors' personnel
- Literature search of available technologies for decontamination and decommissioning of a nuclear facility
- DOE *Decommissioning Handbook* (DOE, 1994c)
- Contact with DOE and National Laboratory personnel currently involved in this area of research.

These sources resulted in the identification of a lengthy list of candidate hold-up material removal technologies.

#### 3.6.2.2 Evaluation of Candidate Technologies

Alternative selection criteria were developed to evaluate and compare candidate technologies in order to identify a set of reasonable chemical, mechanical, disassembly, and protective technologies. The criteria used were:

##### **Criterion 1** - Suitability or Applicability of the Technology

The technology must be appropriate and applicable for removal of hold-up material from ventilation and exhaust ducts, canyon floor, piping, filter boxes, gloveboxes and hoods, and sumps.

##### **Criterion 2** - Technical Feasibility of Potential Technology

The technology must be implementable in a reasonable time frame. Therefore, only proven off-the-shelf technologies were accepted. In addition, the technology must be compatible with the PFP Facility.

**Criterion 3 - Environmental, Health, and Safety Risk Factors to PFP Facility and Hanford Site Workers and the Public.**

Environmental, health, and safety risk factors for PFP Facility and Hanford Site workers and the public are important to the selection of the technologies to be used for removal of plutonium-bearing material. The technologies that posed a higher potential for accident risks to the PFP Facility workers were eliminated from further consideration. Technologies that produced large secondary waste streams were considered less favorable if other technologies with lesser waste volumes were available.

**3.6.2.3 Results of Removal Alternative Selection Process**

The candidates that were evaluated and the results of the evaluation are shown in Tables 3-23, 3-24, 3-25, and 3-26.

As shown in the tables, certain technologies, such as thermal cutting techniques and use of flammable materials, were determined to be unsuitable because of facility safety considerations. Technologies involving use of chemicals identified as strongly carcinogenic or particularly dangerous to the environment (e.g., freon) were considered less suitable because of the potential risk to the PFP Facility and Hanford Site workers, the public, and the environment. Technologies that would result in a product that was hard to treat or to dispose of were considered less favorable. Technologies containing complexing agents were rejected since they would require additional treatments to remove plutonium from hold-up.

The processes and technologies that will be used for hold-up material removal will be selected at the time workplans are developed, using engineering judgment and will depend upon the size, shape, location, and accessibility of the plutonium-bearing material being removed. The candidate technologies identified in these tables include processes that must be used in combination in order to stabilize the variable forms of plutonium-bearing materials at the PFP Facility and to meet the DOE storage standard (DOE, 1994b).

**Table 3-23 Candidate Technologies that Use Chemicals for Removal**

<b>Candidate Technology</b>	<b>Disposition</b>
Freons - technology relies on the characteristic of the gas for the removal of particulates	Not acceptable - Freon implicated in the depletion of the ozone layer
Recyclable Phase Gel Technology - a recyclable treatment option that relies on phase transformation to remove material	Not acceptable - Technology not demonstrated in a comparable environment
Acid/Base Flushing/Rinsing - attack and dissolve metal oxide films	Acceptable
Ethylenediaminetriacetic Acid (EDTA) - solubilizes metal ions and prevents redeposition	Not acceptable - Results in a product requiring extensive pretreatment prior to stabilization
Detergents, Surfactants, and Bleaches - act as wetting agent to remove dirt and certain organic materials	Acceptable
Organic Solvents - used to remove organic materials from surfaces and cloth	Not Acceptable - Solvents flammable and toxic

Carbon Tetrachloride (CCl<sub>4</sub>)

Not Acceptable - Carcinogen and damaging to ozone layer

**Table 3-24 Candidate Technologies that Use Mechanical Means for Removal**

Candidate Technology	Disposition
Steam - acts to dissolve and remove chemicals by eroding and flushing loose surface material	Not acceptable - Limited application to facility
Sandblasting - technique abrades surfaces with various grades of sand or grits	Acceptable
Pressure Jetting Techniques (Carbon dioxide) Blasting - grit blasting technique similar to sandblasting that uses dry ice pellets	Acceptable
Wiping Systems (brooms, brushes, scrapers)	Acceptable
Xenon Arc Laser - uses light energy to photopyrolyze surface contaminants	Acceptable

**Table 3-25 Candidate Disassembly Techniques to Support Removal**

Candidate Technology	Disposition
Plasma Torch Arc, Oxyacetylene, etc. - metal cutting technique that uses a flame or arc to melt through material	Not acceptable - Technique requires an open flame and therefore not compatible with the PFP safety requirements
Explosives - a segmentation method that uses explosives as a cutting agent	Not acceptable - Not compatible with the PFP safety requirements
Saws (hex, circular, abrasive, guillotine) - common industrial tool for cutting materials	Acceptable
Saw, Glass - specialized saw for cutting glass	Acceptable
Laser - uses light generated heat to cut metals	Not acceptable - Slow cutting speed could contribute to PFP Facility worker exposure
Drill, Core Stitch - uses a diamond- or carbide- tipped drill to define an area for removal	Not acceptable - Slow cutting speed could contribute to PFP Facility worker exposure, not suitable for reinforced concrete
Segmentation/Sectioning of Equipment/Components - sectioning is dismantling of equipment, segmentation refers to size reduction using cutting techniques	Acceptable

**Table 3-26 Candidate Coating Technologies to Support Removal**

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Candidate Technology	Disposition
Sealants, Foams, etc. - compounds which become barriers to isolate or confine radioactive particulates or hazardous materials	Acceptable
Tie-down Coatings - coatings on contaminated surfaces to fix the contaminant in place and decrease or eliminate exposure hazards	Acceptable
Strippable Coating Systems - coatings that entrain contaminants and can be removed for disposal or incineration	Acceptable
Segmentation/Sectioning of Equipment/Components - sectioning is dismantling of equipment, segmentation refers to size reduction using cutting techniques	Acceptable
Plastic Tape Applique on Glovebox Windows - use of tape on glass surfaces to reduce fracturing, splintering, and breakage of glass	Acceptable

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## 4.0 AFFECTED ENVIRONMENT

This section describes the environment that may be affected by the proposed alternatives. The affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment" (40 CFR 1508.14). Defining and describing the environment lays the foundation for evaluating the potential environmental impacts of the preferred and other alternatives. The description of the existing environment is limited to information that directly relates to the scope of the preferred alternative and the impacts of the alternatives that are to be analyzed.

For this EIS, the affected environment is the area of and adjacent to the Hanford Site, which is located in southeastern Washington State north of the city of Richland. The location of the Hanford Site is shown in Figure 4-1. The PFP Facility is located in the 200 West Area, approximately 51 km (32 mi) northwest of Richland (See Figure 4-2). Based on the anticipated impacts to the environment of the alternatives described in Section 3, an extensive description from the existing environment has been included for only those areas where impacts may occur. For areas not affected by the alternatives, the description is cursory in nature. For a complete description of the existing environment, the reader is referred to *Hanford Site National Environmental Policy Act (Federal NEPA) Characterization, Revision 7* (PNL, 1995a) and the *Hanford Site Environmental Report for Calendar Year 1994* (PNL, 1995b).

The affected environment is arranged as follows:

- 4.1 Geology, Seismology, and Soils
- 4.2 Water Resources and Hydrology
- 4.3 Physical Environment
- 4.4 Ecosystems
- 4.5 Population and Socioeconomics
- 4.6 Transportation
- 4.7 Land use
- 4.8 Cultural resources
- 4.9 Waste Treatment, Storage, and Disposal Capacity.

### 4.1 GEOLOGY, SEISMOLOGY, AND SOILS

This section presents existing information regarding the Hanford Site's geological setting, seismological characteristics, including Earthquake history, and Soil conditions. Subsection 4.1.1 describes the regional geological resources. Subsection 4.1.2 describes the seismologic setting for the Site, presents the Earthquake history, and presents information regarding the ground acceleration that may be experienced during a seismic event.

[Figure 4-1. Location of Hanford Site](#)

[Figure 4-2. 200 West Developed Areas and Existing Structures](#)

Subsection 4.1.3 presents existing information regarding the agricultural and engineering properties of the Soils at the Site.

#### 4.1.1 Geology

The PFP Facility is located in the 200 West Area which is in the Pasco Basin, a topographic and structural depression in the southwest corner of the Columbia Basin physiographic subprovince. Generally, this subprovince is characterized as relatively flat, low-relief hills with moderately incised river drainages (DOE, 1993a).

The Columbia Basin subprovince is underlain by the Columbia River Basalt Group, which consists of a thick sequence of Miocene basalt flows that are approximately 17 to 6 million years in age. The thickest accumulations occur in the Pasco Basin where the basalt thickness is greater than 3 km (1.8 mi) (DOE, 1988).

Two primary sedimentary rock units overlie the Columbia River Basalt in the 200 West Area: 1) Pliocene fluvial and lacustrine

deposits of the Ringold Formation, and 2) Pleistocene Floods deposits of the Hanford formation. In addition, two discontinuous units of calcium carbonate cemented silts, sands, and gravels (caliche) occur locally between the Ringold Formation and the Hanford formation in the 200 West Area. These units are referred to as the Plio-Pleistocene Unit and the Early "Palouse" Soil. The total thickness of the sedimentary section above basalt in the vicinity of the PFP Facility is approximately 162 m (530 ft). These units become thicker several miles to the south of the PFP Facility toward the axis of the Cold Creek Syncline and thinner toward the north against the flanks of Gable Mountain and Gable Butte (DOE, 1993a). Currently, no mineral resources other than crushed rock, sand, and gravel are produced from the Pasco Basin (DOE, 1988).

Geologic processes which alter topography are Earthquakes, landslides, volcanic activity, liquefaction, and Floods.

- Earthquakes - Earthquakes are discussed in Subsection 4.1.2.
- Landslides – The likelihood of landslides affecting the PFP Facility is low due to the absence of any actively eroding streams.
- Volcanic Activity – The only effect of increased Cascade volcanism to the Hanford Site would be from Ashfall, such as the Ashfall from the 1980 eruption of Mount St. Helens.
- Liquefaction – Liquefaction is not an issue at the PFP Facility due to the deep water table.
- Floods - Floods are discussed in Subsection 4.2.1.

#### 4.1.2 Seismology

The Hanford Site lies in an area of relatively low seismic activity. Between 1870 and 1980, only five Earthquakes that had Modified Mercalli Intensities of VI or greater occurred in the Columbia Plateau region and all these events occurred prior to 1937. The largest event was the July 16, 1936 Milton-Freewater, Oregon Earthquake (Modified Mercalli Intensities = VII; surface wave magnitude = 5.8). Woodward-Clyde Consultants located the epicenter approximately 100 km (62 mi) southeast of the Hanford Site (WHC, 1989).

Seismicity within the Columbia Plateau can be segregated into three depth zones: 0 to 4 km (0 to 2.5 mi); 4 to 8 km (2.5 to 5 mi); and deeper than 8 km (5 mi). Approximately 70 to 80 percent of this activity occurs in the 0 to 4 km (0 to 2.5 mi) zone, and 90 percent of it occurs in the first two zones (WHC, 1993). Most of the Earthquakes in the central Columbia Plateau are north or northeast of the Columbia River and occur as swarms that are not associated with mapped faults.

Applicable DOE guidelines, stipulated in 6430.1ADOE Order 6430.1A, General Design Criteria (DOE, 1989), require that Earthquake ground motions be computed using probabilistic methods. Three Hanford Site-specific studies of this type have been performed. The horizontal peak ground accelerations and their associated annual probabilities of being exceeded were estimated by Coats and Murray (1984) for the Hanford Site in general, and by Geomatrix (WHC, 1993) and Woodward-Clyde Consultants (WHC, 1989) for a specific location within the Hanford Site. The results for the 200 West Area (available only from Woodward-Clyde and Geomatrix) are summarized in Table 4-1.

**Table 4-1 Horizontal Peak Ground Acceleration Estimates for 200 West Area**

200 Area Location	Reference	Annual Probability			
		1 in 500	1 in 1,000	1 in 5,000	1 in 10,000
West	Woodward-Clydea	-	0.073 g	0.19 g	0.26 g
	Geomatrixb	0.10 g	0.14 g	0.30 g	0.39 g

**Sources:** a. WHC, 1989

b. WHC, 1993

**Note:** g = gravity = acceleration rate of 9.8 m/sec<sup>2</sup> (32 ft/sec<sup>2</sup>)

Geomatrix and Woodward-Clyde Consultants report similar horizontal peak ground acceleration values for the 200 West Area, but the differences in peak ground acceleration values reported by both references for a particular annual probability vary between factors of approximately 1.5 to 1.9. The Geomatrix peak ground acceleration values are larger than the Woodward-Clyde Consultants values because Geomatrix computed mean values and Woodward-Clyde Consultants computed median values. Also, the seismic activity

inherent in the Geomatrix seismic source model was greater than that in the Woodward-Clyde Consultants model. Similar peak horizontal accelerations were reported by Coats and Murray. However, slight differences in acceleration for a particular annual probability (beyond 5,000 years) are reported by Coats and Murray. For example, Coats and Murray's best estimate curve indicates a 0.18 gravity event every 5,000 years, a 0.2 gravity event (design basis Earthquake) every 10,000 years and a 0.25 gravity event every 25,000 years compared to higher return frequencies for a particular event as shown in Table 4-1. However, the range of accelerations associated with the curves on either side of the best estimate overlap values reported in Table 4-1. Coats and Murray show a range of acceleration (0.15 gravity to 0.28 gravity) for a return period of 10,000 years. These values overlap values shown in Table 4-1 associated with return periods of 5,000 years and 10,000 years (Coats and Murray, 1984).

Three major structures of the Yakima Fold Belt are found within the Hanford Site: 1) the Umtanum Ridge-Gable Mountain Structure, 2) the Yakima Ridge Structure, and 3) the Rattlesnake Hills Structure (Figure 4-3). Each is composed of an asymmetrical anticline oversteepened to the north, with associated faults along their flanks.

Known faults within the Hanford Site include strike-slip faults as long as 3 km (1.9 mi) on Gable Mountain and the Rattlesnake-Wallula alignment. The faults in Central Gable Mountain are considered Nuclear Regulatory Commission capable by Nuclear Regulatory Commission criteria (10 CFR 100, Appendix A) in that they have slightly displaced the Hanford formation gravels within the last 35,000 years, but their relatively short lengths give them low seismic potential. No seismicity has been observed on or near Gable Mountain. The Rattlesnake-Wallula alignment is interpreted as possibly being "Nuclear Regulatory Commission capable," in part because of the lack of any distinct evidence to the contrary and because this structure continues along the northwest trend of faults that appear active at Wallula Gap, 56 km (35 mi) southeast of the central part of the Hanford Site (WHC, 1993). ("Nuclear Regulatory Commission capable" is defined as fault movement at or near the ground within the last 35,000 years or movement of a recurring nature within the last 500,000 years.)

The location of the 1936 Milton-Freewater Earthquake and its association with the Rattlesnake-Wallula alignment or a known geologic structure is uncertain. This seismic event occurred approximately 50 km (30 mi) southeast of the Wallula Gap and may be associated with the Hite Fault system, the Rattlesnake-Wallula alignment, or an unmapped fault (WHC, 1993).

#### **4.1.3 Soil**

The surface and near-surface Soil in the 200 West Area consist of Rupert Sand and Burbank Loamy Sand. An additional Soil unit, Hezel Sand, is also present on the western boundary of the 200 West Area (PNL, 1995a).

Prime or unique farmland Soils on the Hanford Site have not been mapped to date.

[Figure 4-3. Major Structural Features, Hanford Site and Vicinity.](#)

## **4.2 WATER RESOURCES AND HYDROLOGY**

The Water Resources and Hydrology section presents existing information on the baseline conditions for Surface Water, the Vadose Zone, and Groundwater at the Hanford Site. Each of these hydrological regimes may be affected by the alternatives and each regime would be affected differently. Subsection 4.2.1 describes the Surface watersurface water at the Site. Subsection 4.2.2 characterizes the Site Vadose Zonevadose zone. Subsection 4.2.3 describes the Groundwater at the Site.

### **4.2.1 Surface Water**

There is one naturally occurring lake on the Hanford Site, Westlake, which is located approximately 8 km (5 mi) northeast of the 200 West Area, as shown in Figure 4-4. The lake is situated in a topographically low-lying area and is sustained by Groundwater inflow resulting from intersection with the Groundwater table. Seasonal water table fluctuations are not large.

Two ephemeral creeks, Cold Creek and its tributary Dry Creek, traverse the uplands of the Hanford Site southwest and south of the 200 West Area. The confluence of the two creeks is 5 km (3 mi) southwest of the 200 West Area. Surface runoff from the uplands in and west of the Hanford Site is small. In most years, measurable flow occurs only during brief periods and in only two places, upper Cold Creek Valley and upper Dry Creek Valley.

The Columbia River is downgradient from the PFP Facility, lying nearly 11 km (7 mi) north of the 200 West Area (Figure 4-4). The river forms part of the eastern boundary of the Hanford Site and comprises the base level and receiving water for Groundwater and Surface Water in the region.

Natural Floodsflooding on the Columbia River would be restricted to the immediate Floodsfloodplain of the river. Failure of the upstream dams due either to natural causes or sabotage would not likely affect the PFP Facility (PNL, 1995a).

There are no Floodsfloodplains in the 200 West Area. Floods in Cold and Dry Creeks have occurred historically. However, there have not been any Floodsflood events or evidence of Floods in these creeks reaching the highlands of the 200 West Area before infiltrating into pervious sediments of Cold Creek Valley (GSP, 1972).

Water quality in the ephemeral creeks is not known to be affected by Hanford Site activities. The state of Washington has classified the stretch of the Columbia River from Grand Coulee to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent. Class A waters are suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat. State and federal drinking water standards apply to the Columbia River and are currently being met (PNL, 1995a).

#### **4.2.2 Vadose Zone**

The Vadose Zone extends from the ground surface to the top of the Groundwater. Vadose Zone characteristics determine the rate, extent, and direction of liquid flow downward from the surface.

#### **[Figure 4-4. Hydrological Features on the Hanford Site](#)**

Recharge to the unconfined aquifer is primarily from artificial sources. The principal source of artificial recharge was from Waste managementwaste management units located in the 200 West and 200 East Areas (see Figure 4-4). However, all liquid discharges to these waste units have ceased.

Natural recharge occurs chiefly from precipitation since there are no natural Surface Water bodies in the 200 West Area. Average annual precipitation in the 200 West Area is approximately 16 cm (6.3 in). Estimates of evapotranspiration from precipitation range from 38 to 99 percent (PNL, 1987).

The total natural recharge in the 200 West Area is estimated to be approximately 129 million l (34 million gal) per year (DOE, 1993b). These natural recharge values are significantly lower by an order of magnitude than volumes disposed of by artificial sources.

In areas where artificial recharge is occurring from ponds and trenches, Soils are likely to be close to saturation and could not hold significant amounts of additional liquid. In addition, Groundwater mounds have developed beneath these recharge areas. Drier Soils in other areas of the 200 West Area where artificial recharge is not occurring have a large moisture holding capacity. Perched water was reported between 30 and 35 m (97 and 115 ft) below ground surface (DOE, 1993b).

#### **4.2.3 Groundwater**

Groundwater generally occurs under confined conditions within sedimentary interbeds associated with the basalt sequence and under unconfined conditions within the overlying sedimentary section (uppermost aquifer).

Across the 200 West Area, the regional Groundwater flow is toward the north, east, and southeast. Groundwater discharge occurs locally in Westlake. Regional Groundwater discharge occurs along the course of the Columbia River, which is nearly 11 km (7 mi) north of the 200 West Area.

Generally, Groundwater within the Ringold Formation in the 200 West Area occurs under unconfined conditions and is located approximately 70 m (230 ft) beneath the PFP Facility (DOE, 1993b).

Groundwater has been contaminated by both radionuclide and nonradionuclide contaminants in the 200 West Area. Remedial strategies for the Site have been developed or are being developed to contain and remediate the contaminants and prevent their migration offsite. Vertical migration of contaminants to the deeper confined aquifer systems beneath the Site has not been determined since vertical gradients are poorly defined. In general, downward vertical gradients exist between the unconfined and deeper confined aquifers across the 200 West Area (DOE, 1993b).

Fourteen overlapping contaminant plumes are located within the unconfined gravels in the 200 West Area: Tc-99, uranium, nitrate, carbon tetrachloride, chloroform, trichloroethylene, I-129, gross alpha, gross beta, arsenic, chromium, Fluoridesfluoride, tritium, and plutonium (DOE, 1994a). Five of these plumes (carbon tetrachloride, chloroform, nitrate, trichloroethylene, and plutonium) impinge upon or encompass the ground below the PFP Facility.

Groundwater is not used in the 200 West Area. Water for drinking and emergency use and PFP Facility process water comes from the Columbia River. Regionally, Groundwater is used for irrigation and domestic water supply. On the Hanford Site, the nearest water supply wells are located at the Yakima Barricade approximately 5 km (3.1 mi) west of the 200 West Area (DOE, 1993b).

Hydraulic conductivities measured in the 200 West Area range from approximately 0.02 to 61 m/day (0.06 to 200 ft/day) (DOE, 1994a).

Transmissivities of Ringold Unit E in the vicinity of the PFP Facility range from 0.015 m<sup>2</sup>/sec (14,000 square feet per day [ft<sup>2</sup>/day]) in Well 299-W15-18 situated approximately 76 m (250 ft) west of the PFP Facility to 0.005 m<sup>2</sup>/sec (5,000 ft<sup>2</sup>/day) in Well 299-W15-16 located approximately 79 m (260 ft) northwest of the PFP Facility. Hydraulic conductivities in the same wells ranged from 0.49 to 0.42 cm/sec (1,400 to 1,200 ft/day), respectively (DOE, 1993b).

## 4.3 PHYSICAL ENVIRONMENT

The physical environment section presents existing information on the Meteorologymeteorology, climatology, Air qualityair quality, Radiation, and Noise/Sound levelsnoise and sound levels at the Hanford Site. Subsection 4.3.1 describes the Meteorologymeteorology of the Site and Subsection 4.3.2 describes Site Air qualityair quality. Subsection 4.3.3 characterizes Radiation levels at the Hanford Site. Subsection 4.3.4 presents the existing data on Noise/Sound levelsnoise and sound levels.

### 4.3.1 Meteorology

The Hanford Site is located in a semiarid region of southeastern Washington State. The Cascade Mountains, beyond Yakima to the west, greatly influence the Hanford area climate by means of their "rain shadow" effect. This mountain range also serves as a source of cold air drainage, which has a considerable effect on the wind regime on the Hanford Site (PNL, 1995a).

Climatological data are available for the Hanford Meteorological Station, which is located between the 200 East and West Areas. Data have been collected at this location since 1945, and a summary of these data through 1993 has been published by Hoitink and Burk (1994). Temperature and precipitation data are also available from nearby locations for 1912 through 1943. Data from the Hanford Meteorological Station are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau (PNL, 1995a).

In addition to the Hanford Meteorological Station, there are 24 instrumented 9.1-m (29.9-ft) towers distributed on and near the Hanford Site and three 60-m (200-ft) towers located at the 300, 400, and 100-N Areas. These provide supplementary data for defining wind patterns (PNL, 1995a).

Figure 4-5 shows that prevailing wind directions on the 200 Area Plateau are from the northwest. Secondary maxima occur for southwesterly winds. The point of each rose represents the directions from which the winds come. The larger the bar, the higher the frequency of wind. Summaries of wind direction indicate that winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow (PNL, 1995a).

Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km/hr (6 to 7 mi/hr), and highest during the summer, averaging 14 to 16 km/hr (8 to 10 mi/hr). Wind speeds that are well above average are usually associated with southwesterly winds. However, the summertime drainage winds are generally northwesterly and occasionally reach 50 km/hr (30 mi/hr). These winds are most prevalent over the northern portion of the Hanford Site (PNL, 1995a).

Ranges of daily maximum temperatures at the Hanford Meteorological Station vary from a normal maxima of 2·C (36·F) in late December and early January to 35·C (95·F) in late July (PNL, 1995a).

The annual average relative humidity at the Hanford Meteorological Station is 54 percent. It is highest during the winter months, averaging about 75 percent, and lowest during the summer, averaging about 35 percent (PNL, 1995a).

Average annual precipitation at the Hanford Meteorological Station is 16 cm (6.3 in). Most precipitation occurs during the winter, with more than half of the annual amount occurring in the months of November through February. Days with greater than 1.3 cm (0.5 in) precipitation occur less than 1 percent of the year. Monthly average snowfall ranges from 0.8 cm (0.3 in) in October to 14.5 cm (6 in) in December. Snowfall accounts for about 38 percent of all precipitation in December through February (PNL, 1995a).

Fog has been recorded during every month of the year at the Hanford Meteorological Station. However, 95 percent of the occurrences are in November through February, with less than 1 percent in April through September. There are 46 days of fog (visibility less than or equal to 9.6 km [6 mi]) of which 24 are dense fog days (visibility less than or equal to 0.4 km [0.25 mi]) (PNL, 1995a).

Phenomena other than fog that restrict visibility to less than or equal to 9.6 km (6 mi) include dust, blowing dust, and smoke from field burning. There are few such days. An average of five days per year have dust or blowing dust and less than one day per year has agricultural smoke (PNL, 1995a).

High winds are associated with thunderstorms. The average occurrence of thunderstorms is 10 per year. They are most frequent during the summer. However, they have occurred in every month (PNL, 1995a). Thunderstorms are not responsible for the highest velocity wind gusts.

From the period 1945 through 1993, the peak monthly wind gusts at the Hanford Site have ranged from 100 to 130 km/hr (63 to 80 mi/hr) and have generally originated from the southwest/south-southwest (Hoitink and Burk, 1994).

Tornadoes are infrequent and generally small in strength in the northwest portion of the United States. No violent tornadoes have been recorded for the region surrounding the Hanford Site through 1984. The estimated annual probability of a tornado striking a point at the Hanford Site is  $9.6 \times 10^{-6}$  (PNL, 1995a).

**Source:** PNL, 1995a

[Figure 4-5. Wind Direction for the Hanford Site, 1979 - 1994](#)

#### 4.3.2 Air Quality

Atmospheric dispersion is a function of wind speed, duration, and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist about 57 percent of the time during the summer. Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter when moderately to extremely stable stratification exists about 66 percent of the time. Less favorable conditions also occur periodically for surface and low-level releases in all seasons from about sunset to about an hour after sunrise as a result of ground-based temperature inversions and shallow mixing layers. Mixing-layer thicknesses have been estimated at the Hanford Meteorological Station using remote sensors. These variations in mixing layers are summarized in Table 4-2 (PNL, 1995a).

**Table 4-2 Percent Frequency of Mixing-layer Thickness by Season and Time of Day**

Atmospheric Mixing Layer (m)	Winter (%)		Summer (%)	
	Night	Day	Night	Day
Less than 250	65.7	35.0	48.5	1.2
250-500	24.7	39.8	37.1	9.0
Greater than 500	9.6	25.2	14.4	89.9

**Source:** PNL, 1995a

Occasionally, there are extended periods of poor dispersion conditions associated with stagnant air in stationary high-pressure systems that occur primarily during the winter months. The probability of poor dispersion conditions (inversion periods) extending more than 12 hours varies from a low of about 10 percent in May and June to a high of about 64 percent in September and October (PNL, 1995a).

National Ambient Air quality standardAir Quality Standards have been set by Environmental Protection Agency (EPA), as mandated in the 1970 Clean Air Act. Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access. The standards define levels of Air qualityair quality that are necessary, with an adequate margin of safety, to protect the Publicpublic health (primary standards) and the public welfare (secondary standards). Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, fine Particulate matterparticulate matter (PM10), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods from one hour to one year, depending on the pollutant (PNL, 1995a).

The EPA has established the Prevention of Significant Deterioration process to ensure that new or expanded major sources do not cause Air qualityair quality to significantly deteriorate in areas that currently meet standards. Annual emission rate increase levels have been set for criteria pollutants that trigger other impact considerations (PNL, 1995a). The "Significant Emission Rates" are listed in Table 4-3. The Hanford Plutonium Uranium Extraction Facility (PUREX) and Uranium Oxide Plants operated in the past under a Prevention of Significant Deterioration permit issued by the EPA in 1980. The Washington State Department of Ecology (Ecology) now administers the Prevention of Significant Deterioration program in the state.

**Table 4-3 Emissions Rates for Prevention of Significant Deterioration**

Regulated Criteria Pollutant	Prevention of Significant Deterioration Rate
	(tons/yr)
Carbon Monoxide	100
Nitrogen Oxides	40
Sulfur Dioxide	40
Particulate matterParticulate Matter	25
Fine Particulate matterParticulate Matter	15
Volatile Organic Compounds	40
Lead	0.6

**Source:** Chapter 173-400 Washington Administrative Code (WAC)

Ambient air measurements are compared with the National Ambient Air quality standardAir Quality Standards in air control regions across the nation to determine compliance. Those areas in which the criteria pollutant concentrations are equal to or less than the National Ambient Air quality standardAir Quality Standards are classified as "attainment" areas. Currently, the counties in which the Hanford Site is located (Adams, Benton, Franklin, and Grant) are classified as being in attainment for all criteria pollutants.

State and local governments can impose standards for ambient Air quality standardair quality that are stricter than the national standards. Washington State has established more stringent standards for sulfur dioxide and total suspended particulates (PM). Table 4-4 summarizes the relevant federal and state Air quality standardair quality standards (PNL, 1995a).

**Table 4-4 Federal and Washington State Ambient Air quality standardAir Quality Standards**

Pollutant	Federal		Washington State
	Primary	Secondary	



PM			
Annual geometric mean	a	a	60 mg/m <sup>3</sup>
24-hr average	a	a	150 mg/m <sup>3</sup>
PM10			
Annual arithmetic mean	50 mg/m <sup>3</sup>	50 mg/m <sup>3</sup>	50 mg/m <sup>3</sup>
24-hr average	150 mg/m <sup>3</sup>	150 mg/m <sup>3</sup>	150 mg/m <sup>3</sup>
Sulfur Dioxide			
Annual average	0.03 ppm	a	0.02 ppm
24-hr average	0.14 ppm	a	0.10 ppm
3-hr average	a	0.50 ppm	a
1-hr average	a	a	0.40 ppmb
Carbon Monoxide			
8-hr average	9 ppm	9 ppm	9 ppm
1-hr average	35 ppm	35 ppm	35 ppm
Ozonec			
1-hr average	0.12 ppm	0.12 ppm	0.12 ppm
Nitrogen Dioxide			
Annual average	0.05 ppm	0.05 ppm	0.05 ppm
Lead			
Quarterly average	1.5 mg/m <sup>3</sup>	1.5 mg/m <sup>3</sup>	1.5 mg/m <sup>3</sup>

**Source:** PNL, 1995a

**Notes:** a. No standard

b. 0.25 parts per million (ppm) not to be exceeded more than two times in any seven consecutive days

c. Not to be exceeded more than one day per calendar year

The EPA and Ecology have adopted Federal Washington Stateregulations to limit Air emissionsair emissions in order to meet the ambient Air quality standardair quality standards. Additionally, the Benton County Clean Air Authority has adopted emission Washington Stateregulations to supplement federal and state rules. Emission inventories for permitted pollution sources in Benton County are routinely compiled by the Benton County Clean Air Authority.

Ecology has established emission standards for the criteria air pollutants and Acceptable Source Impact Levels for new toxic air pollutants.

Table 4-5 lists the annual emission rates for stationary sources within the Hanford Site that have been reported to Ecology by DOE for 1993 (PNL, 1995a).

#### **Table 4-5 Total Nonradioactive Constituents in Air emissionsAir Emissions Released During 1993**

<b>Constituent</b>	<b>Quantities (kg)</b>
PM	131,500
Particulate matterPM10	70,800
Sulfur Dioxide	701,300
Nitrogen Oxides	362,900
Carbon Monoxide	116,100
Volatile Organic Compounds	1,800

**Source:** PNL, 1995a

During 1994, ten air samples were collected on the Hanford Site and analyzed for halogenated alkanes and alkenes, benzene, and alkylbenzenes. These compounds are widely used by modern society and are widespread environmental contaminants. All measured organic compound concentrations except carbon tetrachloride were below the maximum allowable concentration and the Acceptable Source Impact Levels (PNL, 1995a).

Onsite monitoring of Particulate matterPM was discontinued in early 1988 when the Basalt Waste Isolation Project, for which those measurements were required, was concluded (PNL, 1995a).

The only offsite monitoring near the Hanford Site in 1993 was Particulate matterPM10 at Kennewick, Washington (approximately 40 km [25 mi] to the southeast), conducted by Ecology (PNL, 1995a). No exceedance of annual arithmetic mean was observed at this station (32  $\mu\text{g}/\text{m}^3$  [ $1.9 \times 10^{-9}$  lb/ft<sup>3</sup>]). However, the 24-hr maximum ( $>150 \mu\text{g}/\text{m}^3$  [ $9.3 \times 10^{-9}$  lb/ft<sup>3</sup>]) was exceeded twice (maximum concentration 1,166  $\mu\text{g}/\text{m}^3$  [ $7.3 \times 10^{-8}$  lb/ft<sup>3</sup>]). Particulate matterPM monitoring at the Tri-Cities locations was discontinued in early 1989. Offsite monitoring by Ecology at two locations, Sunnyside (approximately 32 km [20 mi] to the southwest) and Wallula (approximately 60 km [40 mi] to the southeast), occurred during 1990. The annual geometric means of Particulate matterPM measurements at Sunnyside and Wallula for 1990 were 71 mg/m<sup>3</sup> and 80 mg/m<sup>3</sup> ( $4.4 \times 10^{-9}$  lb/ft<sup>3</sup> and  $5.0 \times 10^{-9}$  lb/ft<sup>3</sup>), respectively. Both values exceeded the Washington State annual standard of 60 mg/m<sup>3</sup> ( $3.7 \times 10^{-9}$  lb/ft<sup>3</sup>). The Washington State 24-hour standard of 150 mg/m<sup>3</sup> ( $9.3 \times 10^{-9}$  lb/ft<sup>3</sup>) was exceeded six times during the year at Sunnyside and seven times at Wallula (PNL, 1995a).

During the past 10 years, Particulate matterPM, carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of the Hanford Site. These ambient urban measurements are typically used to estimate the maximum background pollutant concentrations for the Hanford Site because of the lack of specific onsite monitoring (PNL, 1995a). Maximum measured background concentrations for those pollutants, as measured in the late 1980s, are given in Table 4-6 (PNL, 1991).

**Table 4-6 Maximum Measured Background Concentrations of Air Pollutants at or Near the Hanford Site**

<b>Pollutant</b>	<b>Maximum Background Concentration (<math>\mu\text{g}/\text{m}^3</math>)</b>
Nitrogen Dioxide	
Annual Arithmetic Mean	36
Sulfur Dioxide	
Annual Arithmetic Mean	0.5
24-hr Maximum	6

3-hr Maximum	20
1-hr Maximum	49
1-hr Maximum	49
Carbon Monoxide	
8-hr Maximum	6,500
1-hr Maximum	11,800
PM	
Annual Geometric Mean	56
24-hr Maximum	356

**Source:**PNL, 1991

**Note:** The 1987 measurements for Particulate matterPM<sub>10</sub> yielded an annual geometric mean of 27 µg/m<sup>3</sup> and a maximum daily concentration of 81 µg/m<sup>3</sup>.

Particulate matterPM concentrations can reach relatively high levels in eastern Washington because of exceptional natural events (such as dust storms and large brushfires) that occur in the region. Washington State ambient Air quality standardair quality standards do not differentiate "rural fugitive dust" from exceptional natural events when estimating the maximum background concentrations of particulates in the area east of the Cascade Mountain crest. The rural fugitive dust component of background concentrations has in the past been exempted by the EPA when considering permit applications and enforcement of Air quality standardair quality standards.

EPA has evaluated the prospect of designating the Tri-Cities area as non-attainment for Particulate matterPM due to wind-blown dust (PNL, 1995a). EPA has agreed to defer designating the Tri-Cities area, south of the Hanford Site, as a non-attainment area for Particulate matterPM. A Memorandum of Agreement has been signed by the EPA, Ecology, and the Benton County Clean Air Authority to characterize sources, develop a dust control FederalWashington Stateregulation, and do outreach to encourage dust controls on agricultural land (Ecology, 1994).

#### 4.3.3 Radiation

Many of the activities at the Hanford Site that formerly resulted in releases of Radiation to the environment no longer occur, since the Hanford Site mission has changed from production of plutonium for national defense to environmental restoration. Current levels of radioactivity in environmental media within and in the vicinity of the Hanford Site reflect contributions from naturally occurring radioactivity, fallout from manmade sources (such as past weapons tests and the Chernobyl Accidentaccident), and emissions from Hanford Site facilities.

The 200 Areas contain inactive facilities for nuclear fuel chemical separations, processing, waste handling and Disposal, and steam generation using fossil fuels. All of these facilities are potential sources of emissions. Major potential sources of emissions in the 200 West Area are the PFP Facility, T Plant, and the 222-S Analytical Laboratory. Other sources include the 200 Area Tank Farms200 Area Tank Farms, underground Storage tanks, and inactive waste evaporators.

The following types of monitoring are performed to detect and distinguish the source of radioactivity in the environment (PNL, 1994):

- Facility Effluents/Waste generationeffluent monitoring determines the flow rate of Effluents/Waste generationeffluents being released and when radioactivity levels might exceed specified threshold levels. This monitoring also determines gross alpha and beta activity released and, when appropriate, the activity of specific radionuclides. This information can be used in environmental transport models to predict concentrations of radioactive materials in environmental media.
- Monitoring is conducted near major emissions sources such as the PUREX Plant. Air, Surface Water and springs, external Radiation, Soil, and vegetation are monitored.
- Environmental monitoring is conducted at and beyond the Hanford Site boundary. Air, Surface Water, Groundwater, external

Radiation, Soil, vegetation, wildlife, and food and farm products are included in offsite environmental monitoring. The monitoring program includes sampling locations remote to the Hanford Site that can be used to distinguish between radioactivity from the Site and from other sources.

Sr-90, Cs-137, Pu-239, Pu-240, and uranium were consistently detected in samples collected in the 200 Areas. Concentrations in air samples over the past five years show a general downward trend for most radionuclides due to facility shutdowns, better Effluents/Waste generation/effluent controls, and improved Waste management/waste management practices (PNL, 1995b).

Concentrations in Surface Water, aquatic vegetation, and sediment samples from ditches and ponds were below applicable derived concentration guideline values and in many cases below the limits of detection. Maximum measured values are summarized in Table 4-7 (PNL, 1995b).

**Table 4-7 Maximum Radionuclide Concentrations for 200 Area Surface water in 1994**

Parameter	Concentration			
	Surface Water (pCi/l) <sup>a</sup>	Derived Concentration Values (pCi/l)	Aquatic Vegetation (pCi/g)	Sediment (pCi/g)
Gross Alpha	3.3	30 <sup>b</sup>	d	d
Gross Beta	228	1,000 <sup>c</sup>	d	d
Tritium	1.1 x 10 <sup>5</sup>	2.0 x 10 <sup>6</sup>	d	d
<sup>90</sup> Sr	12.1	1,000	1.5	4.5
<sup>137</sup> Cs	192	3,000	2.4	7.0
<sup>239,240</sup> Pu	d	d	3.5	2.0
Uranium (g/g) <sup>e</sup>	d	d	4.5 x 10 <sup>-8</sup>	7.9 x 10 <sup>-7</sup>

**Source:** PNL, 1995b

**Notes:**a. Picocuries (pCi) per liter

b. Using Pu-239 Derived Concentration Guide for comparison

c. Using Sr-90 Derived Concentration Guide for comparison

d. No data available

e. Grams of uranium per gram of material

Radionuclide concentrations in Soil and vegetation samples from the 200 Areas showed trends similar to those observed for air. Concentrations of Sr-90, Cs-137, Pu-239, and Pu-240 showed a consistent downward trend. Radiological surveys are conducted in areas known or suspected to contain surface or subsurface contamination. Areas exceeding specified levels are posted as radiologically controlled areas. Because the 200 Areas contain many small areas where radiological work is performed and radioactive material is present, the entire 200 East and West Areas have been designated as radiologically controlled areas (DOE, 1996).

Locations at and beyond the Hanford Site boundary were monitored during 1994 (PNL, 1995b). Sample types included air, spring water, Columbia River water and sediments, irrigation water, drinking water, ponds, foodstuffs, wildlife, Soils, vegetation, and direct Radiation. Results for springs discharging into the Columbia River and river water and sediments indicated contributions of radioactivity originating from the Hanford Site. Results for air and vegetation were generally consistent with natural sources for

radioactivity and fallout. For Soil and foodstuffs except milk, there was no difference between locations upwind and downwind of the Hanford Site, suggesting no contribution from Hanford facilities. Slightly elevated levels of I-129 in milk appear to be due to emissions from the Site. Columbia River water and sediment, and springs along the river continue to show detectable levels of radioactivity that originated from the Hanford Site.

Doses to members of the Public for emissions from the Hanford Site are evaluated annually in two documents. The *Hanford Site Environmental Report for Calendar Year 1994* evaluated the dose to the hypothetical Maximally Exposed Individual (MEI) maximally exposed offsite individual and to the general population within 80 km (50 mi) of the Site for air and water exposure pathways. This report is prepared to meet DOE reporting requirements and evaluates the contribution of the 100, 200, 300, and 400 Areas to offsite dose using the GENII computer modeling program (PNL, 1995b). The *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 1992* (DOE, 1993c) evaluated the dose to the hypothetical Maximally Exposed Individual (MEI) maximally exposed offsite individual using the CAP-88 computer modeling program (DOE, 1992) and to the general population within 80 km (50 mi) using the GENII program. This report is prepared to meet EPA reporting requirements under Appendix H, 40 CFR 61.

The doses reported in these two reports for the Maximally Exposed Individual (MEI) maximally exposed offsite individual are summarized in Table 4-8. The Air emissions and water Effluents/Waste generation effluents from the 200 Areas accounted for most of the dose to the Public as the result of Hanford Site operations. These doses are well below the DOE limit of 100 millirem (mrem) per year for members of the general Public, the state of Washington dose limit of 100 mrem per year for the general Public in WAC 246-221-060, and the EPA criterion of 10 mrem per year for Air emissions in 40 CFR 61.92. (The DOE limit of 100 mrem per year includes all pathways, including direct exposures from DOE activities.) There is also agreement between the two reports for the dose via the air pathways. The population dose for the 200 Areas was 0.26 person-rem through air pathways and 0.30 person-rem through water pathways. The population dose for the entire Site was 0.33 person-rem through air pathways and 0.30 person-rem through water pathways (PNL, 1995b).

#### 4.3.4 Noise and Sound Levels

The frequency of sound waves is measured in hertz, and the pressure that sound waves produce is measured in decibels (dB). For regulatory purposes, Noise/Sound levels for perceptible frequencies are weighted to provide an A-weighted Noise/Sound level (dBA) that correlates highly with the frequency response curve of the human ear.

Noise/Sound levels are often reported as the equivalent Noise/Sound level (Leq). The Leq is expressed in dBA over a specified period of time, usually one or 24 hours. The Leq expresses time-varying Noise/Sound levels by averaging Noise/Sound levels over time.

Information studies at the Hanford Site of the propagation of Noise/Sound levels have been concerned primarily with occupational Noise/Sound levels at work sites. Environmental Noise/Sound levels have not been extensively evaluated because of the remoteness of most Hanford Site activities and isolation from receptors that are covered by federal or state statutes. This discussion focuses on the few environmental Noise/Sound levels data that are available.

**Table 4-8 Dose to Hypothetical Maximally Exposed Individual (MEI) Offsite Individual From Hanford Site Operations During 1994**

Effluents/Waste	Pathway	Environmental Report		Air Emissions
		200 Areas (mrem)	All Sources (mrem)	All Sources (mrem)
Air	External	2.8 x 10 <sup>-6</sup>	1.3 x 10 <sup>-4</sup>	a
	Inhalation	6.4 x 10 <sup>-4</sup>	1.0 x 10 <sup>-2</sup>	a
	Foods	1.5 x 10 <sup>-3</sup>	1.5 x 10 <sup>-3</sup>	a
	Subtotal	2.1 x 10 <sup>-3</sup>	1.2 x 10 <sup>-2</sup>	5.0 x 10 <sup>-5</sup>
Water	Recreation	2.0 x 10 <sup>-4</sup>	2.0 x 10 <sup>-4</sup>	a

	Foods	1.4 x 10 <sup>-2</sup>	1.4 x 10 <sup>-2</sup>	a
	Fish	1.7 x 10 <sup>-2</sup>	1.7 x 10 <sup>-2</sup>	a
	Drinking Water	6.7 x 10 <sup>-3</sup>	6.7 x 10 <sup>-3</sup>	a
	Subtotal	3.8 x 10 <sup>-2</sup>	3.9 x 10 <sup>-2</sup>	a
	Total	4.0 x 10 <sup>-2</sup>	5.1 x 10 <sup>-2</sup>	a

**Sources:** PNL, 1995b; DOE, 1995a

**Note:** a. No data available

Site characterization studies performed in 1987 included measurement of background environmental Noise/Sound levels. Noise levels are expressed as Leq for 24 hours (Leq-24). Wind was identified as the primary contributor to background Noise/Sound levels, and winds exceeding 19 km/hr (12 mi/hr) significantly affected Noise/Sound levels. Background Noise/Sound levels in undeveloped areas at the Hanford Site can best be described as a mean Leq-24 of 24 to 36 dBA. Periods of high wind, which normally occur in the spring, would elevate background Noise/Sound levels (PNL, 1995a).

To collect Skagit/Hanford data, preconstruction measurements of environmental Noise/Sound levels were taken in June 1981 on the Hanford Site. Fifteen sites were monitored, and Noise/Sound levels ranged from 30 to 60.5 dBA (Leq). The values for isolated areas ranged from 30 to 38.8 dBA. Measurements taken around the sites where the Washington Public Power Supply System was constructing nuclear power plants ranged from 50.6 to 64 dBA. Measurements taken along the Columbia River near the intake structures for Washington Public Power Supply System Nuclear Plant 2 were 47.7 and 52.1 dBA compared to more remote river Noise/Sound levels of 45.9 dBA measured about 5 km (3 mi) upstream from the intake structures. Noise/Sound levels in North Richland (300 Area at Horn Rapids Road and the by-pass highway) were 60.5 dBA (PNL, 1995a).

## 4.4 Ecosystems

The existing ecosystems in the vicinity of the 200 West Area are characterized according to vegetation, wildlife, and Threatened or Endangered species. These elements are discussed below.

Only about 6 percent of the Hanford Site surface area has been disturbed and used for the production of nuclear materials, waste Storage, and waste Disposal. The remainder of the area is undeveloped, including natural areas and abandoned agricultural lands that remain undisturbed due to restricted public access (PNL, 1995a).

The 200 Area Plateau is dominated by mature sagebrush-steppe habitat with patches of disturbed or man-made habitat. The sagebrush-steppe habitat of the 200 Area plateau supports a wide variety of plants and animals typical of the Hanford Site.

### 4.4.1 Vegetation

The Hanford Site is located in a semiarid region that normally supports sagebrush scrub. The Site consists of large areas of undeveloped land, including abandoned agricultural areas, and widely-separated clusters of industrial buildings. The plant and animal species on the Hanford Site are representative of those inhabiting the shrub-steppe (sagebrush-grass) region of the northwestern United States. The Hanford Site encompasses 1,450 square kilometers (km<sup>2</sup>) (560 square miles [mi<sup>2</sup>]) of shrub-steppe habitat that is adapted to the region's mid-latitude semiarid climate (PNL, 1995a).

The vegetation of the 200 West Area is representative of the Hanford Site as a whole, with sagebrush/cheatgrass and Sandberg's bluegrass being the dominant communities (PNL, 1995a). The area within the perimeter fence of the PFP Facility is disturbed and a recent survey observed no plants in the vicinity (Brandt, 1995).

### 4.4.2 Wildlife

Pocket mice and jackrabbits are the primary small mammal species observed on the Site. Large mammals include deer and elk, although the elk occur almost exclusively on the Fitzner Eberhardt Arid Lands Ecology Reserve located on Rattlesnake Mountain. Coyotes and raptors are the primary predators.

The most common snakes are gopher snakes, yellow-bellied racers, and rattlesnakes. Toads and frogs are found along the Columbia River. Grasshoppers and various species of beetles are the most conspicuous insects in the community.

The horned lark and western meadowlark are the most abundant nesting birds in the local shrub-steppe community.

Within the perimeter fence of the PFP Facility, nests of several migratory birds, including the barn swallow, cliff swallow, and American robin, have been observed (Brandt, 1995).

#### 4.4.3 Threatened or Endangered Species

The 200 West Area and the PFP Facility were examined for threatened or endangered plant and animal species. Discussion of these examinations follows.

An ecological survey for the 200 West Area indicated that there are no federally-listed threatened or endangered plant species present, as specified by the Threatened or Endangered Species Federal Act of 1973 as amended (Brandt, 1994). The ecological review identified the presence of stalked-pod milkvetch (*Astragalus sclerocarpus*), a Class 3 state of Washington monitor plant species. This designation indicates it is either more common or less Threatened or Endangered species than previously believed and therefore is not a species of concern. This species is common throughout the Hanford Site.

The loggerhead shrike (*Lanius ludovicianus*) is classified as a federal and state candidate species. This designation indicates the species is under review for possible listing as a threatened or endangered species. Loggerhead shrikes nest in undisturbed sagebrush and bitterbrush habitats. The northern sagebrush lizard (*Aceloporus graciosus*), also a federal candidate species, is found in the mature sagebrush habitat. The Washington Department of Fish and Wildlife has designated shrub-steppe as a Priority Habitat, which is defined as a habitat providing unique or significant value to a wide variety of wildlife and often especially for species of concern. Designating habitat as priority represents a measure to help prevent species from becoming threatened or endangered.

The sage sparrow (*Amphispiza belli*) is a state candidate species. Habitat requirements for the sage sparrow are sagebrush and chaparral with scattered shrubs. Its breeding range includes central Washington and this species has been found to be nesting in moderate numbers within the 200 West Area.

The bald eagle (*Haliaeetus leucocephalus*), a federal and state threatened species, is a regular winter resident occurring principally along the Columbia River. The peregrine falcon (*Falco peregrinus*), a federal and state Threatened or Endangered Species species, is a casual migrant visitor to the area, but does not nest there. The state of Washington lists the sandhill crane (*Grus canadensis*) as Threatened or Endangered Species, and the ferruginous hawk (*Buteo regalis*), noted for nesting on area power poles, as Threatened or Endangered species. There are several species of animals that are under consideration for listing as Threatened or Endangered species.

An ecological survey of the PFP Facility indicated that there are no plant or animal species protected under the Threatened or Endangered Species Act, candidates for such protection, or species listed by the state of Washington for protection within the perimeter fence of the PFP Facility (Brandt, 1995).

## 4.5 POPULATION AND SOCIOECONOMICS

Hanford Site activity both directly and indirectly influences the socioeconomics of the Tri-Cities, as well as other areas in Benton and Franklin Counties. Since the Tri-Cities (Pasco, Kennewick, and Richland) are a market center for eastern Washington, the Hanford Site also influences, to a lesser degree, the socioeconomics of Grant and Yakima Counties.

For this analysis, three units of study have been defined:

- 1) Tri-Cities - Pasco, Kennewick, and Richland
- 2) Study Area - Benton and Franklin Counties

### 3) Region of Interest (Region) - Benton, Franklin, Grant, and Yakima Counties

Figure 4-6 presents the locations of the Hanford Site, Tri-Cities, Study Area, and Region.

Where possible, data are provided for both the Study Area and Region. In some cases, data are only available for the Tri-Cities.

According to December 1993 employee residence records, 98 percent of all Hanford Site employees reside in the Region, with 93 percent in the Study Area and 81 percent in the Tri-Cities (DOE, 1995b). In addition, more than 62 percent of Hanford's procurements (purchases of goods and services) are made in the Tri-Cities (Scott, 1995).

This section provides a description of the following socioeconomic characteristics:

- Economics
- Demographics
- Housing
- Local Infrastructure and Public Services
- Environmental Justice and Equity

#### 4.5.1 Economics

The following subsections summarize economic activity within the Study Area and the larger Region, including Employment, income sources, and fiscal characteristics.

Table 4-9 provides an economic summary, including information on the primary industries and unemployment rates for each of the counties within the Study Area and Region. Food processing is the primary industry in the Study Area, while food processing and agriculture are the primary industries within the larger Region. In 1990, the average unemployment rate was 6.5 percent for the Study Area and 7.75 percent for the Region.

[Figure 4-6. Socioeconomic Region of Influence for Hanford Site](#)

**Table 4-9 Economic Summary, 1990**

County	Primary Industries	Unemployment Rate (%)
Benton	Food Processing, Chemicals, Metal Products, Nuclear Products	6
Franklin	Food Processing, Publishing, Agriculture, Metal Fabrication	7
Study Area Average		6.5
Grant	Food Processing, Agriculture	8
Yakima	Agriculture, Food Processing, Wood Products, Manufacturing	10
Regional Average		7.75

Source: CENDATA, 1995

##### 4.5.1.1 Local Employment

There have been three major components driving the economy of the Tri-Cities since the early 1970s: 1) DOE and its major contractors, which operate the Hanford Site; 2) Washington Public Power Supply System, which constructed and operates a nuclear power plant; and 3) an export-oriented agricultural and food-processing community. In addition to the contribution these components make to the Tri-Cities economy in terms of Employment and payroll, they also support a significant number of jobs indirectly



through their procurement of equipment, supplies, and business services.

In addition to these major employers, tourism and income generated from retired former employees contribute substantially to the economic base of the Tri-Cities. Table 4-10 provides Employment and income figures for each of the major components of the Tri-Cities economy.

Overall Employment and the size of the available workforce in the Tri-Cities have been steadily increasing since 1988, as can be seen in Table 4-11. Between 1993 and 1994, Tri-Cities unemployment fell from 8 percent to just over 6 percent. Between 1994 and 1995 unemployment rose again to 8.0 percent, and in 1996, increased to an estimated 10 percent. During fiscal year 1994, there were nearly 3,700 Hanford-related job reductions and approximately 1,100 more were expected by October 1995 (Briggs, 1995). Other employers have been reducing their workforces as well, but these data have not been included in the analysis.

**Table 4-10 Tri-Cities Economic Base Information**

Component	Direct Employment	Income (\$ Million)
Hanford Site (DOE and Major Contractors)	18,400	740
Washington Public Power Supply System	1,700	84
Agriculture	9,500	97
Wage Employees <sup>a</sup>	6,300	N/A
Seasonal Wage Employees <sup>b</sup>	2,300	83
Proprietors <sup>b</sup>		
Other Major Employers	3,500	N/A
Tourism	2,300	25
Retirees	0	235

Source: DOE, 1995c

Notes:<sup>a</sup> 1993 figures

<sup>b</sup> 1992 figures

**Table 4-11 Tri-Cities Employment**

	1988	1989	1990	1991	1992	1993	1994	1995
Civilian Labor Force	68,400	72,400	79,600	81,000	86,000	90,800	97,700	93,978
Percent Unemployed	8.5	8.7	6.8	7.9	8.3	8.0	6.1	8.0

Source: Washington, 1995; Haws, 1996

Table 4-12 presents average Employment coefficients by industry for the Study Area and the larger Region. These coefficients give the number of additional jobs created for every \$1 million in additional output produced by each sector. Trade creates the largest number of jobs, followed by services and government.

As mentioned previously, more than 98 percent of all Hanford employees reside in the Region, 93 percent in the Study Area, and 81 percent in the Tri-Cities. Of those who live in the Tri-Cities, 52 percent of the employees live in Richland, 37 percent live in Kennewick, and 11 percent live in Pasco. Other cities in Benton and Franklin Counties, such as West Richland, Benton City, and Prosser, account for 12 percent of the employees (DOE, 1995b).

**Table 4-12 Average Employment Coefficients by Industry, 1991**

Industry	Study Area	Region
	Jobs per \$ Million Output	Jobs per \$ Million Output
Agriculture, Forestry, Fisheries	17	18
Mining	4	5
Construction	12	12
Manufacturing	5	6
Transportation, Commerce, Utilities	9	6
Trade	29	30
Finance, Insurance, Real Estate	9	8
Services	21	25
Government	20	18

**Source:**IMPLAN, 1991

Hanford and its contractors spent nearly \$167 million in procurements (32 percent of all Hanford procurements) in the Tri-Cities during fiscal year 1994. Of these Tri-Cities procurements, 63 percent came from Richland, 28 percent were from Pasco, and 9 percent came from Kennewick (Scott, 1995).

Hanford Employment accounted for 25 percent of non-agricultural Employment in the Study Area in 1994. Total payroll for the Hanford Site was approximately \$740 million in 1993, accounting for close to 45 percent of the total Study Area payroll dollars (DOE, 1995c).

The Hanford Site also supports the Study Area economy indirectly, specifically the service sector. Previous studies indicate that each Hanford Site-related job supports approximately 1.2 additional jobs in the Study Area service sector (about 2.2 total jobs) and approximately 1.5 additional jobs in the state's service sector (about 3.7 total jobs) (Scott, et al., 1987). In addition, each dollar of Hanford income supports about \$2.10 in total Study Area incomes and \$2.40 in total statewide incomes. As a result, the Hanford Site directly or indirectly accounts for more than 40 percent of all jobs in the Study Area.

#### 4.5.1.2 Income Sources

Median household income is defined as the level at which half of the households have income greater than the median and the other half have less. Per capita personal income is defined as all forms of income divided by population.

As shown in Table 4-13, median household incomes in the Tri-Cities have been steadily growing for all three cities. In 1994, Richland had the highest median household income of \$42,032, compared to \$36,141 for Kennewick and \$32,102 for Pasco.

**Table 4-13 Tri-Cities Median Household Income**

Year	Kennewick (\$)	Pasco (\$)	Richland (\$)
1987	24,309	25,812	31,372
1991	32,056	28,230	40,047
1994	36,141	32,102	42,032

Source: TRIDEC, 1995

Table 4-14 presents measures of income at the county level, including per capita personal and median income and percent of persons below poverty level. Of the four counties, Benton County has the highest, while Grant has the lowest per capita personal and median household incomes. Regarding percent below poverty level, Benton County has the lowest, with 11 percent below poverty level, while Franklin County has more than double that of Benton County, with 23 percent below poverty.

#### 4.5.1.3 Fiscal Characteristics

The following subsection summarizes the fiscal characteristics (government finance), including county level revenues and expenditures and city and county level assessed property values.

#### Revenues and Expenditures

Table 4-15 provides the percent contribution of revenue sources at the county level, based on 1993 and 1994 data. Total taxes and intergovernmental transfers are the largest revenue sources in all of the counties in the Region. Total taxes vary from 36 percent of total revenues in Franklin County to 43 percent in Benton and Yakima Counties. Intergovernmental transfers vary from 38 percent of total revenues in Yakima County to 44 percent in Franklin County. Table 4-16 shows the percent expenditures by category at the county level. The largest expenditures for the four counties are for general government, public safety, and Transportation.

**Table 4-14 Measures of Income**

Counties	Per Capita (\$)	Median Household (\$)	Persons Below Poverty <sup>a</sup> (%)
Benton <sup>b</sup>	20,122	40,288	11
Franklin <sup>b</sup>	15,620	28,317	23
Grant <sup>c</sup>	15,511	23,625	20
Yakima <sup>c</sup>	15,374	25,400	20

Sources: DOE, 1995c; DOE, 1994b; DOE, 1994c

Notes: a. 1989 Figures

b. 1990 Figures

c. 1992 Figures

**Table 4-15 Revenue Sources**

Counties	Total Taxes/ Special Assessments	License/ Permits	Inter- Government	Miscellaneous	Interest
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	(%)	(%)	(%)	(%)	(%)
Benton <sup>a</sup>	43	1	43	12	2
Franklin <sup>b</sup>	36	1	44	19	N/A
Grant <sup>c</sup>	40	1	42	12	5
Yakima <sup>d</sup>	43	1	38	18	N/A

**Sources:** a. Benton County Auditors Office

b. Franklin County Auditors Office

c. Grant County Auditors Office

d. Yakima County Auditors Office

**Table 4-16 County Expenditures by Category**

County	General Government (%)	Public Safety (%)	Health/Welfare (%)	Culture/Recreation (%)	Economic Environment (%)	Transportation (%)	Physical Environment (%)	Capital (%)	Debt Service (%)
Benton <sup>a</sup>	29	24	14	1	3	11	3	13	<1
Franklin <sup>b</sup>	28	20	<1	8	1	26	1	15	<1
Grant <sup>c</sup>	24	23	3	4	2	24	<1	19	<1
Yakima <sup>d</sup>	22	26	3	1	7	23	1	15	3

**Source:**a.Benton County Auditors Office

b. Franklin County Auditors Office

c. Grant County Auditors Office

d. Yakima County Auditors Office

#### Property Values

Assessed property values, as shown in Table 4-17, have been growing rapidly for all of the cities and counties. At the county level, assessed property values grew the most rapidly between the years 1992 and 1993 in Benton County, with a growth rate of 15.3 percent. For the same years at the city level, property values in the city of Richland grew the most rapidly at a rate of 23.85 percent. Between the years 1993 and 1994, Yakima County had the largest growth (18 percent) in property values of all of the counties, while Kennewick, with a growth rate of 18 percent, experienced the highest city growth rate.

**Table 4-17 Assessed Property Values**

County/City	1992 (\$ Million)	1993 (\$ Million)	1994 (\$ Million)
County			

Benton	3,319	3,827	4,323
Franklin	1,164	1,242	1,377
Grant	1,969	2,115	2,328
Yakima	4,650	4,918	5,811
City			
Kennewick	1,158	1,274	1,506
Pasco	382	423	453
Richland	1,015	1,256	1,335

**Source:** Washington, 1992

Average selling prices in the Tri-Cities area increased steadily between 1991 and 1994, but dropped substantially from \$119,000 to \$112,000 between 1994 and 1995. During the first three months of 1996, the average selling price was \$104,900. This reduction is viewed as being a sign of the local economy leveling off from the peak in activity in 1994. A major downturn in the housing market as a result of the recent workforce reductions has not been realized (Powers, 1995; Powers, 1996).

#### 4.5.2 Demographics

The following subsection summarizes population growth trends and projections, urban and rural population, and age and gender distribution of the population. Racial and ethnic characteristics are addressed in Subsection 4.5.5, Environmental Justice and Equity. Environmental Justice and Equity.

Table 4-18 summarizes population trends from 1940 to 1994 for the Region as well as population projections for 1995 to 2010. Population growth in the Region reflects the impacts of activities at the Hanford Site. The large growth between 1940 and 1950 reflects the creation of the Hanford Site. Growth between 1960 and 1990 represents growth at the Hanford Site and related supporting activities. As mentioned previously, the Regional economy is still highly dependent on Employment at the Hanford Site, as reflected in population growth trends. Although present projections show continued growth at the county level, these numbers may not reflect recent labor force reductions at the Hanford Site and in the Tri-Cities. These reductions could result in a slowing or reversal in population growth since the Employment base at the Hanford Site is unstable.

With respect to urban and rural distribution of the population, all of the counties in the Region, except for Grant County, are primarily urban, with more than 50 percent of their populations residing in urban areas. Benton is the most urban, with 87 percent of its population residing in urban areas, while Grant is the most rural, with 56 percent of its population residing in rural areas (DOE, 1994b).

All of the counties in the Region tend to have relatively young populations, below the state median age of 33. Franklin County's median age of 29 is the lowest among the counties, while Benton County has the highest with a median age of 32 (DOE, 1994b). With respect to gender, the populations of the state and each of the four counties are balanced (50 percent male and 50 percent female) (Office of Financial Management, 1993).

#### 4.5.3 Housing

This subsection provides information on relevant housing characteristics of the Region, including housing units by type, vacancy rates, housing sale information, and apartment vacancy rates. Table 4-19 presents data on total housing units, vacancy rates, and percent housing by type for the Region.

Of the four counties, Grant and Franklin Counties have the highest vacancy rates while Benton County has the lowest. For the Tri-Cities, Pasco has the highest vacancy rate, while Richland has the lowest. With respect to housing types, single family dwellings are the most common housing type, while mobile homes are the least common among all four counties and the Tri-Cities.

Table 4-20 presents information on trends in residential listings, sales, and average selling prices in the Tri-Cities. The average number of active residential listings has been growing every year since 1992. The average number of homes sold per month steadily increased between 1991 and 1994. This number dropped from 176 to 101 homes sold per month between 1994 and 1995. Since May 1995, residential listings have dropped to approximately 800, which is below what is typical for an area the size of the Tri-Cities (Powers, 1996).

Apartment vacancy rates have typically been low in the Tri-Cities, varying from a Tri-City average of less than 2 percent to just over 5 percent vacancy between late-1993 and early-1995. Between late-1993 and mid-1994, there was a steady decline in apartment vacancy rates in all of the Tri-Cities. During this time, the Tri-Cities average apartment vacancy rate fell from just under 2 percent to just over 1 percent. This trend reversed in late-1994, when the Tri-Cities average jumped to 4 percent. Vacancy rates in all of the Tri-Cities have been increasing since 1994 (TRIDEC, 1995). Within the last few years, 15 new apartment complexes were contracted to be built in the Tri-Cities to accommodate Employment growth at Hanford and within the Tri-Cities. However, this substantial expansion in available apartments,

**Table 4-18 Population Trends and Projections, 1940-2010**

Year	County				Tri-Cities			Total Tri-Cities
	Benton	Franklin	Grant	Yakima	Kennewick	Pasco	Richland	
1940	12,053	6,207	N/A	N/A	1,918	3,913	247	6,078
1950	51,370	13,563	N/A	N/A	10,106	9,228	21,809	41,143
1960	62,070	23,342	N/A	N/A	14,244	14,522	23,548	53,661
1970	67,540	25,816	N/A	N/A	15,212	13,920	26,290	56,529
1980	109,444	35,025	N/A	N/A	34,397	17,944	33,578	88,857
1990	112,560	37,473	54,798	18,823	42,152	20,337	32,315	98,769
1991	114,800	38,600	56,440	190,500	42,773	20,660	32,740	96,173
1992	118,500	39,200	58,240	193,900	44,490	20,840	35,550	98,880
1993	122,800	41,100	60,300	197,000	45,110	21,370	34,080	100,560
1994	127,000	42,900	62,220	202,100	46,960	22,170	35,430	104,560
1995a	121,328	41,336	58,026	199,578	N/A	N/A	N/A	N/A
2000a	128,752	44,630	60,518	207,870	N/A	N/A	N/A	N/A
2005a	136,892	48,213	62,983	216,245	N/A	N/A	N/A	N/A
2010a	145,452	52,388	65,508	226,067	N/A	N/A	N/A	N/A

Sources:DOE, 1994c; Office of Financial Management, 1994

Note:a.1993 Projections, Office of Financial Management, 1993

**Table 4-19 Housing Units, Vacancy Rates, and Housing Units by Type**

County/City	Total Units	Vacancy Rate (%)	Single Family (%)	Multiple Family (%)	Mobile Homes (%)

County					
Benton	44,877	5.9	63	24	13
Franklin	13,664	10.7	57	24	19
Grant	22,809	13.4	60	12	28
Yakima	70,852	6.9	70	16	14
City					
Richland	14,388	4.0	69	27	4
Pasco	7,846	8.0	47	38	13
Kennewick	18,110	5.0	54	33	11
Tri-Cities	40,344	6.0	58	32	9

Source:DOE, 1994b

Notes:a. 1990 Figures

b. 1993 Estimates

**Table 4-20 Tri-Cities Residential Listings, Sales, Average Selling Prices,**

	1991	1992	1993	1994	1995a
Active Residential Listings (average for year)	458	472	520	794	1,089
Average Sold Per Month	133	144	163	176	101
Average Selling Price Per Unit (\$ Thousands)	79	94	111	120	112

Source:Powers, 1995

Note:a. Annual Average as of May 1995

coupled with the unexpected reductions in the labor force at the Hanford Site and in the Tri-Cities, has resulted in a surplus in available apartment units and an associated increase in vacancy rates. Between June 1995 and April 1996, apartment vacancy rates increased dramatically in the Tri-Cities.

In Richland, rates increased from 10.3 to 19.8 percent. In Pasco, rates increased from 6.5 to 16.3 percent. In Kennewick, rates increased from 9.9 to 14.6 percent. By comparison, apartment vacancy rates in a healthy market average between 3 and 5 percent. In the future, it is expected that rents will decline but there will not be substantial increases in vacancies (Dukelow 1995; Dukelow, 1996).

#### 4.5.4 Local Infrastructure and Public Services

The following subsections summarize local infrastructure and public services, including information on education, health care, human

services, police, and fire protection. Information on local infrastructure and public services is only provided for the Tri-Cities and Study Area because Grant and Yakima Counties are beyond the local public service area.

#### **4.5.4.1 Education**

In the Study Area, primary and secondary education is served by the Richland, Kennewick, Pasco, and Kiona-Benton school districts. In 1994, the combined total spring enrollment was 31,970 students, an increase of 7.4 percent from 1993. For the same year, Richland was operating near capacity, Pasco and Kennewick were at capacity for primary education, Kennewick was over capacity for secondary, and Kiona-Benton was over capacity at both levels. Kennewick recently passed a \$43 million bond issue and is in the process of constructing a high school and middle school, as well as two elementary schools. While there has been some concern over whether these schools will be fully utilized, given the local Employment situation, student enrollment has not decreased and is considered stable (Ferguson, 1995).

The two post-secondary institutions in the Tri-Cities area are Columbia Basin College, with a 1994 fall enrollment of 6,800, and Washington State University Tri-City Branch, with an enrollment of 1,300 students.

#### **4.5.4.2 Health Care**

There are three major hospitals (Kadlec, Kennewick General, and Our Lady of Lourdes) and five minor emergency centers in the Tri-Cities. Combined, these hospitals had 346 available beds and about 15,000 annual admissions in 1994, 58 percent of which were Medicare or Medicaid patients.

All three hospitals offer general medical services as well as a 24-hr emergency room, basic surgical services, intensive care, and neonatal care. Our Lady of Lourdes Hospital in Pasco offers skilled nursing and rehabilitation and alcohol and chemical dependency services. In addition, Our Lady of Lourdes operates the Carondelet Psychiatric Care Center in Richland, a 32-bed psychiatric hospital which provides a significant amount of outpatient and home health services as well.

#### **4.5.4.3 Human Services**

A broad range of social services are available in the Tri-Cities. State human service offices include: a Job Services Office of the Employment Security Department, Food Stamp Offices, the Division of Developmental Disabilities, financial and medical assistance, the Child Protective Services, emergency medical service, a senior companion program, and vocational rehabilitation. Additionally, the local United Way incorporates 24 participating agencies and 48 programs, with a cumulative 1994 budget of \$21.1 million.

#### **4.5.4.4 Police and Fire Protection**

Police protection in the Study Area is provided by county sheriffs' departments, municipal police departments, and the Washington State Patrol Division headquartered in Kennewick.

At the city level, there was a combined Tri-Cities total of 266 commissioned officers, 114 reserve officers, and 129 patrol cars in February 1995 (DOE, 1995b).

Fire protection in the Tri-Cities is provided by three city fire departments and three additional rural fire districts. Together, there are 145 paid personnel and 181 volunteers.

A separate Hanford Fire Department, composed of 155 firefighters, is trained to dispose of hazardous waste and to fight chemical fires. The Hanford Fire Patrol owns five ambulances and maintains contact with local hospitals. The Hanford Fire Department is currently discussing with DOE, the city of Richland, and the maintenance and operations contractor the possibility of contracting with the city of Richland for Hanford's fire protection services.

### **4.5.5 Environmental Justice and Equity**

Executive Order 12898 dated February 11, 1994 (59 FR 7629), requires federal agencies to identify disproportionately high and adverse human Health effects/Radiation exposurehealth or environmental effects on minority or low-income populations, including Native Americans. To support the analysis of Environmental Justice and Equityenvironmental justice and equity impacts, this subsection presents a comparison of the socioeconomic baseline conditions for minority and low-income populations and the larger population of the Region. In general, the data indicate differences in both Demographicdemographic and economic



characteristics for these populations, and that those differences are consistent across the counties in the Region.

#### 4.5.5.1 Racial Composition of the Population

Several racial and ethnic groups are represented in the Region. The primary groups within the Region include Caucasian and Hispanic populations, but persons of Asian, Native American, Afro-American, and other descents are represented as well.

Franklin, Yakima, and Grant Counties typically have the largest Hispanic populations in the region. Of these, Franklin has had the largest concentration of Hispanics. Benton and Franklin Counties have tended to have the largest proportion of Asians (although these proportions have been relatively low). Yakima County has had the largest Native American population while Franklin County has had the largest Afro-American concentration (Office of Financial Management, 1994).

Percent population by race and Hispanic origin for the four counties is presented in Table 4-21. In summary, Benton County has the largest percentage of Caucasian (89 percent) and Asian (3 percent) residents, Franklin County has the largest concentration of Afro-Americans (3 percent), persons of other race (31 percent) and Hispanic origin (39 percent), while Yakima County has the largest proportion of Native Americans (5 percent).

**Table 4-21 Population by Race and Hispanic Origin**

County	Caucasiana (%)	Afro- Americana (%)	Native Americana (%)	Asiana (%)	Other Racea (%)	Hispanic Originb (%)
Benton	89	1	1	3	6	10
Franklin	62	3	1	2	31	39
Grant	81	1	1	1	15	22
Yakima	67	1	5	1	25	31

**Source:**Office of Financial Management, 1994

**Notes:**a.Percent totals by race may not add to 100 percent due to rounding.

b.Populations of Hispanic origin are classified separately from racial categories.

In the four-county Region, educational attainment for all races and people of Hispanic origin is highest in Benton County. In Benton County, the percentage of people who have attended at least some college is 68 percent for Afro-Americans, 64 percent for Asians, 57 percent for Caucasians, 53 percent for Native Americans, 22 percent for other races, and 35 percent for Hispanics. In the other three counties, the percentage of people with at least some college ranges from 43 to 44 percent for Caucasians, 34 to 42 percent for Afro-Americans, 33 to 40 percent for Native Americans, 19 to 44 percent for Asians, 10 to 14 percent for other races, 6 to 12 percent for Hispanics (CENDATA, 1995).

#### 4.5.5.2 Economics

Table 4-22 presents 1990 Unemployment data for the four counties. In general, unemployment rates are substantially higher for non-Caucasian populations. In Franklin County, average unemployment rates for Afro-Americans, Native Americans, and Asians were three or more times higher than the rates for

**Table 4-22 Unemployment/employment by Race and Hispanic Origin, 1990**

County	Caucasian (%)	Afro- American (%)	Native American (%)	Asian (%)	Other Race (%)	Hispanic Origin (%)
Benton	6	12	12	7	12	10
Franklin	6	22	21	18	13	13

Grant	6	17	24	9	16	14
Yakima	7	14	21	3	21	21

Source: CENDATA, 1995

Caucasians. Unemployment rates exceeded 20 percent for Native Americans in Grant and Yakima Counties, and for other races and persons of Hispanic origin in Yakima County. In Grant County, unemployment rates for all non-Caucasian groups, with the exception of Asians, were more than twice the rate for Caucasians.

A comparison of per capita income by race indicates comparable differences, as shown in Table 4-23. The lowest per capita income figures are for Hispanic populations in Franklin and Yakima Counties and other races in Yakima County. In all four counties, Caucasians had the highest per capita income, followed by Afro-Americans in Benton County and Asians in Franklin, Grant, and Yakima Counties.

**Table 4-23 Per Capita Income by Race and Hispanic Origin, 1989**

County	Caucasian (\$)	Afro- American (\$)	Native American (\$)	Asian (\$)	Other Race (\$)	Hispanic Origin (\$)
Benton	14,470	13,397	11,061	13,052	6,686	6,954
Franklin	12,434	5,918	7,153	8,075	5,692	4,732
Grant	11,030	6,092	9,942	9,992	5,469	5,438
Yakima	12,686	8,408	5,676	8,740	4,729	4,832

Source: CENDATA, 1995

Table 4-24 illustrates how household income is distributed within the Region. Benton County had the highest percentage of annual household incomes greater than \$35,000, while Grant had the lowest. Benton County also had the lowest percentage of households with less than \$15,000 annual incomes.

**Table 4-24 Percent Households by Income Level**

Annual Income Group	Benton (%)	Franklin (%)	Grant (%)	Yakima (%)
Less than \$10,000	13	20	20	20
\$10,000-\$14,999	8	11	12	11
\$15,000-\$19,999	8	10	13	11
\$20,000-\$24,999	9	11	11	10
\$25,000-\$29,999	7	9	8	9
\$30,000-\$34,999	8	8	9	8
\$35,000-\$49,999	21	15	15	16
\$50,000 or more	26	17	13	15

Source: CENDATA, 1995

## 4.6 Transportation

Transportation to the Hanford Site is provided by highways, air, water, and railroad. The most frequently used mode of Transportation is the local highway system. Subsection 4.6.1 focuses on vehicular traffic. Barge transport and rail transport are described in Subsection 4.6.2.

### 4.6.1 Vehicular Traffic

To evaluate existing conditions, documents and traffic data for national and state roadway systems and the Hanford Site roadways were reviewed. Descriptions of these reviews are presented in the following subsections.

#### 4.6.1.1 National and State Roadway Systems

Regional access to the Hanford Site is provided by a number of national and state highway systems shown in Figure 4-7. The major route adjacent to the

Hanford Site is Interstate 82, a four-lane divided highway that links the city of Richland with the Yakima Valley. State Routes 240 and 24 traverse the Hanford Site and are maintained by Washington State. These two-lane highways link the Hanford Site with Interstate 90 to the north. State Route 395, located west of the Hanford Site, connects the region with Spokane to the northeast.

#### [Figure 4-7. Hanford Site Roadway System](#)

#### 4.6.1.2 Hanford Site Roadways

Roadways within the Hanford Site that provide local service to the PFP Facility include Route 4, Route 10, Route 2, Route 11A, Route 5, and the State Route 240 access road. Peak traffic hours for these roadways typically occur between 6:00 a.m. and 9:30 a.m. (Trost, 1995). A second peak occurs between 3:00 p.m. and 5:30 p.m. The Wye Barricade, referred to below, is a security checkpoint that separates former Hanford Site special nuclear material production areas from other Hanford Site areas.

As identified in Figure 4-7, Route 4 is classified as the principal arterial roadway within the Hanford Site. Route 4 has two travel lanes in either direction south of the Wye Barricade and one lane in either direction north of the Wye Barricade. Route 4 carries most of the traffic from the city of Richland to the 200 East Area. Traffic volumes during shift changes at the Hanford Site create traffic congestion and a safety problem onsite. Traffic flow has improved since the 3.5 km (2.2 mi) State Route 240 access road was opened (Trost, 1995). This access road is open only at peak traffic hours.

South of the Wye Barricade, Route 4 has an estimated 17,000 vehicles per day. The traffic volume for Route 4 north of the Wye Barricade to the primary exit to the 200 East Area is estimated at 8,000 vehicles per day (DOE, 1993d). The number of vehicles per day is expected to decrease as a result of continued workforce reductions. According to a traffic study conducted in October 1995, the peak traffic volume consists of approximately 1,870 vehicles (Trost, 1995). Based on the average daily traffic on Route 4 between the Wye Barricade and the primary exit to the 200 East Area, Route 4 is currently operating at Level of Service "D". Level of Service is a qualitative measure of a roadway's ability to accommodate vehicular traffic. Level of Service ranges are from "A" to "F", with "A" presenting excellent (free-flow) conditions and "F" representing extreme congestion. Level of Service "D" or better is considered satisfactory (Trost, 1994).

Route 10 provides access to State Route 240 at its southern terminus and Route 4 at its northern terminus. Route 10 has one travel lane in either direction. Traffic counts for Route 10 taken at its connection with State Route 240 reveals a daily traffic volume of approximately 2,200 vehicles (DOE, 1993d). Route 10 is currently operating at Level of Service "B."

The State Route 240 access road connects State Route 240 to the 200 West Area. The access road consists of a two-lane blacktop road capable of handling light traffic. The peak traffic volume consist of approximately 970 vehicles (Trost, 1995). Traffic volumes on the access route have steadily increased since it was opened in December 1994 (Trost, 1994).

For alternative access to the Hanford Site, Ben Franklin Transit, a private Transportation company under DOE contract, provides bus service south of the Wye Barricade. This service route connects the Hanford Site with the city of Richland. Park-and-ride lots are provided in the 1100 Area for employees commuting from the cities of Kennewick and Pasco.

## 4.6.2 Other Transportation Facilities

The Port of Benton is the port-of-call for all vessel traffic to the Hanford Site. Port terminals are also provided in the cities of Kennewick and Pasco. The Port of Benton does not place restrictions on the type of vessels entering the port, although the access to the port is limited by water depths. Vessel traffic at the Port of Benton is about 15 to 20 vessels per year (Keller, 1994).

The railroad system on the Hanford Site consists of approximately 204 km (127 mi) of track. The system begins at the Richland Junction (Columbia Center) where it joins the Union Pacific commercial track. Figure 4-8 illustrates the layout of the Hanford Site trackage. The railspur closest to the PFP Facility is located approximately 150 feet west of the Facility boundary.

Approximately 139 km (86 mi) of the system are considered in service to active facilities across the Site. There are approximately 64 km (40 mi) of track that are in standby or out-of-service condition. This track serves areas or facilities having no current rail shipping activity. The standby trackage receives no maintenance at present, but could be restored, if needed, for Decontamination and decommissioning, environmental restoration, or future programs that may require rail service.

The in-service track accommodates approximately 4,000 movements of 1,500 commercial rail cars annually to provide essential materials to Site-wide facilities. In addition, the onsite rail transport of materials between areas and facilities accounts for roughly 1,000 car movements annually. The wide variety of materials transported by rail on the Hanford Site ranges from fuels (such as oil and coal) to hazardous and toxic process chemicals, and includes transport of radioactive materials and equipment.

## 4.7 Land Use

The Hanford Site is a federally-controlled area and is not subject to state and local Land use Federal Washington State regulations, such as zoning and planning. Consequently, there are no relevant state and local Land use plans and policies that apply to the activities outlined in this EIS. However, the *Hanford Site Development Plan* and the *Hanford Future Site Uses Working Group Report* guide Land use and land use policies and plans at the Hanford Site.

The *Hanford Site Development Plan* (DOE, 1993e) provides an overview of Land use, infrastructure, and facility requirements to support analyses for DOE programs and an existing and future Land use plan for the Hanford Site. It is updated annually. The plan contains a master plan which outlines the relationship of the land and infrastructure needed by Hanford Site missions.

### [Figure 4-8. Hanford Site Rail Transportation](#)

The master plan includes the following guidelines for land development:

- Minimize the disturbance of clean land
- Consolidate support activities to improve productivity and maximize flexibility
- Develop the Site in accordance with applicable environmental, cultural, safety, and health requirements.

The plan states that for planning purposes, the 200 Areas are to be used exclusively for the collection of Site waste materials and as the location for associated waste facilities. For approximately 50 years, the 200 West Area has been exclusively used for fuel reprocessing, and waste processing, management, and Disposal (see Figure 4-2).

The Hanford Future Site Uses Working Group was organized by DOE to recommend on required cleanup levels under the Hanford Remedial Action EIS Hanford Remedial Action EIS (DOE, 1995d). The group consisted of federal, tribal, state, and local governments with interests in the Hanford Site. The Working Group was charged with the task of articulating a range of visions for the future use of the Hanford Site, discussing the implications of those visions, and finding common ground on cleanup issues among the members of the group. As part of its final report, the Working Group made recommendations for future uses of the 200 Areas (FSUWG, 1992).

The Working Group's findings and recommendations included a recommendation to concentrate waste from the Hanford Site into the 200 Areas, including transporting wastes across the Hanford Site to the 200 Areas. This would help minimize the amount of land devoted to or contaminated by Waste management waste management activities. Further, the report recommended that waste and contaminants within the 200 Areas be treated and managed to prevent offsite migration.

The Working Group also developed six future use options for the Central Plateau, which includes the 200 Areas. The options include a goal "...that the overall cleanup criteria for the Central Plateau should enable general usage of the land and Groundwater for other than Waste management waste management activities in the horizon of 100 years from the decommissioning of Waste management waste management facilities and closure of waste Disposal facilities." The options differentiate between types of waste

and different types of Waste managementwaste management or commercial activities. They are further distinguished by three major criteria: 1) type of waste; 2) methods of treatment or Disposal; and 3) length of time for Storage. The options range from the fulfillment of existing obligations for Disposal or Storage of Hanford onsite waste to allowing for additional Storage, treatment, or Disposal of offsite DOE and commercial waste.

The Hanford Remedial Action EIS will provide an assessment of the impacts (primarily from remediation activities) associated with achieving broad classes of future land uses for the Hanford Site. The Hanford Remedial Action EIS will build on the three broad classes of potential future land uses developed by the Hanford Future Site Uses Working Group (restricted, unrestricted, and exclusive future uses).

The Hanford Remedial Action EIS will evaluate the potential environmental consequences associated with sitewide remediation efforts. Once established, future land use designations will guide the process of remediating Hanford Site radioactive and hazardous wastes and facilitate the development of a coordinated and cost-effective remediation strategy. However, decisions regarding site-specific remediation technologies and specific activities will not be made in the Hanford Remedial Action EIS. Instead these decisions will be made through the Resource Conservation and Recovery Act of 1976 (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) process, in accordance with the Hanford Federal Facilities Agreement and Consent Order, also known as the Tri-Party Agreement (Jason, 1996).

The Hanford Comprehensive Land use Plan will build on and implement the broad Land use objectives established in the Hanford Remedial Action EISHanford Remedial Action EIS. It will narrow the range of potential Land useland uses by evaluating, in a holistic manner, the constraints and opportunities posed by factors such as:

1. DOE responsibilities and authority as dictated by its charter under the federal government and applicable law
2. Environmental characteristics, such as the presence of sensitive Cultural Resourcescultural or biological resources
3. Physical characteristics, such as the presence of steep slopes, unstable Soil types, or potential physical hazards
4. The socioeconomic characteristics and values of the surrounding region.

Land use values of other agencies, governments, and organizations are being solicited by DOE to ensure that the Hanford Comprehensive Land useLand Use Plan reflects a broad spectrum of input. The development of this information, integrated with the requirements to support the components of DOE's mission (identified in the *Hanford Site Development Plan*), is expected to guide future Hanford Site Land use decisions by DOE over the next 30 to 50 years (Jason, 1995).

## 4.8 Cultural Resources

A Cultural resourcescultural resource is any phenomenon with a demonstrable association with prehistory, historical events or individuals, or extinct cultural systems. Cultural resources include such things as archaeological sites, districts, and objects; standing historical structures, objects, or groups of either; locations of important historic events; or places, objects, and living or non-living things that are important to the practices and continuity of traditional cultures. For the purpose of this document, three terms with more restrictive meanings will be used. These are "historic property," "traditional use area," and "sacred" or "religious site."

"Historic property" is a legal term that refers to any Cultural resourcescultural resource listed on or considered eligible for the National Register of Historic Places. A historic property may be an archaeological site, a historical site, or a "traditional use area," but not all such phenomena meet the criteria for being historic properties.

A "traditional use area" is any place or landscape that is important to the continuation of a traditional culture. It includes such things as a community, a sacred site, or an area from which food and non-food resources are obtained.

"Sacred sites" are places important to the practice of traditional religions. Their relationship to traditional religions makes it possible for sacred sites to become historic properties, but they are also considered under statutes designed to protect First Amendment guarantees regarding the free practice of religion.

The Hanford Site contains a rich diversity of known Cultural resourcescultural resources. Because the Site has been closed to the public for over 50 years, Cultural resourcescultural resource sites have been provided more relative protection than other sites in the Mid-Columbia Basin.

### 4.8.1 Historical Resources

DOE has determined that the 236-Z Building (PRF), the Remote Mechanical A Line (RMA)RMA Line portion of the 234-5Z Building (PFP), the 2704-Z Administration Building, and the 231-Z (Plutonium Metallurgy Facility), are eligible for inclusion in the National Register of Historic Places. The 234-5ZA South Annex, the 242-Z Waste Treatment Facility, the 291-Z Stack, the 2701-ZA Central Alarm Station, the 2736-Z Primary Plutonium Storage Facility, the 2736-ZA Annex and the 2736-ZB Support Facility are associated properties, located within the PFP Facility and are also eligible for inclusion in the National Register of Historic Places (MOA, 1996). These structures are eligible due to their relation to the Manhattan Project, the Cold War, and historical industrial processes.

#### **4.8.2 Archaeological Resources**

The locations related to the *PFP Stabilization EIS* have been previously subjected to archaeological surveys. These surveys were conducted either for this or other projects on the Hanford Site. No archaeological resources were identified from these investigations (Chatters and Cadoret, 1990).

#### **4.8.3 Native American Concerns**

No natural features in the vicinity of the PFP Facility are considered sacred by Native Americans. However, there are natural features within the Hanford Site outside the 200 West Area that are considered sacred by members of the Wanapum people, Yakama Indian Nation, the Confederated Tribes of the Umatilla Reservation, and the Nez Perce Tribe. These landmarks include, but are not limited to Rattlesnake Mountain, Gable Mountain, Gable Butte, Goose Egg Hill, and many sites along the Columbia River. The tribes have expressed a desire that cleanup be completed so that general use of the land and Groundwater within the 200 West Area will be available within 100 years of Site closure.

### **4.9 WASTE TREATMENT, STORAGE, AND DISPOSAL CAPACITY**

This subsection describes the waste treatment, Storage, and Disposal units that would manage waste generated by the alternatives described in Section 3. Units that would potentially manage waste generated at the PFP Facility include Hanford Site solid waste management facilities, the 200 Area Tank Farms200 Area Tank Farms (Double-Shell Tank System), the City of Richland Landfillcity of Richland landfill, and the 200 Area Treated Effluent Disposal Facility200 Area Treated Effluent Disposal Facility.

#### **4.9.1 Hanford Site Solid Waste Management Facilities**

Hanford Site solid waste management facilitiesHanford Site solid waste management facilities includes the Transuranic Waste Storage and Assay FacilityTransuranic Waste Storage and Assay Facility, Central Waste ComplexCentral Waste Complex, Low-Level Burial Grounds, and the Waste Receiving and Processing FacilityWaste Receiving and Processing Facility.

##### **Transuranic Waste Storage and Assay Facility**

The Transuranic Waste Storage and Assay Facility is located in the 200 West Area of the Hanford Site and provides a centralized Storage unit for containerized transuranic mixed waste and low-level mixed waste from various Hanford operations. The Transuranic Waste Storage and Assay Facility is a permitted Federal RCRA Interim Status Unit. Assay of the waste consists of nondestructive testing of the Transuranic mixed waste to confirm the fissile isotope content and to confirm the absence of prohibited items before shipment to approved Disposal sites.

The total process design capacity for Storage at the Transuranic Waste Storage and Assay Facility is 2,000 55-gallon drums (DOE, 1995e). Each drum may contain up to 200 g (0.44 lb) of plutonium (WHC, 1995). There are approximately 1,500 drums currently stored at the facility.

##### **Central Waste Complex**

The Central Waste Complex is located in the 200 West Area of the Hanford Site and consists of multiple Storage structures for mixed waste. It provides permitted structures to support inspection, verification, sampling, and repackaging of mixed waste. The Central

Waste Complex is a Federal RCRA Interim Status Unit (DOE, 1995e).

The design capacity for the mixed waste Storage structures at the Central Waste Complex has both radiological and volume constraints. From a radiological standpoint, the Complex can store up to 3,600 dose-equivalent curies of radioactive material. A dose equivalent curie is a unit that allows ready comparison among all radioactive isotopes. There are approximately 1,100 dose-equivalent curies of radioactive material currently stored at the Central Waste Complex. An additional 2,500 dose-equivalent curies may be stored at the Complex. Up to 60,000 55-gallon drums may be stored at the Complex as long as the dose-equivalent curies limit is not exceeded (Martin, 1996). A project is in progress that would increase the Storage capacity by an additional 14,300 55-gallon drums and is expected to be on line in early 1997.

### **Low-Level Burial Grounds**

The Low-Level Burial Grounds are located in the 200 East and 200 West Areas of the Hanford Site. The Low-Level Burial Grounds are a Interim Status Unit. This Waste management unit consists of two types of trenches: Federal RCRA-compliant trenches, and past-practice trenches. The Federal RCRA compliant trenches have either liners and leachate collection systems or use alternative technologies such as high-integrity packaging. The past-practice trenches were used for mixed waste Disposal prior to Regulations/Environmental Laws regulation and continue to be used on a case-by-case basis for the Disposal of remotely-handled mixed waste packages. The process design capacity for mixed waste in the Low-Level Burial Grounds is approximately 1,200,000 m<sup>3</sup> (41,000,000 ft<sup>3</sup>), of which 910,000 m<sup>3</sup> (33,000,000 ft<sup>3</sup>) is dedicated solely for Disposal submarine reactor compartments (DOE, 1995f).

### **Waste Receiving and Processing Facility**

The Waste Receiving and Processing Facility is located in the 200 West Area of the Hanford Site. The Facility is an Interim Status Unit that is under construction. When completed, the Waste Receiving and Processing Facility will be a treatment and Storage unit that will provide waste receipt, confirmation, repackaging, certification, treatment, and limited Storage capabilities (DOE, 1995e). Space will be available for the Storage of approximately 240 drums necessary to support waste receipt, processing, and shipment. The Waste Receiving and Processing Facility will be able to process on an annual basis approximately 2,100 newly generated drums of Transuranic waste. The daily rate would be approximately 12 drums of transuranic waste.

#### **4.9.2 200 Area Tank Farms (Double-Shell Tank System)**

The 200 Area Tank Farms (Double-Shell Tank System) is used for the interim storage of Liquid mixed waste generated on the Hanford Site. The Double-Shell Tank System is an Interim Status Unit. Several operating units in the 200 East and 200 West Areas transfer Liquid mixed waste through buried double-encased transfer lines to designated underground double-shell tanks. Other types of Liquid mixed waste are received from railroad car transfers, tank truck transfers, and other waste Storage tanks. The tanks in the Double-Shell Tank System are considered treatment units because chemicals can be added for corrosion control, the waste can be mixed, and water can be evaporated by adding heat. The Storage and treatment design capacities for the Double-Shell Tank System are approximately 150,000,000 l (40,000,000 gal) (DOE, 1995e).

#### **4.9.3 City of Richland Landfill**

The City of Richland Landfill operates a permitted landfill designed for municipal and commercial customers located northwest of Richland. The landfill operates under Permit Number 95-755TA issued by the Benton Franklin Health Department. The city has recently been awarded a contract to landfill non-regulated, non-radioactive Solid waste from the Hanford Site. Approximately 230,000 m<sup>3</sup> (7,500,000 ft<sup>3</sup>) are currently permitted and being used to dispose of Solid waste. An estimated 56,000,000 kg (62,000 tons) of refuse is placed in the landfill each year. An additional 780,000 m<sup>3</sup> (1,020,000 yd<sup>3</sup>) has been designated for future solid waste management activities. Non-regulated, non-radioactive solid waste associated with PFP stabilization and removal activities would be placed in the City of Richland Landfill (Penor, 1995).

#### **4.9.4 200 Area Treated Effluent Disposal Facility**

The 200 Area Treated Effluent Disposal Facility, Washington State Waste Discharge Permit Number 4502, receives non-radioactive, non-contact Liquid Effluents/Waste generation discharged by the PFP Facility and six other facilities at the Hanford Site. It has a

permitted average monthly flow of 2,500 l/min (620 g/min) from all seven sources. Liquid from sources such as ventilation heating/cooling wastewater, steam condensate, rainwater, and potable water overflow is treated through a series of source controls and end-of-pipe treatment before being piped to the 2200 Area Treated Effluent Disposal Facility (Ecology, 1995).

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## 5.0 ENVIRONMENTAL IMPACTS

Implementation of the alternatives described in Section 3 would impact the environment. The purpose of this section is to analyze the potential impacts each alternative would have on PFP Facility and Hanford Site workers, the public, and the environment. Each alternative identified in Section 3 is evaluated in terms of the areas noted below:

- Geology, seismology, and soils
- Water resources and hydrology
- Physical environment
- Ecosystems
- Population and socioeconomics
- Environmental justice and equity
- Transportation
- Land use
- Cultural resources
- Anticipated health effects.

In addition to the areas identified above, the alternatives have been evaluated for the following:

- Unavoidable adverse environmental impacts
- Potential mitigation measures
- Irreversible and irretrievable commitments of resources
- Relationship between short-term use and long-term productivity of the environment.

The environmental impact analyses is arranged as follows:

- 5.1 Anticipated Impacts of the Preferred Alternative
- 5.2 Anticipated Impacts of the Alternative for Plutonium-bearing Solutions
- 5.3 Anticipated Impacts of the Alternative for Oxides, Fluorides, and Process Residues
- 5.4 Anticipated Impacts of the Alternative for Metals and Alloys
- 5.5 Anticipated Impacts of the Alternatives for Polycubes and Combustibles
- 5.6 Anticipated Impacts of the Immobilization Alternative
- 5.7 Anticipated Impacts of the No Action Alternative.





## 5.1 ANTICIPATED IMPACTS OF THE PREFERRED ALTERNATIVE

The analysis of the environmental impacts of the preferred alternative considers both stabilization and removal activities.

### 5.1.1 Geology, Seismology, and Soils

No impact on Site geology, geological resources or soils would be expected from the preferred alternative. Because the facilities already exist, there would be no need for Site modification. No leaks or spills outside of the Facility are anticipated.

#### Geologic Resources

The primary mineral resources that exist in the vicinity of the Hanford Site include sand, gravel, stone, and diatomaceous earth. Mining of these relatively low-value resources is limited to surface extraction methods. No mining activity is occurring in the vicinity of the PFP Facility.

#### Seismology

No potentially capable faults, as described in Section 4.1.2, have been identified beneath the 200 West Area. Landslides or slope failure are not a hazard due to the generally subdued topography associated with the Facility.

The PFP Facility is designed to standards associated with the Uniform Building Code that were applicable at the time of construction. The Facility was designed in 1947 in accordance with the Uniform Building Code of 1946 which did not include seismic criteria. However, results of seismic evaluations of key PFP Facility buildings (see Appendix C for definition of key buildings) show that they can withstand an earthquake with a 0.25 gravity peak horizontal ground acceleration with a concurrent 0.17 gravity peak vertical ground acceleration. Data indicate that this magnitude of an earthquake has a frequency of once every 25,000 years (extrapolated) (Coats and Murray, 1984). These results show that key Facility buildings exceed the design standards currently used at the Hanford Site of a 0.20 gravity earthquake with an associated frequency of every 10,000 years (WHC, 1995a). Key buildings of the Facility can resist seismic loads. Seismic loads are those resulting from:

- Passage of seismic waves (i.e., wave-propagation effects)
- Seismic-induced building settlements and seismic anchor movements
- Soil failure due to liquefaction, landslide, etc., if applicable
- Soil-structure interaction ground-motion magnification by thick, unconsolidated soils during a strong-motion earthquake.

#### Soil Resources

No impacts on soil resources are anticipated from the preferred alternative. Implementation of the preferred alternative would not modify the existing terrain or use soil resources.

### 5.1.2 Water Resources and Hydrology

Potential spills and leaks outside the Facility from the preferred alternative are not expected during normal operations. No impacts to the water resources are anticipated.

No impacts are anticipated to the water resources resulting from off normal conditions or unplanned releases (e.g., spills, leaks). The potential exists for only small leaks and spills associated with leaking containers, gloveboxes, or operator error. Any spill or leak is expected to be contained in the building. All floor drains have been sealed with grout to prevent any spilled liquid from escaping to the soil or outside environment. In addition, depth to groundwater of approximately 70 m (230 ft), lack of driving force, and the strong affinity of plutonium and americium for soil in the vadose zone combine to reduce the likelihood of impacts to water resources from small spills or leaks that might escape to the environment. This is supported by analytical data from soil collected beneath the 216-Z-1A and 216-U-9 cribs where maximum plutonium and americium soil concentrations were reported within the first 15 m (49 ft) of soil beneath the cribs with a maximum depth of penetration to 30 m (98 ft) (DOE, 1993a). Moreover, no impacts are expected to the nearest surface waters of Westlake and the Columbia River due to the distance, approximately 8 and 9.7 km (5 and 6 mi) from the PFP Facility respectively, and since any potential spill is expected to be contained in the Facility.

### **5.1.3 Physical Environment**

Impacts of the preferred alternative on the physical environment are examined in terms of the following elements:

- Air Quality
- Noise and Sound Levels
- Waste Treatment, Storage, and Disposal Capacity.

#### **5.1.3.1 Air Quality**

The following air contaminants and final stack release rates are based on conservative assumptions to bound the maximum release rates of plutonium and gases for this alternative. These release rates are continuous averages for the process described in Section 3.

#### **Plutonium-bearing Solutions**

Ion exchange followed by vertical calcination and muffle furnace:

- Ion exchange
- No air emissions
- Vertical calcination
- Nitrogen oxides:  $9.8 \times 10^{-3}$  g/sec ( $2.2 \times 10^{-5}$  lb/sec). Essentially all particulate matter is removed by a ceramic filter and a scrubber unit
- Muffle furnace
- PM10:  $2.3 \times 10^{-8}$  g/sec ( $5.0 \times 10^{-11}$  lb/sec).

#### **Oxides, Fluorides, and Process Residues**

Continuous thermal treatment:

- Continuous thermal treatment

- PM10:  $3.3 \times 10^{-8}$  g/sec ( $7.3 \times 10^{-11}$  lb/sec).

## Metals and Alloys

Repackaging followed by thermal stabilization:

- Repackaging
- Argon; not an air contaminant emission
- Thermal stabilization of the oxide brushings
- PM10:  $2.8 \times 10^{-8}$  g/sec ( $6.1 \times 10^{-11}$  lb/sec).

## Polycubes and Combustibles

Pyrolysis:

- Pyrolysis
- PM10:  $2.8 \times 10^{-9}$  g/sec ( $6.1 \times 10^{-12}$  lb/sec)
  - Styrene:  $7.4 \times 10^{-4}$  g/sec ( $1.6 \times 10^{-6}$  lb/sec)
  - Carbon monoxide:  $1.7 \times 10^{-3}$  g/sec ( $3.7 \times 10^{-6}$  lb/sec).

The expected air contaminants fall into two categories of regulated pollutants, specifically, criteria pollutants (carbon monoxide, nitrogen dioxide, and particulate matter) and a hazardous air pollutant (styrene). The particulate matter would be emitted as very fine particulates after the PFP Facility exhaust air is filtered by HEPA filters. The emitted particulate matter would, therefore, be referred to as PM10 (particles less than 10 microns in size). A portion of the PM10 includes plutonium oxide and the radiation level and effects are discussed in Subsection 5.1.10.

The release rates shown above represent small process exhausts, compared with many industrial process exhausts. However, implementation of the preferred alternative, as conservatively estimated, would increase the PFP Facility emissions compared to recent annualized releases from that source. Release rates are important in that each was used to calculate the downwind concentration.

The released air contaminants would be drawn along the existing PFP Facility building ventilation ducting to the exhaust system. The PFP Facility building exhaust system has a total flow rate of approximately 7,080 m<sup>3</sup>/min (250,000 ft<sup>3</sup>/min). Thus, small contributing air flows become minuscule in the overall exhausted air.

The entire air flow to be exhausted is double-filtered (in series) with HEPA filters. Because the HEPA filter system consists of two filters in series, each rated at 99.95 percent efficient, a 99.999 percent efficiency was assumed with regard to removal of particulate matter (Letourneau, et al., 1989). It was assumed that the filters would have no effect on gaseous (non-particulate) emissions.

Final exhaust air would be emitted to the atmosphere from the top of a 61 m (200 ft) high stack, located south of the main PFP Facility building. The height above ground, and the rapid exhaust velocity combine to create stack conditions which enhance the dispersion of contaminants in the atmosphere.

The two criteria pollutants, PM10 and nitrogen dioxide, have ambient air criteria levels which apply (see Table 5-1 for a summary of applicable ambient criteria). The Hanford Region is in compliance with EPA and Ecology ambient air quality standards, but new sources must not add significantly to atmospheric concentrations so that the Region would move toward non-compliance.

**Table 5-1 Applicable Air Contaminant Standards for the Stabilization Processes**

Stabilization Process Contaminant	Ambient Air Standard	Ambient Air Equivalent Standard ( $\mu\text{g}/\text{m}^3$ )	Federal or State Standard
Carbon Monoxide	35 ppm (1-hr Avg.)	40,000 (1-hr Avg.)	Federal and State
	9 ppm (8-hr Avg.)	10,000 (8-hr Avg.)	
PM	150 $\mu\text{g}/\text{m}^3$ (24-hr Avg.)	150 (24-hr Avg.)	State
	60 $\mu\text{g}/\text{m}^3$ (Annual Geo. Mean)	60 (Annual Geo. Mean)	
PM10	150 $\mu\text{g}/\text{m}^3$ (24-hr Avg.)	150 (24-hr Avg.)	Federal and State
	50 $\mu\text{g}/\text{m}^3$ (Annual Arith. Mean)	50 (Annual Arith. Mean)	
Nitrogen Dioxide	100 $\mu\text{g}/\text{m}^3$ (Annual Avg.)	100 (Annual Avg.)	Federal and State
Styrene	1,000 $\mu\text{g}/\text{m}^3$ (24-hr Avg.)	1,000 (24-hr Avg.)	State Acceptable Source Impact Level

**Note:**a. The contaminant styrene is a listed Toxic Air Pollutant by Ecology, WAC 173-460-160. It is not a known or suspected carcinogen, and thus it is listed as a Class B Toxic Air Pollutant with an Acceptable Source Impact Level of 1,000  $\mu\text{g}/\text{m}^3$ .

Ground level concentrations of the above contaminants were estimated by utilizing an atmospheric dispersion model. The EPA model ISCST3, Version 95-250 (40 CFR 51, Appendix W) was used to determine such concentrations at varying distances from the PFP Facility main stack out to 29 km (18 mi). This dispersion model is approved by the EPA and appropriate for emissions of this nature.

The maximum downwind contaminant concentrations projected by the computer model and the ambient air standards are given in Table 5-2 for the preferred alternative. When these concentrations, added to measured background levels, are compared with the applicable ambient air standards, all of the downwind concentrations are significantly lower than the standards. Therefore, impacts from the preferred alternative appear to be insignificant.

The increase in criteria air pollutant emissions from the preferred alternative is below the significant rates listed by Ecology. These rates, if exceeded, would trigger Prevention of Significant Deterioration requirements including the need for best available control technology.

#### 5.1.3.2 Noise and Sound Levels

Potential noise impacts from the installation and operation of equipment to support the stabilization activities would not be expected to exceed allowable noise levels for the protection of hearing of directly involved PFP Facility workers. However, potential noise impacts from removing readily retrievable plutonium-bearing materials in hold-up



would be expected to temporarily increase ambient noise levels at the Facility. Noise levels created by the mechanical disassembly and removal techniques have the potential to affect directly involved PFP Facility workers. No adverse noise impacts are expected from the chemical or protective techniques.

Occupational noise exposure would be monitored in the work areas expected to exhibit noise levels beyond limits set by and threshold limit values established by the American Conference of Governmental Industrial Hygienists (ACGIH, 1995). A hearing conservation program, including the use of approved hearing protection, would be implemented to protect all individuals as needed.

Noise impacts external to the Facility are not anticipated since each stabilization alternative and all removal activities would be implemented inside the existing Facility. No new construction outside of the PFP Facility is anticipated, thus there are no anticipated noise impacts on the environment. In addition, the distance between the Facility and the nearest offsite receptor creates a large buffer zone for noise abatement and control.

### 5.1.3.3 Waste Treatment, Storage, and Disposal Capacity

Facilities that would potentially manage waste generated at the PFP Facility include the Hanford Site solid waste management facilities, the 200 Area Tank Farms (Double-Shell Tank System), and the city of Richland Landfill. Waste that is hazardous (i.e., not radioactive) would be transported off the Hanford Site to a permitted treatment, storage, or disposal facility. Non-contact fluids, such as ventilation heating/cooling wastewater, steam condensate, rainwater, and potable water overflow, from the PFP Facility are currently managed at the 200 Area Treated Effluent Disposal Facility.

**Table 5-2 Projected Maximum Ground Level Concentration of Chemical and Particulate Air Contaminants for the Preferred Alternative**

Material Category	Alternative Process	Air Contaminant	Maximum Average Concentration <sup>a</sup> ( $\mu\text{g}/\text{m}^3$ )	Background Concentration <sup>b</sup> ( $\mu\text{g}/\text{m}^3$ )	Ambient Air Standard ( $\mu\text{g}/\text{m}^3$ )
Plutonium-bearing Solutions	Ion Exchange, Vertical Calcination and Thermal Stabilization	NO <sub>2</sub> (Annual)	$5.40 \times 10^{-3}$	36	100
		PM <sub>10</sub> (24-hr)	$6.34 \times 10^{-8}$	81	150
		PM <sub>10</sub> (Annual)	$1.27 \times 10^{-8}$	27	50
Oxides, Fluorides and Process Residues	Continuous Thermal Treatment	PM <sub>10</sub> (24-hr)	$9.22 \times 10^{-8}$	81	150
		PM <sub>10</sub> (Annual)	$1.84 \times 10^{-9}$	27	50
Metals and Alloys	Repackaging	PM <sub>10</sub> (24-hr)	$7.67 \times 10^{-8}$	81	150
		PM <sub>10</sub> (Annual)	$1.53 \times 10^{-8}$	27	50

Polycubes and Combustibles	Pyrolysis	Styrene (24-hr)	2.05 x 10 <sup>-3</sup>	N/A	1,000
		PM10 (24-hr)	7.70 x 10 <sup>-9</sup>	81	150
			1.54 x 10 <sup>-9</sup>	27	50
		PM10 (Annual)	1.16 x 10 <sup>-2</sup>	11,800	40,000
		CO (1-hr)	8.09 x 10 <sup>-3</sup>	6,500	10,000
		CO (8-hr)			

**Source:**PNL, 1991

**Notes:**a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data.

The amount of transuranic, radioactive and mixed solid, radioactive and mixed liquid, and nonradioactive nonregulated solid waste that would be generated by PFP stabilization and removal activities associated with the preferred alternative would not exceed the design capacities of the waste management units described in Subsection 4.9. Therefore, no additional capacity would be required as a result of the preferred alternative.

The volume of non-contact liquid would slightly increase due to the additional employees supporting the preferred alternative. This slight increase, however, would not appreciably impact activities at the 200 Area Treated Effluent Disposal Facility. The permitted capacity would not be exceeded. Therefore, no additional capacity would be required at the 200 Area Treated Effluent Disposal Facility as a result of the preferred alternative.

#### 5.1.4 Ecosystems

This section discusses the potential impact of the preferred alternative on the ecosystems. The ecosystems are characterized according to vegetation, wildlife, and threatened or endangered species.

##### Vegetation

Since there would be no ground disturbance at the PFP Facility, no habitat impact would occur under the preferred alternative.

##### Wildlife

Although increased worker traffic would result in increased roadkills of birds, small mammals and reptiles, the preferred alternative would not have a meaningful impact on wildlife populations.

##### Threatened or Endangered Species

Since no threatened or endangered plant or animal species exist at the PFP Facility and work activities would be confined to the inside of buildings, no impact to threatened or endangered plant or animal species would result from the preferred alternative.

#### 5.1.5 Population and Socioeconomics

The following section describes impacts of the preferred alternative on employment, income, population, housing, and infrastructure. The Study Area, as described in Subsection 4.5, consists of Benton and Franklin Counties.

Socioeconomic impacts are presented in terms of direct, secondary, and total impacts. Changes in PFP Facility employment and expenditures are defined as direct impacts. Additional changes that occur in the larger Study Area economy as a result of these direct changes are defined as secondary impacts. Changes in retail and service employment or the demand for goods and services are examples of secondary impacts. The total socioeconomic impact on the Study Area economy is equal to the sum of direct and secondary impacts.

For this study, three economic indicators, which together are commonly thought to reflect the overall condition of the Study Area economy, were selected to assess socioeconomic impacts. These indicators are employment, total industry output (output), and place-of-work income (income). Employment impacts are the number of full-time equivalent jobs gained or lost. Full-time equivalent is a budget term that roughly equates to full-time job positions, not personnel numbers. Output impacts result from changes in the dollar value of goods and services produced. Direct impacts on output are equivalent to PFP Facility expenditures. Income impacts are changes in payroll, proprietor (self-employment), and other property income.

Estimates of impacts on employment, output, and income were calculated using the IMPLAN regional economic model for the Study Area (IMPLAN, 1995). This analysis is based on the PFP Facility staffing estimates identified in the *DNFSB Recommendation 94-1 Hanford Site Integrated Stabilization Management Implementation Plan* (WHC, 1995b); the PFP Facility funding, staffing, and extrapolated cost estimates provided by DOE's maintenance and operations contractor (Schilling, 1995), the PFP Facility procurement and staffing data provided by DOE's maintenance and operations contractor (WHC, 1995c), and Hanford procurement data (Scott, 1995).

Impacts on population, housing, and infrastructure are largely based on interviews with local government officials and local economists who provided information on historical and recent trends in the Study Area. All socioeconomic impacts presented in the following subsections must be viewed in the context of the Hanford Site environmental restoration mission. In 1994, Hanford's 18,700 employees accounted for 21 percent of the Study Area employment. The 1996 Site-wide employment is expected to decline to less than 14,000, of which the PFP Facility will account for approximately 592. Refer to Cumulative Impacts, Section 6 for a discussion of the broader impacts of Hanford Site activities on the Study Area economy.

#### **5.1.5.1 Local Economy, Employment, and Income**

The *DNFSB Recommendation 94-1 Hanford Site Integrated Stabilization Management Implementation Plan* (WHC, 1995b) and funding and cost estimates from DOE's maintenance and operations contractor (Schilling, 1995) provide guidelines for PFP Facility employment and expenditures under the preferred alternative. These projections are the direct impacts of the preferred alternative.

Under the preferred alternative, direct PFP Facility employment would rise from its fiscal year 1995 level of 592 full-time equivalents to a peak employment level of about 654 full-time equivalents upon implementation of the preferred alternative in fiscal year 1997. During fiscal year 1997, the initial round of direct impacts would be an increase in employment of 62 jobs, a 10 percent increase from fiscal year 1995. The average employment would be about 640 full-time equivalents through the duration of the PFP Facility stabilization and removal activities. These activities are expected to be completed in the year 2002, after which PFP Facility employment would drop to approximately 254 full-time equivalents. The direct employment loss from a peak of 654 full-time equivalents to 254 full-time equivalents following completion of the PFP Facility stabilization and removal activities would be 400 PFP Facility jobs, or 61 percent of fiscal year 1997 employment.

Associated with changes in PFP Facility employment are changes in PFP Facility expenditures. Upon implementation of the preferred alternative, there would be a corresponding 10 percent increase in expenditures from the estimated fiscal year 1995 level of \$80 million to approximately \$89 million in fiscal year 1997. Following completion of

stabilization and removal activities in fiscal year 2002, there would be an estimated \$55 million, or 61 percent decrease in PFP Facility expenditures, from the 1997 estimated level of \$89 million to approximately \$34 million.

The following presents the IMPLAN modeling of secondary and total impacts of direct changes in PFP Facility employment and expenditures on Study Area employment, output, and income. Modeling results are presented for the difference between peak employment and spending in fiscal year 1997 and employment and spending following completion of the preferred alternative during fiscal year 2002. The secondary and total impacts of initiating the preferred alternative in fiscal year 1997 are not presented because the overall impacts on the Study Area economy are negligible.

Table 5-3 shows a summary of the IMPLAN modeling of impacts of the preferred alternative on employment, output, and income. Direct changes in PFP Facility employment would result in an associated decrease in secondary employment from 711 full-time equivalents in fiscal year 1997 to 276 in fiscal year 2002. The total impact on Study Area employment would be a loss of 835 full-time equivalents. This translates into a 1 percent decrease in total Study Area employment. As a result, overall unemployment levels would be only slightly affected by completion of the preferred alternative.

Impacts of the preferred alternative on Study Area output result from changes in PFP Facility expenditures. Direct changes in PFP Facility expenditures would lead to a decrease in secondary output from \$38 million in fiscal year 1997 to \$15 million in fiscal year 2002. The total impact on the Study Area would be a \$78 million reduction in output. This would mean an overall 1.3 percent decline in total Study Area output. The Study Area economic activity would be relatively unaffected by this small decline in Study Area output associated with the preferred alternative.

Direct changes in PFP Facility expenditures would also result in a decrease in secondary income from \$21 million in fiscal year 1997 to \$8 million in fiscal year 2002. The total impact on the Study Area would be a \$49 million expenditure reduction from \$80 million in fiscal year 1997 to \$31 million in fiscal year 2002. This translates into an overall 1.8 percent decline in total Study Area income. This relatively minor change in income under the preferred alternative is not expected to substantially affect personal or household income levels or poverty status in the Study Area.

Direct changes in PFP Facility employment and expenditures would be experienced by the government sector, since the PFP Facility operations are classified in this sector. Secondary impacts, or changes in the larger economy that result from these direct changes, would be experienced by all sectors in the Study Area economy, as shown in Table 5-4. The preferred alternative would have the largest total impact on employment in the government sector with a 3.4 percent decline, followed by trade with a 1.4 percent decline. In terms of Study Area output, the government sector would experience the largest impact, with a 7.0 percent decline in output, followed by trade, with a decline of 1.2 percent. Income in the government sector would fall by 6.4 percent, while income in the trade sector would fall by 1.2 percent.

**Table 5-3 Impacts of the Preferred Alternative by Component Fiscal Year 1997 to 2002**

<b>Economic Indicator</b>	<b>FY 1997</b>	<b>FY 2002</b>	<b>Impact FY 2002</b>	<b>Study Area Total</b>	<b>Study Area Impact FY 2002 (%)</b>
Employment	.	.	.	.	.
Direct FTE	654	254	-400	N/A	N/A
Secondary FTE	711	276	-435	N/A	N/A
Total FTE	1,365	530	-835	79,680	-1.0

Output	.	.	.	.	.
Direct (\$Million)	89	34	-55	N/A	N/A
Secondary (\$Million)	38	15	-23	N/A	N/A
Total (\$Million)	127	49	-78	5,805	-1.3
Income	.	.	.	.	.
Direct (\$Million)	59	23	-36	N/A	N/A
Secondary (\$Million)	21	8	-13	N/A	N/A
Total (\$Million)	80	31	-49	2,728	-1.8

**Sources:** IMPLAN, 1995; Schilling, 1995; WHC, 1995b

**Note:** FTE =Full-time equivalent

FY =Fiscal year

#### 5.1.5.2 Population

Between the years 1992 and 1994, the population of the Study Area grew at an average rate of 3.8 percent per year. Most likely, this was due to economic expansion resulting from growth at the Hanford Site and related supporting activities. These growth rates are expected to decline as a result of recent economic contraction associated with labor force reductions at Hanford and in the surrounding community. While no systematic data is available to quantitatively estimate the impacts of the preferred alternative upon the population of the Study Area, it can be inferred that the estimated 1 percent reduction in total Study Area employment would not contribute substantially to the overall decline in population growth.

**Table 5-4 Summary of Total Impacts of the Preferred Alternative on Study Area Employment, Output, and Income, by Sector After Fiscal Year 2002**

Sector	Impact on Study Area Employment (%)	Impact on Study Area Output (%)	Impact on Study Area Income (%)
Agriculture, Forestry, Fisheries	0	0	0
Mining	0	0	0
Construction	-0.2	-0.3	-0.2
Manufacturing	0	0	0
Transportation,	-0.6	-0.6	-0.8

Communication, Utilities			
Trade	-1.4	-1.2	-1.2
Finance, Insurance, Real Estate	-0.8	-1.0	-1.0
Services	-0.8	-0.8	-0.8
Government	-3.4	-7.0	-6.4

**Sources:** IMPLAN, 1995; Schilling, 1995; WHC, 1995b

### 5.1.5.3 Housing

Information obtained from the Tri-City Board of Realtors reveals that apartment vacancy rates are rapidly increasing. During August 1995, apartment vacancy rates were 8 percent, a 100 percent increase from August 1994 (Powers, 1995). This trend is expected to continue in the near future. In addition, the average number of residential listings has been growing rapidly while the average number of homes sold has been falling since 1994. This is resulting in an ever-increasing surplus of available housing and an overall decline in the average selling prices of homes. These trends are expected to continue as a result of labor force reductions at the Hanford Site and in the surrounding community. While no systematic data are available to assess the impacts of the preferred alternative on the Study Area housing market, total impacts on employment, output, and income are expected to be relatively small. Therefore, it can be inferred that the preferred alternative will have very minor, if any, impacts on current and future housing market trends.

### 5.1.5.4 Local Infrastructure

Local infrastructure needs would only be affected if the Study Area economy encountered a change in available tax base as a result of an influx or outflux of people in the Study Area. Because total impacts of the preferred alternative on employment, output, and income are expected to be relatively minor and population impacts are expected to be negligible, it can be inferred that the demands on local infrastructure will remain unchanged.

### 5.1.6 Environmental Justice and Equity

Executive Order 12898 (59 FR 7629) directs the Administrator of the EPA to convene an interagency Federal Working Group on Environmental Justice. The Working Group is directed to provide guidance to federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority and low-income populations. Since this guidance is not yet finalized, draft working definitions are used to assess environmental justice impacts in this analysis, and the approach taken may depart from the guidance eventually issued by the Working Group and DOE.

This approach is consistent with the *Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel*, (DOE, 1995). The working definitions in that Draft EIS are as follows:

- Minority -- Individuals classified by the U.S. Bureau of the Census as Negro/Black/African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other non-White persons. The minority

- population in an affected area is the number of individuals residing in the area who are members of a minority group.
- Low-income community -- An area for which the median household income is 80 percent or below the median household income for the metropolitan statistical area (urban) or county (rural).
  - Disproportionately high and adverse human health effects -- Any human health effects, including cumulative or synergistic effects, on minority or low-income populations which substantially exceed generally accepted levels of risk.
  - Substantially affect human health -- To impact human health such that there is a measurable incidence of any specific illness, disease, or disorder significantly higher than the national average.

With respect to this project, environmental justice issues concern either socioeconomic conditions or health risk exposures.

Socioeconomic Issues -- Socioeconomic issues include the potential for direct effects in terms of disproportionately more layoffs among low-income or minority employees and indirect economic effects on minority or low-income populations. There are no data available indicating that there would be a disproportionate employment impact on minority or low-income populations. DOE, along with their management and operations contractor and their subcontractors, maintain small business and small, disadvantaged business programs as well as Equal Employment Opportunity programs. The Equal Employment Opportunity programs require that no group is discriminated against in terms of employment at the Hanford Site.

Where economies are dependent on one industry, there is substantial potential for indirect effects from fluctuations in activity in this industry. Hanford represents approximately 21 percent of the Study Area labor force. In the high growth periods of boom-bust cycles, the population influx tends to drive housing values up, which can make housing unaffordable for low-income persons. By contrast, during business contractions, business activity drops, and unemployment rises.

As shown in Table 5-3, 835 jobs are estimated to be lost after fiscal year 2002 under the preferred alternative. This represents 1 percent of the total labor force in the Study Area. The estimated reduction in income is \$49 million, which represents 1.3 percent of the Study Area total. Direct effects will be felt by relatively highly paid Hanford Site employees and indirect effects will be dispersed throughout the area, primarily in the government and trade sectors. This impact on the Study Area economy will be relatively small, and is not expected to disproportionately affect minority or low-income populations, except to the extent that these populations may have more difficulty recovering from unemployment or business losses.

In addition, indirect effects of the preferred alternative and those of other projects in the Region cannot be separated. Although the incremental actions of the preferred alternative are small, the effect of the preferred alternative combined with other projects at the Site could affect low-income groups and minority groups, as discussed in Section 6, Cumulative Impacts.

Health Risk Exposures -- Within 80 km (50 mi) of the Hanford Site, the minority population comprises approximately 25 percent of the population and 42 percent of households are classified as low-income. Block groups where more than 50 percent of households are low-income are located south of the Site (DOE, 1995). Although some minority and low-income populations live relatively close to the Hanford Site, minimal health risks are projected for any offsite population for the preferred alternative. Routine emissions from the preferred alternative would be within allowable limits, and normal emissions at the Site boundary from the preferred alternative would be well within legal limits which are protective of human health. The only people affected by routine emissions would be Hanford Site personnel. To limit individual radiation exposure and meet health and safety requirements, additional employees will be rotated, as necessary. Hanford Equal Employment Opportunity programs are designed to prevent onsite institutional biases regarding exposure of minority groups to project actions. The preferred alternative is not expected to substantially affect human health or result in disproportionately high and adverse impacts to minority and low-income populations.

## **5.1.7 Transportation**

The following subsections identify impacts to the Hanford Site transportation system associated with stabilization and removal activities at the PFP Facility and provide details regarding shipping waste by truck and by rail at the Hanford Site.

### **5.1.7.1 Hanford Site Transportation System**

In preparation for stabilization and removal activities, equipment and chemicals would be transported to the PFP Facility. The small amount of additional equipment needed to support stabilization and removal activities would generate approximately two or three truck trips total. A total of approximately six truck trips would be generated to transport liquid chemicals during the initial phase of removal and stabilization. Because the number of truck trips needed to transport equipment and chemicals would be small and would occur infrequently, the transportation system would not be appreciably impacted to support the preferred alternative.

Activities supported by the 592 PFP Facility employees include ongoing sludge stabilization activities and other interim actions. It is anticipated that an additional 62 employees would be required to support stabilization and removal activities associated with the preferred alternative. The affected roadway service levels or distribution would not appreciably change with the 9 percent increase of PFP Facility personnel required to support the preferred alternative. Consequently, the transportation system would not be appreciably impacted by personal vehicles as a result of implementing the preferred alternative.

Following completion of the preferred alternative, employment is expected to decrease to 254 employees. The expected reduction in employment at the PFP Facility could result in a reduction of Hanford Site traffic volume. Consequently, a beneficial impact to the transportation system could be realized.

During stabilization and removal activities, solid and liquid waste material would be generated and would require shipment to an appropriate Hanford Site solid waste management facility.

Approximately one truck trip per month of solid material would be expected from the PFP Facility during the stabilization and removal activity. Compared with the current volume of vehicular traffic on Hanford Site transport roadways, one additional trip per month would not be expected to adversely impact the existing or future transportation system. Moreover, adverse transportation impacts would not be expected since waste shipments would be made during off-peak hours and prior notice to onsite operations would be made.

Liquids generated during the stabilization and removal process would be transferred to the 200 Area Tank Farms (Double-Shell Tank System) for storage via the existing liquid effluent transfer system. Transfer of the liquid using the effluent transfer system would not impact the transportation system.

The Hanford Site rail system could be used to transport the liquid material, but would not be as practical as the effluent transfer system. This is because no existing track enters the double-fenced security enclosure around the PFP Facility. If the rail system were used to ship liquid material from the PFP Facility to the Double-Shell Tank System, additional track would have to be laid. Alternatively, the liquid could first be loaded into tank trucks, transported to the nearest rail spur, and then loaded into a tank rail car. The loaded tank rail car would be transported to the 204-AR Building, off-loaded, and piped into the 200 Area Tank Farms (Double-Shell Tank System).

### **5.1.7.2 Radioactive Waste Shipment by Truck**

Radioactive waste shipments occur routinely at the Hanford Site. Truck accident data since 1983 indicate that there have been no accidents involving radioactive waste (Green, 1995). However, of the 26 million truck miles driven since



1983, there were 114 truck accidents involving other types of cargo (WHC, 1993). Depending on the radioactive waste being transported (i.e., type, quantity, and activity of the material), varying degrees of packaging requirements and administrative controls are placed on the shipment. Examples of administrative controls for truck shipments are listed below:

- Speed restrictions
- Required escorts
- Shipping during off-peak hours
- No shipments during icy conditions.

### **5.1.7.3 Radioactive Waste Shipment by Rail**

The Hanford Site has transported radioactive waste by rail without incident for many years. Typically, onsite track and equipment are maintained to higher standards than commercial equipment. The assembly of the track is of a higher standard than normally used on commercial track of equal class. The result is a more stable track with a lower likelihood of track-caused derailments. While train wheels have slipped off the tracks several times, no train has tipped over or been in danger of tipping over.

Site procedures do not allow trains to operate in a conflicting manner on the Hanford Site tracks; therefore, a collision between two trains is highly improbable. Collisions between a train and a road vehicle are highly unlikely because waste is shipped normally during off-peak vehicle usage hours when there is little traffic and rail crossings along the train route are barricaded.

Other factors that promote a safe rail transport include:

- Low speed limits during normal travel, at speed-grade crossings, and at facility rail spurs. (These speed limits are lower than commercial limits for the same class of track.)
- The track is inspected no more than eight hours before a radioactive waste shipment.
- One crew member is assigned to watch the cars constantly for abnormalities.
- Rail shipments are not made during conditions of low visibility such as fog or darkness.
- Onsite train lengths are considerably shorter than commercial trains (7 cars vs. 60 cars), which reduces the amount of rolling mass and subsequently allows the train to stop in a shorter distance from a given speed.

These factors plus others help ensure safe transport of radioactive materials within the Hanford Site boundary.

### **5.1.8 Land Use**

No changes in land use in the 200 West Area and the PFP Facility would result from the preferred alternative. The 200 West Area is dedicated to waste management activities. In addition, the PFP Facility has been historically used for processing plutonium. As a result, the preferred alternative would be compatible with existing and planned land uses.

All operations would be conducted in buildings and facilities that are part of the existing environment. Furthermore, there would be no added visual impacts to the landscape as a result of this alternative.

### **5.1.9 Cultural Resources**

There are no anticipated impacts on the historic value of the Facility or any other cultural or historic resources as a result of stabilization activities. However, implementation of the removal activities would have the potential to impact

the historic value of several structures at the PFP Facility as a result of the removal of equipment. No archaeological resources or sites considered sacred by the Native Americans would be impacted by PFP Facility stabilization or removal activities.

The National Historic Preservation Act requires recordation of significant historic properties by Federal agencies whenever an agency action, or an action assisted by a Federal agency, may substantially alter or demolish a significant historic property. Section 101 of the National Historic Preservation Act requires that in such case appropriate records be made of the property and deposited in an institution with long-term curatorial capabilities. A Memorandum of Agreement between DOE and the Washington State Historic Preservation Officer has been signed and accepted by the Advisory Council on Historic Preservation. The Memorandum of Agreement addresses the measures that would be undertaken by DOE to record, document, and maintain the materials that would be produced (MOA, 1996).

### 5.1.10 Anticipated Health Effects

The following subsections present an evaluation of the health effects associated with routine and accident conditions for the preferred alternative. See Appendix D for the normal and accident exposures associated with stabilization and removal actions.

The health effects associated with plutonium are caused by spontaneous nuclear transformations which release excess energy in the form of radiation. These transformations are referred to as radioactive decay. As a result of the radioactive decay process, one element is transformed into another. This newly formed element is called a decay product and possesses physical and chemical properties different from those of its parent. The decay product may also be a radioactive atom, which will undergo radioactive decay. For example, Am-241 is included in this EIS because Pu-241 undergoes radioactive decay resulting in the production of Am-241.

To aid in the understanding of the magnitude of health effects from the alternatives developed in this EIS, the concept of excess latent cancer fatalities (LCF) is used. The principal health effect associated with exposure to low doses of radiation is cancer. The concept of LCF is based on the belief that there is a certain probability that individuals in a population will contract fatal cancers at a rate proportional to the level of radiation exposure received. For example, if an individual receives a radiation dose that corresponds to an LCF of 0.01, this means that individual is estimated to have a 1 in 100 increased chance of contracting a fatal cancer because of that radiation exposure. The magnitude of the risk of radiation-induced cancer depends on the individual's age at the time of exposure and gender. The currently accepted conservative dose-to-risk conversion factors of  $4 \times 10^{-4}$  LCF per person-rem for workers and  $5 \times 10^{-4}$  LCF per person-rem for the general population (including children) are based on the recommendations of national and international agencies (DOE, 1993b).

Occupational radiation exposures during normal conditions are limited by DOE and EPA. 10 CFR 835 (which replaced DOE Order 5480.11, Radiation Protection for Occupational Workers [DOE, 1992]) limits radiation exposure of workers to 5 rem per year. DOE Order 5400.5, Radiation Protection of the Public and the Environment (DOE, 1993c), limits radiation exposures to individual members of the general public from all exposure pathways to 100 millirem per year. In addition, Subpart H of 40 CFR 61, *National Emission Standards for Emission of Radionuclides other than Radon from Department of Energy Facilities*, limits radiation exposures from DOE facilities to the general public via air pathways to 10 millirem per year.

Radiation exposures during normal conditions would be maintained ALARA using a combination of facility design, operating procedures, engineering features, and administrative controls, as necessary. Both process and facility design would incorporate features to minimize emissions and exposure to direct radiation. For example, airborne emissions would be filtered and monitored during release.

#### 5.1.10.1 Projected Routine Exposures from Implementing the Preferred Alternative

During routine operations, only minimal releases of radioactive material to the environment are anticipated due to the extensive filtration systems used at the PFP Facility. From a health effects standpoint, there would be no meaningful effect from the preferred alternative on Hanford Site workers, the public, or the environment. However, health impacts to PFP Facility workers are anticipated and are discussed below.

The estimation of health effects to PFP Facility workers is based on a comparison of doses received by PFP Facility workers during earlier plutonium sludge stabilization activities with anticipated conditions during implementation of the preferred alternative. The following general process steps are involved in the projected stabilization activities:

1. Retrieve inventory
2. Transfer from vaults
3. Prepare feed
4. Stabilize material
5. Package product
6. Test for loss on ignition
7. Transfer to nondestructive analysis
8. Nondestructive analysis
9. Prepare for storage
10. Return to vault.

For each of the four treatment processes under the preferred alternative, Steps 1 through 10 have been evaluated. The estimate includes the dose that PFP Facility workers would receive from performing the steps noted above and from ambient radiation levels in the PFP Facility. The doses and times associated with each alternative have been calculated using information and dose rate data provided by PFP Facility personnel on comparable processes, with adjustments made to consider differences in source material radiation characteristics (see Appendix D).

The doses and LCF for routine operations under the preferred alternative applicable to each inventory group are presented in the following sections. The total PFP Facility worker dose and corresponding LCF associated with stabilization is conservatively estimated to be 730 person-rem and 0.29, respectively. Tables 5-5 and 5-6 provide a summary for each affected population. The total PFP Facility worker dose associated with removal is conservatively estimated to be 200 person-rem, with corresponding LCF of 0.080.

### Plutonium-bearing Solutions

The preferred alternative for plutonium-bearing solutions is ion exchange, vertical calcination, and thermal stabilization. A detailed description of the process is presented in Subsection 3.2.1.1. The PFP Facility worker dose resulting from this operation is 86 person-rem. Using the conversion factor of  $4 \times 10^{-4}$  LCF per person-rem, there would be 0.034 LCF resulting from this operation.

Health effects to Hanford Site workers and offsite individuals from this inventory group are minimal. Based on air quality information provided in Subsection 5.1.3.1, the dose for Hanford Site workers from this step in the preferred alternative is  $2.0 \times 10^{-4}$  person-rem with corresponding LCF of  $7.9 \times 10^{-8}$ . The dose for the maximally exposed hypothetical offsite individual is  $7.4 \times 10^{-6}$  rem with a corresponding LCF of  $3.7 \times 10^{-9}$ . The 80-km (50-mi) radius offsite population dose and associated health effects are shown in Tables 5-5 and 5-6.

**Table 5-5 Summary of Radiation Exposures from the Preferred Alternative for Stabilization**

Inventory Group	Affected Population		
	PFP Facility Worker	Hanford Site Worker	80-km Radius

	(person-rem)	(person-rem)	Public (person-rem)
Plutonium-bearing Solutions	86	$2.0 \times 10^{-4}$	0.80
Oxides, Fluorides, and Process Residues	450	$3.6 \times 10^{-3}$	13
Metal and Alloys	180	$4.6 \times 10^{-5}$	0.16
Polycubes and Combustibles	15	$4.7 \times 10^{-4}$	0.16
Total	730	$3.9 \times 10^{-3}$	14

**Table 5-6 Summary of Radiological Health Effects from the Preferred Alternative for Stabilization**

Inventory Group	Affected Population		
	PFP Facility Worker (LCF)	Hanford Site Worker (LCF)	80-km Radius Public (LCF)
Plutonium-bearing Solutions	0.034	$7.9 \times 10^{-8}$	$3.5 \times 10^{-4}$
Oxides, Fluorides, and Process Residues	0.18	$1.4 \times 10^{-6}$	$6.4 \times 10^{-3}$
Metal and Alloys	0.072	$1.9 \times 10^{-8}$	$8.2 \times 10^{-5}$
Polycubes and Combustibles	0.0060	$1.8 \times 10^{-8}$	$8.1 \times 10^{-5}$
Total	0.29	$1.6 \times 10^{-6}$	$6.9 \times 10^{-3}$

### Oxides, Fluorides, and Process Residues

The preferred alternative for oxides, fluorides, and process residues is continuous thermal stabilization. A detailed description of the process is presented in Subsection 3.2.1.2. The estimated PFP Facility worker dose for this alternative is 450 person-rem, with a resulting 0.18 LCF.

Health effects to Hanford Site workers and offsite individuals from this inventory group are minimal. Based on air quality information provided in Subsection 5.1.3.1 the dose for the Hanford Site workers from this step in the preferred alternative is  $3.6 \times 10^{-3}$  person-rem, with a corresponding LCF of  $1.4 \times 10^{-6}$ . The dose for the maximally exposed hypothetical offsite individual is  $1.3 \times 10^{-4}$  rem with a corresponding LCF of  $6.5 \times 10^{-8}$ . The 80-km (50-mi) radius population dose and effects for this step are shown in Tables 5-5 and 5-6.

### Metals and Alloys

The preferred alternative for metals and alloys is repackaging. A detailed description of this alternative is presented in Subsection 3.2.1.3. The estimated PFP Facility worker dose and corresponding LCF for this alternative are 180 person-rem and 0.072, respectively.

Health effects to Hanford Site workers and offsite individuals from this inventory group are minimal. Based on air quality information provided in Subsection 5.1.3.1, the dose for the Hanford Site workers from this step in the preferred alternative is  $4.6 \times 10^{-5}$  person-rem, with a corresponding LCF of  $1.9 \times 10^{-8}$ . The dose for the maximally exposed hypothetical offsite individual is  $1.7 \times 10^{-6}$  rem, with a corresponding LCF of  $8.5 \times 10^{-10}$ . The 80-km (50-mi) radius population dose and effects for this step are shown in Tables 5-7 and 5-6.

### Polycubes and Combustibles

The preferred alternative for polycubes and combustibles is pyrolysis. A detailed description of this alternative is presented in Subsection 3.2.1.4. The estimated PFP Facility worker dose for this alternative is 15 person-rem, with a corresponding LCF of  $6.0 \times 10^{-3}$ .

Health effects to Hanford Site workers and offsite individuals from this inventory group are minimal. Based on air quality information provided in Subsection 5.1.3.1, the dose for the Hanford Site workers from this step in the preferred alternative is  $4.6 \times 10^{-5}$  person-rem, with a corresponding LCF of  $1.8 \times 10^{-8}$ . The dose for the maximally exposed hypothetical offsite individual is  $1.7 \times 10^{-6}$  rem with a corresponding LCF of  $8.5 \times 10^{-10}$ . The 80-km (50-mi) radius population dose and effects for this step are shown on Tables 5-5 and 5-6.

### Removal of Readily Recoverable Plutonium from PFP Systems

Routine PFP Facility worker exposures have been estimated for the removal of retrievable hold-up material from PFP systems. These estimates are based on estimated dose rates, working conditions, and process efficiencies. In addition to the doses received during the actual removal steps, there will also be exposure to PFP Facility workers during subsequent stabilization processes. Table 5-7 summarizes the anticipated routine PFP Facility worker exposures and associated health effects for the removal alternative steps.

**Table 5-7 Summary of Radiological Dose and Health Effects From the Preferred Alternative for Removal for PFP Facility Workers**

Activities	Routine PFP Facility Worker Dose (person-rem)	LCF
Plutonium Removal from the E-4 Ventilation System Ductwork	130	$5.2 \times 10^{-2}$
Plutonium Removal from the Process Vacuum System Piping	56	$2.2 \times 10^{-2}$
Plutonium Removal from the Glove Boxes	5.1	$2.0 \times 10^{-3}$
Plutonium Removal from the PRF Canyon	1.0	$4.0 \times 10^{-4}$
Thermal Stabilization of Removed Plutonium	7.5	$3.0 \times 10^{-3}$
Total	200	$8.0 \times 10^{-2}$

#### 5.1.10.2 Accidents Associated with the Preferred Alternative

The following subsections examine accident scenarios for the preferred alternative. Accident scenarios could involve the entire Facility or non-specific portions of processes that do not depend specifically on the alternative being performed. These accident phenomena are common to all of the alternatives presented in this EIS and are briefly

examined in Appendix C. These common shared accidents and natural phenomena are as follows:

- Greater than sustained 145 km/hr (90 mi/hr) straight wind and/or missile associated with a 145 km/hr (90 mi/hr) wind
- Greater than 0.20 gravity peak horizontal ground acceleration earthquake
- External flooding
- Aircraft accident involving the PFP Facility
- An accident at the PFP Facility, induced by an accident on nearby transportation routes or an accident at another nearby facility
- Criticality anywhere in the PFP Facility.

Table 5-8 provides quantitative definitions of the words "anticipated," "unlikely," "extremely unlikely," and "incredible." Appendix C provides a discussion on the basis of these definitions. Wherever these words appear in the discussion of accident scenarios, they should be understood as defined in Table 5-8 and in Appendix C.

**Table 5-8 Accident Nomenclature**

<b>Accident Term</b>	<b>Estimated Annual Frequency</b>	<b>Description</b>
Anticipated	Once per year to once per 100 years	Accidents that definitely may occur once or more during the lifetime of the facility
Unlikely	Once per 100 years to once per 10,000 years	Accidents that could occur at some time during the lifetime of the facility  Natural phenomena of this probability class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gusts, etc.
Extremely Unlikely	Once per 10,000 years to once per million years	Accidents that will probably not occur during the life-cycle of the facility
Incredible	Less than once per million years	Accidents that could not credibly occur and that are not reasonably foreseeable

The remainder of this subsection describes bounding case accidents analyzed for each of the four inventory groups under the preferred alternative.

The operation of systems and equipment associated with the preferred alternative would not be allowed to begin until a safety analysis has been completed. Throughout this and other sections of the EIS that discuss accident scenarios, the *PFP Final Safety Analysis Report* (FSAR) (WHC, 1995a) should be considered the primary reference. ALARA evaluations and dose reduction provisions would be in place prior to implementing the alternative processes. The consequences of implementing the alternative described in the following paragraphs and subsections are based on estimates that conservatively bound the anticipated effects. Atmospheric dispersion and dose calculations models used are also very conservative. Safety practices and radiological controls currently in place at the PFP Facility will furthermore ensure that actual PFP Facility worker doses associated with any of the alternatives are well below the estimated levels.

### **Quantification of Health Effects from Accident Scenarios**

Several accident scenarios for the preferred alternative are described in this subsection. Individual accident scenarios have been selected from this set to be further analyzed for the purpose of determining and comparing potential health-related impacts.

Based upon engineering analysis and a review of historical events associated with DOE facilities, most of the accident phenomena discussed in this subsection are expected to have small consequences. For some events such as an aircraft crash involving the PFP Facility or an accident at the PFP Facility induced by man-made external events (e.g., by an accident on a nearby transportation route or by an accident at a facility nearby the PFP), there is a high degree of confidence for determining that these events are incredible or extremely unlikely. After screening the accident phenomena, two scenarios were recognized as predominant contributors to accident risks.

A fire or small explosion in a process vessel or glovebox involving radiological material represents an anticipated accident and could result in moderate to large consequences. Based on historical events and evaluation of PFP Facility equipment and processes, a fire/explosion would be expected to result in less severe consequences than those presented here.

The second bounding accident/natural phenomena selected to represent risk to Hanford Site workers and the public involves a severe earthquake.

A 0.20 gravity earthquake is extremely unlikely (with an estimated return period of 10,000 years), but could potentially result in large consequences, especially in terms of deaths and disabling injuries due to collapsing structures and falling equipment. The consequences from this earthquake do not depend on the specific alternative implemented at the PFP Facility, but will affect the entire Facility and inventory. The calculated consequences are taken from the PFP FSAR and are presented in this EIS to bound the effects of natural events that could be associated with operations. Implementation of the stabilization and removal alternatives would eventually lead to a reduction of the risks associated with this event by placing the inventory of plutonium now at risk in a more stable controlled configuration.

The anticipated health effects from this bounding seismic event are presented for Hanford Site workers and offsite individuals calculated in the same manner as for the other accidents. The source term given in the PFP FSAR postulates release of 1.9 g ( $4.1 \times 10^{-3}$  lb) plutonium, which corresponds to an effective dose equivalent of 15.2 rem for the Hanford Site worker and 0.31 rem for the offsite individual. The corresponding LCF for these maximally exposed hypothetical receptors are 0.006 and  $2 \times 10^{-4}$ , respectively.

A fire/explosion is the accident scenario examined for potential health effects from implementing the preferred alternative for each of the four plutonium inventory groups. A duct segment drop during removal is evaluated to represent risks from removal activities.

## **Plutonium-bearing Solutions**

The preferred alternative associated with this inventory group involves the use of an ion exchanger to pretreat some of the plutonium-bearing solutions and a vertical calciner and thermal stabilization equipment.

### **Muffle Furnace**

A muffle furnace would likely be used to thermally stabilize the plutonium oxides powder produced during vertical calcination. Appendix C provides a more detailed evaluation of potential muffle furnace accident scenarios. The following three general types of potential accident phenomena pertain to muffle furnace operations:

- Explosion and/or fire
- Loss of ventilation not due to explosion or fire
- Breach/bypass of radiological material confinement or contamination control barrier(s) not due to explosion or fire.

As described earlier, the fire/explosion accident scenario is bounding. The pertinent factors used to quantify the releases and health effects from a fire/explosion associated with muffle furnace operations include a total mass of material being processed at one time (one batch) of 1,200 g (2.64 lbs) (600 g [1.32 lb]) plutonium. An airborne release fraction of  $5.0 \times 10^{-3}$  was chosen to represent the types of materials and processes involved. Forty percent of the released material is assumed to be of respirable size. Most anticipated events would be confined in the glovebox.

However, to conservatively estimate the potential impacts, it is assumed that the fire/explosion would damage the glovebox and allow 10 percent of the airborne material to leak directly into the adjacent room, exposing the PFP Facility workers present. A directly involved PFP Facility worker exposed to the contaminated atmosphere for 60 seconds would receive an effective dose equivalent of 100 rem, with an associated LCF of 0.04. Since this postulated accident would not affect the operation of the HEPA filters, no Hanford Site workers or offsite population would be meaningfully affected.

## **Vertical Calciner**

The accident scenarios postulated for vertical calciner operations have been developed from: 1) direct observation of a pilot vertical calciner at the PFP Facility that is undergoing non-radiological operational testing; 2) discussions with PFP Facility personnel; and 3) review of the PFP FSAR. The accident scenarios and frequency of occurrence information for muffle furnace operations are assumed to be applicable to vertical calciner operations. This is because the fundamentals of each operation are the same, namely, a high temperature process occurring in a glovebox. It is assumed that vertical calciner operations would be performed in a glovebox that is seismically qualified.

The following highlights the differences between vertical calciner and muffle furnace operations.

Temperature is essentially the only parameter that is monitored and alarmed during muffle furnace operations. Vertical calciner operations would also measure select flow and pressure parameters such as feed flowrate and offgas pressure. These parameters, along with calciner temperature and glovebox temperature, would be monitored and/or alarmed, thereby notifying operators of the need to take action.

After leaving the glovebox, vertical calciner offgases from vertical calciner operations would be treated similarly to muffle furnace offgases (i.e., receive additional HEPA filtration prior to release from the main ventilation stack). However, the offgas flowrate would be greater from vertical calciner operations. A breach of the offgas system in the glovebox could conceivably pressurize the glovebox but is extremely unlikely because of various process parameters and the likelihood of human intervention.

A relief valve is also provided on the main calciner unit (as opposed to the chiller/scrubber unit). The glovebox could be breached or pressurized if the relief valve fails to open and/or opens at a much higher pressure than planned.

It is assumed that the relief valve would rarely be required to operate because this would indicate an operational problem requiring corrective action. Analysis indicates that the relief valve could be needed three times per year and failure to open would remain an unlikely event. Likewise, the data indicate that failure to reclose would be an unlikely event.

Based on the above discussion, it is unlikely that the vertical calciner offgas system in the glovebox could cause an accident that would expose PFP Facility workers to radiological materials and/or harmful chemicals.

Vertical calciner offgases would be passed through a scrubber/chiller unit located in the same glovebox as the vertical calciner. Operation of the scrubber/chiller unit involves various solutions as discussed in Section 3 of this EIS. Should the scrubber/chiller unit be breached, tens of liters of liquid chemicals would be released into the glovebox. Unless the breaching is due to a fire or explosion, the liquid would be contained in or drain from the glovebox in a controlled manner. In general, potential accidents associated with operation of the scrubber/chiller unit pose a much lower risk to PFP Facility workers than other aspects of vertical calciner operations.

To quantify the impacts from vertical calciner accidents, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 141 g (0.31 lb) plutonium. The airborne release fraction is taken to be  $2.0 \times 10^{-6}$  with all airborne material assumed to be of respirable size. Under the same conditions as described for the muffle furnace accident, doses to a PFP Facility worker would be 0.024 rem, with an associated LCF of  $9.6 \times 10^{-6}$ .

## **Ion Exchange**

Ion exchange would be performed in a glovebox that would be seismically qualified. Ion exchange would present a



low accident-related risk. High temperatures would not be involved, and there would be essentially no offgases. Normal ion exchange system pressure would present a very low energy hazard. However, the extensive use of nitric acid for the ion exchange process adds a chemical hazard aspect to this activity. The following represent a reasonable range of accidents that could be associated with ion exchange activities:

- Overpressurization/explosion of an ion exchange column
- Equipment failure or human error resulting in a spill
- Contaminated wound.

Few explosions and ruptures of ion exchangers have occurred at DOE facilities. The most notable explosion of glovebox-sized ion exchanger occurred in 1976. This accident was associated with the Americium Recovery Process in Building 242-Z (McMurray, 1983).

Credible mechanisms for the rupture or explosion of the ion exchange column(s) can be postulated. Assuming prolonged stagnant conditions in an ion exchanger with heavily loaded resin, decay heat and/or radiolysis of water could lead to a rupture or explosion. Prolonged stagnant conditions could be caused by intentional or inadvertent isolation of an ion exchange column. For decay heat to pose a significant threat, the loading on the resin would need to be skewed heavily toward Pu-238 and/or Am-241. Radiolysis presents a somewhat more significant concern. Assuming a 1,000-g (2.2-lb) loading of Pu-239 on the ion exchange resin, it would take about 40 hours to generate 1 l (0.035 ft<sup>3</sup>) of hydrogen gas. If an ion exchange column were hermetically isolated for many days, rupture due to overpressurization (or explosion if an ignition source were present) could occur. It is unlikely that an ion exchanger would be hermetically isolated, and it is also unlikely that an ion exchanger would be left isolated for many days with loaded resin.

Select resins can experience decomposition reactions that can also be explosive under certain circumstances.

Though at least one rupture/explosion of an ion exchange column has occurred over a period of decades, and though plausible mechanisms can be postulated for such events, these accident phenomena are unlikely. "Lessons learned" from similar historical events have been rigorously applied throughout the DOE complex, resulting in greatly improved conduct of operations practices and the sensitizing of workers to potentially hazardous situations. Additionally, various process parameters (e.g., temperature, pressure, flow rate) associated with ion exchange operations would be routinely monitored. If a rupture or explosion were to occur, it is improbable that unfiltered radiological material releases to the environment would occur. PFP Facility workers in the immediate area would be subject to direct contact with nitric acid and radiological materials.

### **Ion Exchange Accident**

Since there has been at least one historical example in the DOE complex of an ion exchanger exploding, an ion exchanger explosion accident scenario was also evaluated for the plutonium-bearing solution process involving that technology. This section evaluates the health effects that could occur as a result of potential accidents involving ion exchange operations.

The bounding ion exchange accident scenario for PFP Facility workers is an explosion in the glovebox containing the ion exchange column. The explosion causes a breach of all glovebox filtering equipment and allows the instantaneous release of plutonium to the surrounding room. The release from this accident is assumed to be contained in the immediate area so only PFP Facility workers in the immediate area would be affected. It is assumed that the column is fully loaded with plutonium (1,330 g [2.93 lb]) when the explosion occurs.

Under the same conditions as described for the muffle furnace accident, doses to the involved PFP Facility worker would be 0.22 rem, with an LCF of  $8.8 \times 10^{-5}$ .

Under accident conditions, minimal releases to the environment of radiological constituents are anticipated due to the extensive filtration systems used at the PFP Facility. From a health effects standpoint, there would be no meaningful effect from the accident scenarios on Hanford Site workers, the public, or the environment.

## Other Accidents

Equipment failure or human error could cause a spill, resulting in PFP Facility worker skin contamination, and/or inhalation of radiological materials, and/or direct contact with nitric acid. Ion exchange operations would involve extensive handling, packaging, and transfer (into and out of gloveboxes) of radiological and chemically hazardous materials. Any of these activities could conceivably lead to a spill scenario. Historical events indicate that spills should be an anticipated event.

A Hanford Site-specific study documents that 12 contaminated wounds associated with glovebox operations occurred from 1972 through 1986 (Sudmann, 1992). Contaminated wounds are anticipated events.

The only "liquid reduction technology" deemed a viable supplementary pretreatment option is evaporation. Evaporation would concentrate selected feed solutions into smaller volumes through the use of steam pressure. Temperatures as high as 135°C (275°F) would be associated with the process. Because the solute is generally non-volatile, the vapor/condensate would normally be only slightly contaminated. The PRF currently has evaporation equipment in a standby mode. However, some additional equipment and controls may be needed before operations could begin. The evaporation process could be performed semi-remotely, thereby minimizing PFP Facility worker exposure. The accidents postulated above for ion exchange, vertical calciner, and muffle furnace operations bound potential accidents associated with the evaporation process. Evaporation operations would present a small accident-related risk to PFP Facility and Hanford Site workers, the public, and the environment.

## Oxides, Fluorides, and Process Residues

The preferred alternative associated with this inventory group involves the use of thermal stabilization equipment that operates in a continuous mode. With the exception of an earthquake that results in a spill/release of radiological materials, the accident scenarios and frequency of occurrence information shown in Appendix C for muffle furnace operations are also applicable to continuous furnace operations. A continuous thermal stabilization system would likely be installed in new glovebox(es) that would be seismically qualified.

In association with the stabilization of fluorides and low-fired oxides, acid dissolution is a possible pretreatment step. Nitric acid and aluminum nitrate would be involved in the dissolution process. High organic bearing process residues (i.e., greater than 2.0 weight percent) are not expected to be encountered, but if they are, hydrolysis may be performed as a pretreatment. Acidic and/or caustic solutions would be involved in the hydrolysis process. PFP Facility workers would be protected from these chemical hazards through engineered barriers supplemented by administrative controls consisting of proper training, procedures, supervisory oversight, an industrial hygiene program, and other administrative controls, as necessary. Personal protective clothing and equipment would be worn as appropriate.

Flameups could occur during dissolution. Volatilized compounds associated with the hydrolysis process would present potential explosion/fire hazards. However, abnormal conditions would need to occur for these hazards to develop into accidents. For example, an explosion/fire scenario could develop if: 1) ventilation of the hydrolysis process was lost; 2) elevated temperatures and/or elevated volatilization rates persisted/occurred; and 3) an ignition source existed.

To quantify the impacts from accidents associated with the continuous thermal stabilization step of the preferred alternative, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 600 g (1.3 lb) plutonium. The airborne release fraction is taken to be  $5.0 \times 10^{-3}$ , with 40 percent of the airborne material assumed to be of respirable size. Under the same conditions as described for the muffle furnace accident, doses to a PFP Facility worker would be 250 rem, with an associated LCF of 0.1.

## Metals and Alloys

Repackaging is the preferred alternative associated with this plutonium inventory group. Repackaging of plutonium metals and alloys would present the lowest accident-related risk of all the stabilization activities presented in this EIS. Nevertheless, with the exception of an explosion, all of the accident scenarios and frequency of occurrence information for muffle furnace operations are also applicable to repackaging.

A concern during repackaging operations would be the potential for a pyrophoric event involving plutonium metal upon exposure to the atmosphere. The pyrophoric nature of plutonium has exhibited itself in a number of instances at DOE facilities over the past 50 years. In association with repackaging, this is sufficient to categorize a fire involving radiological materials as an anticipated event. However, exposure of the plutonium metal to the atmosphere would occur in a glovebox that is free of combustible materials (except for gloves), thereby minimizing the likelihood of a plutonium fire breaching the glovebox.

Brushing loose oxide from the metal would generate airborne radioactive material and high dose rates in the glovebox. During the bagless packaging phase, an argon purge would be employed. This purge gas flow could also facilitate radioactive materials becoming airborne. Loss of ventilation would represent a potentially hazardous situation.

As with each stabilization alternative, repackaging would involve numerous transfers of radiological materials into and out of gloveboxes. Transfers of the brushed-off oxides and packaging waste would employ traditional bag methods. The brushed metal would be transferred out of the glovebox using a bagless technique. Bag transfer events involving skin contamination and/or the internal deposition of radiological materials have occurred. DOE Savannah River Site personnel have developed a bagless transfer system that uses a hollow plug insert (Bigler, et al., 1994). This or a similar system would be used at the Hanford Site. Because of the history of events associated with bag-in and bag-out activities, and because of the novelty of bagless operations, an event resulting in a PFP Facility worker incurring skin contamination and/or the internal deposition of radiological materials is anticipated.

To quantify the impacts from accidents associated with the repackaging of metals and alloys step of the preferred alternative, a fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox during the repackaging step is 1,400 g (3.1 lb) plutonium. The airborne release fraction is taken to be  $5.0 \times 10^{-4}$ , with 50 percent of the airborne material assumed to be of respirable size. Under the same conditions as described for the muffle furnace accident, dose to a PFP Facility worker would be 52 rem, with an associated LCF of 0.02.

In addition to repackaging, this process would also involve a thermal stabilization step for a portion of the material. To quantify the impacts from accidents associated with the thermal stabilization step for metals and alloys under the preferred alternative, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox during the thermal stabilization step is 840 g (1.85 lb) plutonium. The airborne release fraction is taken to be  $5.0 \times 10^{-4}$ , with 50 percent of the airborne material assumed to be of respirable size. Under the same conditions as described for the plutonium-bearing solutions muffle furnace accident, doses to a PFP Facility worker would be 31 rem, with an associated LCF of 0.01.

## **Polycubes and Combustibles**

Pyrolysis is the preferred alternative associated with this plutonium inventory group. The accident scenarios and frequency of occurrence for muffle furnace operations are also applicable to pyrolysis operations. This is because each operation involves a high temperature process involving transuranic isotopes.

Pyrolysis operations have been performed at the PFP Facility. There are three operational aspects associated with pyrolysis that are not associated with the "muffle furnace with secondary combustion chamber" option that increase accident-related risk.

- The pyrolysis alternative is a more complex process option. More hardware and tasks are involved. Therefore, there is greater opportunity for hardware failure or human error resulting in an accident.
- In the past, scrubbing of distillation offgases was performed with the use of carbon tetrachloride. It is improbable that carbon tetrachloride would be used in the future. It is possible that the replacement scrubbing agent could also be hazardous to human health.
- The hot water bath that would be used to facilitate removal of krylon or tape from polycubes would present a potential hazard to PFP Facility workers.

To quantify the impacts from accidents associated with the pyrolysis step of the preferred alternative, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 90 g (0.2 lb) plutonium. The airborne release fraction is taken to be  $6.0 \times 10^{-3}$ , with 1 percent of the airborne material assumed to

be of respirable size. Under the same conditions as described for the muffle furnace accident, doses to a PFP Facility worker would be 0.74 rem, with an associated LCF of  $3.0 \times 10^{-4}$ .

### Accidents Associated with Removal of Hold-up Material

As discussed in Section 3 of this EIS, the removal of hold-up material would involve the use of chemical, mechanical, and disassembly techniques. The following types of accidents have the greatest potential for occurring during removal activities and should be considered as anticipated events:

- Industrial accidents
- Chemical accidents
- Accidents leading to the inhalation of radiological materials or skin contamination
- Contaminated wound.

Though each of these types of accidents is categorized as anticipated, it is extremely unlikely that any of them could affect Hanford Site workers, the public, or the environment. The dominant risk associated with removal efforts would be to the PFP Facility workers actually performing the removal activities.

Industrial-type accidents are the primary accident-related concern associated with removal activities. Various abrasive jetting methods, wiping systems, and cutting techniques are described in Section 3 of this EIS. Accident-related data for each of these are not readily available or do not exist. However, PFP Facility workers who perform labor with mechanical equipment (especially in constricted work areas and while wearing personal protective clothing and equipment) have higher accidental death and disabling injury rates than those associated with many other occupations. Table 5-9 gives the rates for reportable injury and illness and for workplace fatalities for DOE and its contractors. The average rates for private industry in the United States are also provided for comparison.

**Table 5-9 Average Occupational Injury, Illness and Fatality Rates<sup>a</sup>**

Worker Category	All Labor Categories		Construction Workers	
	Total Injury/Illness	Fatalities	Total Injury/Illness	Fatalities
DOE and contractors <sup>b</sup>	3.2	0.0032	6.2	0.011
Private industry <sup>c</sup>	8.4	0.0097	13	0.034

**Notes:**a. All incidence rates are given per 100 worker-years

b. 1988-1992 averages (DOE, 1993d)

c. 1983-1992 averages (NSC, 1993)

To quantify the impacts from accidents associated with the removal of readily retrievable plutonium from the ducts, piping, gloveboxes and PRF canyon at the PFP Facility, the duct drop accident is evaluated as bounding. (Note that the removal work in the PRF canyon is all remote, posing minimal risk to PFP Facility workers from accidents.) The maximum amount of material at risk in the 0.76-m (2.5-ft) long duct segment is estimated to be 35 g (0.07 lb) plutonium. The airborne release fraction is taken to be 0.01, with 20 percent of the airborne material assumed to be of respirable size. Doses to a PFP Facility worker without respiratory protection (failed respirator or damaged in duct drop) would be 150 rem, with an associated LCF of 0.06.

### Other Accidents

Different types of acids, detergents, and bleaches would be used in conjunction with removal efforts. The hazard posed by these chemicals could lead to accidents that include inhalation of chemical fumes, chemical contact with the skin, or chemical contact with the eyes or other highly sensitive areas of the body.

Various scenarios leading to the inhalation of radiological materials by PFP Facility worker(s) have been postulated. These include inadequate sealing around the face of respiratory equipment, malfunctioning respiratory equipment filters, the failure to wear respiratory equipment when necessary, or the airborne escape of contamination from radiologically controlled areas (e.g., a greenhouse or glovebox) while removal activities are underway. PFP Facility workers would be protected from airborne radiological hazards and skin contamination events primarily through proper training, procedures, supervisory oversight, a radiological controls program, and other administrative controls. Personal protective clothing and equipment would be worn as appropriate for the task being undertaken. Additionally, continuous air monitors would be placed at strategic locations so that PFP Facility workers could be made aware of unusually high airborne concentrations of radiological materials.

### **5.1.11 Unavoidable Adverse Environmental Impacts**

Environmental Impact Statements often identify land use and/or water resources as the foremost areas to experience unavoidable adverse environmental impacts. Because all activities would take place inside an existing facility, implementation of the preferred alternative would not impact land usage or water resources. Implementation of the preferred alternative would have the potential for unavoidable adverse environmental impacts in three areas: health effects, accident phenomena, and cultural resources.

Under routine operations, health impacts to PFP Facility workers would be anticipated. The total potential PFP Facility worker dose for all stabilization and removal activities would be 930 person-rem with a corresponding LCF of 0.37.

Accident phenomena associated with the preferred alternative can be postulated that could lead to unavoidable adverse environmental impacts. Since no accidents are anticipated, accidents are not expected to contribute to adverse environmental impacts. The hazards and activities associated with the preferred alternative generally do not possess sufficient energy to disperse radioactive and/or chemically hazardous materials in such a manner as to adversely impact Hanford Site workers, the public, or the environment. The dominant risk and safety concern associated with the preferred alternative is for the PFP Facility workers.

Several structures located at the PFP Facility have been found to be eligible for the National Register of Historic Places. These structures have all been placed on the eligibility list that was submitted to the State Historic Preservation Officer. These structures are eligible due to their relation to the Manhattan Project, the Cold War, and historical industrial processes. Therefore, implementation of the preferred alternative could result in an unavoidable adverse environmental impact on "historic property." Mitigation measures have been prescribed by a memorandum of agreement with the State Historic Preservation Officer and the Advisory Council on Historic Preservation.

### **5.1.12 Potential Mitigation Measures**

Since land use and water resources would not be impacted by the preferred alternative, no mitigation measures would need to be taken in regard to these commodities. Mitigation measures have been discussed in this EIS (e.g., HEPA filtration of exhaust pathways).

To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal/routine activities would remain within established requirements, and to ensure that the risk of accidents would be minimized, numerous measures would be taken in association with the preferred alternative. These measures include adequate (engineered) design features for gloveboxes, systems, and components; the development of safety analyses consistent with the

process established by DOE; and the implementation of numerous programs that already exist at the Hanford Site. Examples of these programs are as follows:

- Maintenance program - Ensures hardware performs as expected when demanded
- Fire protection program - Mitigates property loss and minimizes human health impacts due to fire
- Criticality prevention program - Mitigates potential human health impacts of an inadvertent criticality
- Radiological controls program - Mitigates routine and accident-related doses
- Industrial hygiene program - Mitigates routine and accident-related chemical exposure
- Training program - Minimizes and mitigates adverse impacts to personnel by training them in proper ways to perform their job and to respond during emergency events.

### **5.1.13 Irreversible and Irretrievable Commitments of Resources**

There would be irreversible and irretrievable commitments of natural and manmade resources because of the installation and operation of the preferred alternative. These resources include the following:

- Materials
- Money
- Person-hours of labor
- Potentially, human life.

Various new gloveboxes, systems, and components would be installed and used if the preferred alternative were implemented. An ion exchanger, vertical calciner, furnaces (including muffle, continuous, and pyrolysis furnaces), and gloveboxes are the primary materials necessary for implementation of the preferred alternative. However, it should be noted that substantial support equipment (e.g., hold tanks, small pumps, local control panels, and various electrical components) would also be required. However, implementation of the preferred alternative would not be materials-intensive relative to many commercial/industrial undertakings, and the required materials are not rare or unique. Furthermore, use of these materials to implement the preferred alternative would not cause a negative impact on the availability of the subject materials. Because many of the subject materials would become contaminated, and because decontamination of the materials may not be technically feasible and/or cost-effective, it is assumed that they would not be recycled and would be irretrievably committed.

Installation and operation costs associated with the preferred alternative would be 144 million dollars. Should the no action alternative be chosen, the ongoing costs associated with that decision would quickly exceed the cost to implement the preferred alternative.

Implementation of the preferred alternative would entail the expenditure of many person-years of labor at the PFP Facility. As with money, it is noted that should the no action alternative be chosen, the ongoing person-years of labor at the PFP Facility associated with the no action decision would exceed the person-years of labor at the PFP Facility necessary to implement the preferred alternative.

Hundreds of person-rem could be accrued by implementing the preferred alternative. The effects on human health due to ongoing exposure to low levels of ionizing radiation are indeterminate. However, under the assumption that all radiation exposure is deleterious to human health, national and international organizations have established dose-to-risk conversion factors, where risk is expressed in terms of LCF. It is postulated that implementation of the preferred alternative would result in some short-term increase in LCF. It is noted that should the no action alternative be chosen, the ongoing LCF associated with that decision would eventually exceed the LCF associated with implementation of the preferred alternative.

### **5.1.14 Relationship Between Short-term Use and Long-term Productivity of the Environment**

No new facilities, buildings, or structures would be built under the preferred alternative. Additionally, land usage and water resources would not be impacted by implementation of the preferred alternative. All activities proposed under the preferred alternative would occur inside existing PFP Facility structures. Hence, the relationship between short-term use and long-term productivity of the environment is addressed in the context of the history and potential future uses of the PFP Facility (and the Hanford Site in general).

Implementation of the preferred alternative would partially facilitate decontamination and decommissioning. If the preferred alternative were implemented, all stabilized PFP Facility material would be stored in the PFP Facility pending a DOE decision on future disposition. Such a decision will be made with the issuance of the Record of Decision for the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement*. The Draft Programmatic EIS was issued in February 1996 (DOE, 1996). This Programmatic EIS evaluates alternatives for long-term storage of all weapons-usable fissile materials and the disposition of weapons-usable fissile materials declared surplus to national defense needs by the President.





## 5.2 ANTICIPATED IMPACTS OF THE ALTERNATIVE FOR PLUTONIUM-BEARING SOLUTIONS

Impacts from the alternative for plutonium-bearing solutions are evaluated in terms of the elements noted below. For areas not identified, there would be no meaningful difference between the anticipated impacts associated with the preferred alternative and the anticipated impacts associated with alternatives discussed in this section.

- Anticipated health effects
- Physical environment
- Unavoidable adverse environmental impacts
- Potential mitigation measures.

### 5.2.1 Anticipated Health Effects

The following sections present an evaluation of the health effects associated with routine and accident conditions for the plutonium-bearing solution alternative.

#### 5.2.1.1 Routine

Under routine operations, minimal releases to the environment of radiological constituents are anticipated due to the extensive confinement barriers (e.g., walls, piping, and filtration systems) used at the PFP Facility for controlling releases. From a health effects standpoint, there would be no meaningful effect from this alternative on Hanford Site workers, the public, or the environment. However, health impacts to PFP Facility workers are anticipated. This discussion will concentrate on the health impacts to PFP Facility workers. A detailed description of this alternative is given in Subsection 3.2.1.1.

The anticipated PFP Facility worker dose associated with the performance of this alternative is 86 person-rem. This dose results in a corresponding LCF of 0.03.

#### 5.2.1.2 Accidents Associated with the Plutonium-bearing Solution Alternatives

The alternative for stabilization of plutonium-bearing solutions identified in Subsection 3.3.1.1 is hydroxide precipitation, followed by thermal stabilization in (most likely) a muffle furnace. Accidents associated with muffle furnace operations are analyzed in detail in Appendix C.

Since a precipitation process would not involve the use of resin and ion exchange columns, the process would present less potential for accidents than ion exchange operations. Furthermore, select PFP Facility personnel have experience with the precipitation process because it was used in the production process at the PFP Facility in past years. Near ambient pressure and temperature conditions would be involved in a precipitation process. Hence, pressure and temperature related hazards would not exist. Also, there would be nearly negligible offgases. The use of solid magnesium hydroxide as a reagent adds a relatively small hazard to the process.

To quantify the impacts from accidents associated with hydroxide precipitation, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 704 g (1.5 lb) plutonium. The airborne



release fraction is taken to be  $1.2 \times 10^{-6}$ , with all of the airborne material assumed to be of respirable size. Doses to the hypothetical maximally exposed PFP Facility worker from this step under the same conditions as described for the muffle furnace accident would be 0.072 rem, with an associated LCF of  $2.9 \times 10^{-5}$ . This step would be followed by thermal stabilization, so the impacts from the muffle furnace accident described under the preferred alternative would also apply.

## Other Accidents

The discussions regarding a spill and a contaminated wound that were provided for the preferred alternative are also applicable to precipitation activities. However, in the event of a spill associated with precipitation activities, the nitric acid hazard would be much smaller or nonexistent.

Liquid reduction via evaporation as discussed in Subsection 5.1.10.2 may also be performed in conjunction with the precipitation (followed by thermal stabilization) alternative. The accidents postulated for precipitation and thermal stabilization activities bound potential accidents associated with the evaporation process.

## 5.2.2 Physical Environment

Impacts from the alternative for plutonium-bearing solutions on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage, and disposal capacity.

### 5.2.2.1 Air Quality

The following air contaminants and final stack release rates have been conservatively assumed to bound the maximum release rates of plutonium for this alternative. These release rates are continuous averages for the process described in Section 3.

Hydroxide precipitation followed by thermal stabilization

· Hydroxide precipitation

- No air emissions

· Thermal stabilization

- PM10:  $1.4 \times 10^{-8}$  g/sec ( $3.0 \times 10^{-11}$  lb/sec).

The hydroxide precipitation method would not have air emissions associated with the process, but the followup muffle furnace process would have projected emissions. The indicated particulate matter emissions for thermal stabilization would be made up of plutonium oxides which, for purposes of this portion of the EIS, were considered as a single emission contaminant, PM10.

By industrial standards, the muffle furnace process would produce small quantities of material per any given hour. Therefore, the exhaust from the followup process is projected to emit a small amount of particulate matter for atmospheric discharge. The offgas from any process located in a glovebox in the PFP Facility will be removed by the ventilation system and conveyed through a double HEPA filtration unit to the main stack (291-Z-1). This stack is 61 m (200 ft) above ground level with a measured exhaust flow rate of 7,080 m<sup>3</sup>/min (250,000 ft<sup>3</sup>/min).

A description of the factors involved in the dispersion modeling of air contaminants is given in Subsection 5.1.3.1. Maximum modeled concentrations are summarized in Table 5-10. From a standpoint of criteria pollutants from this alternative, the impact appears insignificant.

#### 5.2.2.2 Impacts to Waste Treatment, Storage, and Disposal Capacity

The impacts would be the same as those discussed in Subsection 5.1.3.3.

#### 5.2.3 Unavoidable Adverse Environmental Impacts

Implementation of this alternative would have the potential for unavoidable adverse environmental impacts in two areas, namely, health effects, and accident phenomena.

**Table 5-10 Projected Maximum Ground Level Concentrations of Particulate Air Contaminants from the Plutonium-bearing Solutions Alternative**

Alternative Process	Air Contaminant	Maximum Average Concentration <sup>a</sup> ( $\mu\text{g}/\text{m}^3$ )	Background Concentration <sup>b</sup> ( $\mu\text{g}/\text{m}^3$ )	Ambient Air Standard ( $\mu\text{g}/\text{m}^3$ )
Hydroxide Precipitation Followed by Thermal Stabilization	PM10 (24-hr)	$3.74 \times 10^{-8}$	81	150
	PM10 (Annual)	$7.47 \times 10^{-9}$	27	50

Source:PNL, 1991

Notes:a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 are taken from 1987 data.

Under routine operations, health impacts to PFP Facility workers would be anticipated. The total PFP Facility worker dose would be 85 person-rem with corresponding LCF of 0.03.

Accident phenomena associated with the hydroxide precipitation followed by thermal stabilization alternative could lead to unavoidable adverse environmental impacts. Since no accidents are anticipated, accidents are not expected to contribute to adverse environmental impacts. It is noted that the hazards and activities associated with the subject alternative generally do not possess sufficient energy to disperse radioactive and/or chemically hazardous materials in such a manner as to adversely affect Hanford Site workers, the public, or the environment. The dominant risk and safety concern associated with the subject alternative is for the PFP Facility workers.

#### 5.2.4 Potential Mitigation Measures

Potential mitigation measures have been discussed in this EIS (e.g., HEPA filtration of exhaust pathways). To ensure

that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal/routine activities would remain within established requirements and protocol, and to ensure that the risk of accidents would be minimized, numerous measures would be taken in association with the hydroxide precipitation followed by thermal stabilization alternative. These measures include the use of engineered design features for gloveboxes consistent with standards and requirements for nuclear equipment. Examples of these programs are discussed in Subsection 5.1.12.





## **5.3 ANTICIPATED IMPACTS OF THE ALTERNATIVE FOR OXIDES, FLUORIDES, AND PROCESS RESIDUES**

Impacts from the alternative for oxides, fluorides, and process residues are evaluated in terms of the elements noted below. For areas not identified, there would be no measurable difference between the preferred alternative and the alternative discussed in this section.

- Anticipated health effects
- Physical environment
- Unavoidable adverse environmental impacts
- Potential mitigation measures.

### **5.3.1 Anticipated Health Effects**

The following sections present an evaluation of anticipated health effects for routine and accident conditions associated with the alternative for oxides, fluorides, and process residues. The alternative selected for evaluation uses the muffle furnace for batch thermal stabilization.

#### **5.3.1.1 Routine**

Under routine operations, minimal releases to the environment of radiological constituents are anticipated due to the extensive filtration systems used at the PFP Facility. From a health effects standpoint, there would be no meaningful effect from this alternative on Hanford Site workers, the public, or the environment. However, health impacts to PFP Facility workers are anticipated. The discussion below will concentrate on the health impacts to PFP Facility workers. A detailed description of the steps involved in this alternative is given in Subsection 3.3.2.

The anticipated PFP Facility worker dose associated with the performance of this alternative is 640 person-rem. This dose results in a corresponding PFP Facility worker LCF of 0.26.

#### **5.3.1.2 Accidents Associated with the Oxides, Fluorides, and Process Residues Alternative**

An alternative for the stabilization of oxides, fluorides, and process residues is muffle furnace treatment. Accidents for muffle furnace operations are analyzed in detail in Appendix C.

Acid dissolution and hydrolysis, as previously discussed in Subsection 5.1.10.2, may be employed as pretreatment steps.

To quantify the impacts from accidents associated with thermal stabilization using a muffle furnace, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 600 g (1.3 lb) plutonium. The airborne release factor is taken to be  $5.0 \times 10^{-3}$ , with 40 percent of the airborne material assumed to be of respirable size. Doses to a directly involved hypothetical maximally exposed PFP Facility worker from this step under the same conditions as described for the preferred alternative plutonium-bearing solutions group muffle furnace accident would be 250 rem, with an associated LCF of 0.10.

### 5.3.2 Physical Environment

Impacts from the alternative for oxides, fluorides, and process residues on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage, and disposal.

#### 5.3.2.1 Air Quality

The following air contaminants and final stack release rates have been conservatively assumed to bound the maximum release rates of plutonium for this alternative. These release rates are continuous averages for the process described in Section 3.

- Batch thermal stabilization
- PM10:  $2.4 \times 10^{-8}$  g/sec ( $5.3 \times 10^{-11}$  lb/sec).

By industrial standards, the batch thermal stabilization process would handle small quantities of material during processing. Therefore, this process is projected to produce small amounts of particulate matter for atmospheric discharge. The offgas from any process located in a glovebox in the PFP Facility would be removed by the ventilation system and conveyed through a double HEPA filtration unit to the main stack (291-Z-1). This stack is 61 m (200 ft) above ground level with a measured exhaust flow rate of 7,080 m<sup>3</sup>/min (250,000 ft<sup>3</sup>/min).

A description of the factors involved in the dispersion modeling of air contaminants is given in Subsection 5.1.3.1. The pertinent onsite and offsite maximum downwind concentrations projected by the model are given in Table 5-11 for the muffle furnace alternative. From a standpoint of criteria pollutants, the impact appears insignificant.

**Table 5-11 Projected Maximum Ground-Level Concentrations of Particulate Air Contaminants for the Oxides, Fluorides, and Process Residues Alternative**

Alternative Process	Air Contaminant	Maximum Average Concentration <sup>a</sup> (µg/m <sup>3</sup> )	Background Concentration <sup>b</sup> (µg/m <sup>3</sup> )	Ambient Air Standard (µg/m <sup>3</sup> )
Batch Thermal Stabilization	PM10 (24-hr)	$6.59 \times 10^{-8}$	81	150
	PM10 (Annual)	$1.32 \times 10^{-8}$	27	50

Source:PNL, 1991

Notes:a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data.

### 5.3.2.2 Waste Treatment, Storage, and Disposal Capacity

The impacts would be the same as those discussed in Subsection 5.1.3.3.

### 5.3.3 Unavoidable Adverse Environmental Impacts

Implementation of this alternative would have the potential for unavoidable adverse environmental impacts in two areas: health effects and accident phenomena. Potential impacts from accident phenomena are discussed in Subsection 5.2.3 of this EIS. The impacts discussed in Subsection 5.2.3 are also considered applicable here. Under routine operations, health impacts to PFP Facility workers would be anticipated. The total PFP Facility worker dose associated with implementing this alternative would be 640 person-rem, with a corresponding LCF of 0.26.

### 5.3.4 Potential Mitigation Measures

Potential mitigation measures have been discussed in this EIS (e.g., HEPA filtration of exhaust pathways). To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for routine activities would remain within established requirements and to ensure that the risk of accidents would be minimized, measures would be taken in association with the batch thermal stabilization alternative. These include the use of engineered design features for gloveboxes consistent with standards and requirements for nuclear equipment. Examples of these programs are discussed in Subsection 5.1.12.





## 5.4 ANTICIPATED IMPACTS OF THE ALTERNATIVE FOR METALS AND ALLOYS

Impacts from the alternative for metals and alloys are evaluated in terms of the elements noted below. For areas not identified, there would be no measurable difference between the preferred alternative and the alternative discussed in this subsection.

- Health effects
- Physical environment
- Unavoidable adverse environmental impacts
- Potential mitigation measures.

### 5.4.1 Anticipated Health Effects

The following sections present an evaluation of anticipated health effects for routine and accident conditions associated with the alternative for metals and alloys. This alternative uses the batch thermal stabilization process.

#### 5.4.1.1 Routine

Under routine operations, minimal releases to the environment of radiological constituents are anticipated due to the extensive filtration systems used at the PFP Facility. From a health effects standpoint, there would be no meaningful effect from this alternative on Hanford Site workers, the public, or the environment. However, health impacts to PFP Facility workers are anticipated. The discussion below will concentrate on the health impacts to PFP Facility workers. The anticipated PFP Facility worker dose associated with the performance of this alternative is 320 person-rem. This dose results in a corresponding PFP Facility worker LCF of 0.13. A detailed description of the steps involved in this alternative is given in Subsection 3.3.3.

#### 5.4.1.2 Accidents Associated with the Batch Thermal Stabilization Alternative for Metals and Alloys

An alternative for the stabilization of metals and alloys is muffle furnace treatment. Muffle furnace operations are analyzed in Appendix C.

To quantify the impacts from accidents associated with thermal stabilization of 100 percent of the metals and alloys using a muffle furnace, the fire/ explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 840 g (1.9 lb) of plutonium. The airborne release fraction is taken to be  $5.0 \times 10^{-4}$ , with 50 percent of the airborne material assumed to be of respirable size. Doses to a hypothetical maximally exposed PFP Facility worker from this step under the same conditions as described for the preferred alternative plutonium-bearing solutions group muffle furnace accident would be 31 rem, with an associated LCF of 0.01.

### 5.4.2 Physical Environment

Impacts from the alternatives for metals and alloys on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage, and disposal.

#### 5.4.2.1 Air Quality

The following air contaminants and final stack release rates have been conservatively assumed to bound the maximum release rates of plutonium for this alternative. These release rates are continuous averages for the process described in Section 3.

- Batch thermal stabilization
- PM10:  $3.7 \times 10^{-8}$  g/sec ( $8.1 \times 10^{-11}$  lb/sec).

By industrial standards, the batch thermal stabilization process would handle small quantities of material. Therefore, this process is projected to produce small amounts of particulate matter for atmospheric discharge. The offgas from any process located in a glovebox in the PFP Facility would be removed by the ventilation system and conveyed through a double HEPA filtration unit to the main stack (291-Z-1). This main stack (291-Z-1) at the PFP Facility is 61 m (200 ft) above ground level with a measured exhaust flow rate of 7,080 m<sup>3</sup>/min (250,000 ft<sup>3</sup>/min).

A description of the factors involved in the dispersion modeling of air contaminants is given in Subsection 5.1.3.1. The pertinent onsite and offsite maximum downwind concentrations projected by the model are given in Table 5-12 for the muffle furnace alternative. From a standpoint of criteria pollutants, the impact appears insignificant.

**Table 5-12 Projected Maximum Ground-Level Concentrations of Particulate Air Contaminants for the Metals and Alloys Alternative**

Alternative Process	Air Contaminant	Maximum Average Concentration <sup>a</sup> (µg/m <sup>3</sup> )	Concentration Background <sup>b</sup> (µg/m <sup>3</sup> )	Ambient Air Standard (µg/m <sup>3</sup> )
Batch Thermal Stabilization	PM10 (24-hr)	$05 \times 10^{-7}$	81	150
	PM10 (Annual)	$09 \times 10^{-8}$	27	50

**Source:**PNL, 1991

**Notes:**a. Maximum modeled ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data.

#### 5.4.2.2 Waste Treatment, Storage, and Disposal Capacity

The impacts would be the same as those discussed in Subsection 5.1.3.3.



### 5.4.3 Unavoidable Adverse Environmental Impacts

Implementation of this alternative would have the potential for unavoidable adverse environmental impacts in two areas, namely, health effects, and accident phenomena. Potential impacts from accident phenomena are discussed in Subsection 5.2.3 of this EIS. The impacts discussed in Subsection 5.2.3 are also applicable here.

Under routine operation, health impacts to PFP Facility workers would be anticipated. The total PFP Facility worker dose associated with implementing this alternative would be 320 person-rem with a corresponding LCF of 0.13.

### 5.4.4 Potential Mitigation Measures

Potential mitigation measures have been discussed in this EIS (e.g., HEPA filtration of exhaust pathways). To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal/routine activities would remain within established requirements and protocol, and to ensure that the risk of accidents would be minimized, numerous measures would be taken in association with the batch thermal stabilization alternative. These measures include the use of engineered design features for gloveboxes consistent with standards and requirements for nuclear equipment. Examples of these programs are discussed in Subsection 5.1.12.





## 5.5 ANTICIPATED IMPACTS OF ALTERNATIVES FOR POLYCUBES AND COMBUSTIBLES

Impacts from the alternatives for polycubes and combustibles are evaluated in terms of the elements noted below. For areas not identified, there would be no measurable difference between the preferred alternative and the alternatives discussed in this section.

- Health effects
- Physical environment
- Unavoidable adverse environmental impacts
- Potential mitigation measures.

### 5.5.1 Anticipated Health Effects

The following sections present an evaluation of anticipated health effects for routine and accident conditions associated with the alternatives for polycubes and combustibles. These two alternatives are batch thermal stabilization with secondary combustion chamber and molten salt oxidation.

#### 5.5.1.1 Routine

Under routine operations, only minimal releases to the environment of radiological constituents are anticipated due to the extensive filtration systems used at the PFP Facility. From a health effects standpoint, there would be no meaningful effect from these alternatives on Hanford Site workers, the public, or the environment. However, health impacts to PFP Facility workers are anticipated. The discussion below will concentrate on the health impacts to PFP Facility workers. A detailed description of the steps involved in these alternatives is given in Subsection 3.3.4.

The alternatives that are evaluated in this section are batch thermal stabilization and molten salt oxidation. The anticipated PFP Facility worker dose associated with the performance of the batch thermal stabilization alternative is 29 person-rem. This dose results in a corresponding PFP Facility worker LCF of 0.012. The estimated PFP Facility worker dose from the molten salt oxidation alternative is 19 person-rem, and the corresponding LCF is 0.008.

#### 5.5.1.2 Accidents Associated with Polycubes and Combustibles Alternatives

Two alternatives for the stabilization of polycubes and combustibles are muffle furnace treatment (with a secondary combustion chamber) and molten salt oxidation. The shared-in-common accident phenomena discussed in Appendix C are applicable to both alternatives. Muffle furnace operations (with a secondary combustion chamber) and the accident scenarios and frequency of occurrence information for muffle furnace operations are also applicable to the molten salt oxidation alternative and are discussed in Appendix C.

To quantify the impacts from accidents associated with thermal stabilization of the polycubes and combustibles using a muffle furnace with secondary chamber combustion, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 90 g (0.2 lb) plutonium. The airborne release factor is taken to be  $6.0 \times 10^{-3}$ , with 1 percent of the airborne material assumed to be of respirable size. Doses to a hypothetical maximally exposed PFP Facility worker from this step under the same conditions as described for the preferred alternative

plutonium-bearing solution muffle furnace accident would be 0.74 rem, with an associated LCF of  $3.0 \times 10^{-4}$ .

There are four aspects associated with the molten salt oxidation alternative that are not associated with the muffle furnace with secondary combustion chamber alternative that increase accident-related risk.

- The high-temperature molten salt bath solution would present a hazard to PFP Facility workers.
- Equipment associated with pre-feed and feed activities would present a hazard to PFP Facility workers. Equipment such as a shredder, heated hopper, crusher, and pneumatic feed injector would potentially be involved.
- The molten salt oxidation alternative is a more complex process than the muffle furnace with secondary combustion chamber alternative. More equipment and tasks are involved. Therefore, the opportunity for equipment failure or human error resulting in an accident would be greater.
- Molten salt oxidation operations have not been performed at the PFP Facility. PFP Facility personnel have no experience with the process.

It is currently unknown as to where in the PFP Facility molten salt oxidation operations would occur. If new glovebox(es) are used, they would be seismically qualified.

To quantify the impacts from accidents associated with thermal stabilization of the polycubes and combustibles using molten salt oxidation, the fire/explosion accident is evaluated as bounding. The total amount of material at risk in the process glovebox is 63 g (0.14 lb) plutonium. The airborne release factor is taken to be  $6.0 \times 10^{-3}$ , with 1 percent of the airborne material assumed to be of respirable size. Doses to an hypothetical maximally exposed PFP Facility worker from this step under the same conditions as described for the preferred alternative plutonium-bearing solutions muffle furnace accident would be 0.52 rem, with an associated LCF of  $2.1 \times 10^{-4}$ .

## 5.5.2 Physical Environment

Impacts from the alternatives for polycubes and combustibles on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage and disposal.

### 5.5.2.1 Air Quality

The following air contaminants and final stack release rates have been conservatively assumed to bound the maximum release rates of plutonium and gases for this alternative. These release rates are continuous averages for the process described in Section 3.

Batch thermal stabilization with secondary combustion

- PM10:  $2.0 \times 10^{-10}$  g/sec ( $4.4 \times 10^{-3}$  lb/sec)
- Carbon monoxide:  $1.7 \times 10^{-3}$  g/sec ( $3.8 \times 10^{-6}$  lb/sec)
- Styrene:  $7.9 \times 10^{-4}$  g/sec ( $1.7 \times 10^{-6}$  lb/sec)

Molten Salt Oxidation

- PM10:  $2.3 \times 10^{-8}$  g/sec ( $5.1 \times 10^{-11}$  lb/sec)
- Carbon monoxide:  $1.7 \times 10^{-2}$  g/sec ( $3.7 \times 10^{-5}$  lb/sec)
- Styrene:  $7.8 \times 10^{-3}$  g/sec ( $1.7 \times 10^{-5}$  lb/sec).

The indicated particulate matter emissions are comprised of plutonium dioxide. The gaseous emissions are carbon monoxide and styrene.

By industrial standards, the batch thermal stabilization and molten salt oxidation processes would involve only small quantities of material. The offgas from any process located in a glovebox in the PFP Facility would be removed by the ventilation system and conveyed through a double HEPA filtration unit to the main stack (291-Z-1). The main stack (291-Z-1) at the PFP Facility is 61 m (200 ft) above ground level with a measured exhaust flow rate of 7,080 m<sup>3</sup>/min (250,000 ft<sup>3</sup>/min).

A description of the factors involved in the dispersion modeling of air contaminants is given in Subsection 5.1.3.1. The pertinent onsite and offsite maximum downwind concentrations projected by the model are given in Table 5-13 for the batch thermal stabilization and molten salt alternatives. From a standard point of criteria pollutants, the impact appears insignificant.

#### 5.5.2.2 Waste Treatment, Storage, and Disposal Capacity

The impacts would be the same as those discussed in Subsection 5.1.3.3.

**Table 5-13 Projected Maximum Ground-Level Concentrations of Chemical and Particulate Air Contaminants from the Polycube and Combustibles Alternatives**

Alternative Process	Air Contaminant	Maximum Average Concentration <sup>a</sup> (µg/m <sup>3</sup> )	Background Concentration <sup>b</sup> (µg/m <sup>3</sup> )	Ambient Air Standard (µg/m <sup>3</sup> )
Thermal Stabilization	CO (1-hr)	1.2 x 10 <sup>-2</sup>	11,800	40,000
	CO (8-hr)	8.3 x 10 <sup>-3</sup>	6,500	10,000
	Styrene (24-hr)	2.2 x 10 <sup>-3</sup>	N/A	1,000
	PM10 (24-hr)	5.5 x 10 <sup>-10</sup>	81	150
	PM10 (Annual)	1.1 x 10 <sup>-10</sup>	27	50
Molten Salt Oxidation	CO (1-hr)	1.2 x 10 <sup>-1</sup>	11,000	40,000
	CO (8-hr)	8.1 x 10 <sup>-2</sup>	6,500	10,000
	Styrene (24-hr)	2.2 x 10 <sup>-2</sup>	N/A	1,000
	PM10 (24-hr)	6.6 x 10 <sup>-8</sup>	81	150
	PM10 (Annual)	1.3 x 10 <sup>-8</sup>	27	50

Source:PNL, 1991

**Notes:**a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data.

### 5.5.3 Unavoidable Adverse Environmental Impacts

Implementation of the batch thermal stabilization alternative or molten salt oxidation alternative for polycubes and combustibles would have the potential for unavoidable adverse environmental impacts in two areas, namely, health effects, and accident phenomena. Potential impacts from accident phenomena are discussed in Subsection 5.2.3 of this EIS. The impacts discussed in Subsection 5.2.3 are also applicable here.

Under routine operations, health impacts to PFP Facility workers would be anticipated for both batch thermal stabilization and molten salt oxidation. The total PFP Facility worker dose for batch thermal stabilization would be 29 person-rem with a corresponding LCF of 0.012. The total PFP Facility worker dose for molten salt oxidation would be 19 person-rem with a corresponding LCF of  $7.6 \times 10^{-3}$ .

### 5.5.4 Potential Mitigation Measures

Potential mitigation measures have been discussed in this EIS (e.g., HEPA filtration of exhaust pathways). To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal/routine activities would remain within established requirements and protocol, and to ensure that the risk of accidents would be minimized, numerous measures would be taken in association with either of the two subject alternatives. These measures include the use of engineered design features for gloveboxes consistent with standards and requirements for nuclear equipment. Examples of these programs are discussed in Subsection 5.1.12.





## 5.6 ANTICIPATED IMPACTS OF THE IMMOBILIZATION ALTERNATIVE

Impacts from the alternative for immobilizing plutonium-bearing materials are evaluated in terms of the elements noted below. For areas not identified, there would be no meaningful difference between the anticipated impacts associated with the preferred alternative and the anticipated impacts associated with alternatives discussed within this section.

- Health effects
- Physical environment
- Transportation
- Unavoidable adverse impacts to the environment
- Potential mitigation measures.

### 5.6.1 Anticipated Health Effects

Both normal operations and accident conditions could contribute to radiation exposures to PFP Facility workers, other Hanford Site workers, and members of the public. As in previous subsections, the possible consequences have been conservatively bounded to ensure that any actual impacts associated with the implementation of this alternative would be less than those presented in this EIS. The methods, factors, and parameters used in estimating doses and consequent health effects are contained in Appendix E.

#### 5.6.1.1 Routine

Exposures to radiation would result from normal operational activities associated with the immobilization alternative. PFP Facility workers would be subject to direct external radiation exposures while in the proximity of the plutonium-bearing source material. During routine operations, they would be protected from inhalation hazards by engineered barriers, monitoring, and personal protective devices. Routine releases of small quantities of plutonium from the PFP

Facility stack during operations could contribute to doses to Hanford Site workers and the offsite public. Potential exposures to each of these population groups will be addressed in the following paragraphs.

The actual external radiation doses that could be received by PFP Facility workers during implementation of the immobilization alternative would be affected by the length of time each individual is exposed to the plutonium source, the source strength, distance from the source, shielding between the individual and the source, and background radiation levels in the area. Direct radiation doses that could be received by PFP Facility workers implementing the immobilization alternative have been extrapolated from current PFP Facility exposure data. The extrapolation was based on the physical characteristics of the materials being processed and the technologies involved.

A scenario for immobilizing the candidate plutonium-bearing materials has been developed and consists of a series of steps, each of which contributes a certain amount of radiation dose to the PFP Facility workers. The scenario and associated estimates of worker dose for each operational step are provided in Appendix E of this EIS. These steps would be repeated until all immobilized materials have been shipped to a storage facility.

The total routine exposure to the PFP Facility workers involved in the immobilization alternative is conservatively estimated to be 74 person-rem. Based on the International Commission on Radiological Protection factor of  $4 \times 10^{-4}$  LCF per rem effective-dose-equivalent, the LCF probability for the PFP Facility workers is 0.03.

Other Hanford Site workers and the public would receive radiation dose from the implementation of the immobilization alternative because small releases of the material being handled would result from routine operations. The releases would be filtered through the main PFP Facility ventilation system before being released to the atmosphere through the main exhaust stack. After discharge from the stack, atmospheric dispersion would affect the concentration of the released activity. The conservatively estimated dose and health effect to Hanford Site workers and the public are shown in Table 5-14. A detailed discussion of the assumptions and calculation methods for these estimates is provided in Appendix E.

**Table 5-14 Estimated Doses and Health Effects from Routine Releases from Implementing the Immobilization Alternative**

Exposed Individual or Population	Dose Received	LCF Probability
PFP Facility Workers	74 person-rem	0.03
Hypothetical Maximally Exposed Individual (Hanford Site Worker)	1.2 x 10 <sup>-4</sup> rem	4.8 x 10 <sup>-8</sup>
Hanford Site Workers	6.2 x 10 <sup>-4</sup> person-rem	2.5 x 10 <sup>-7</sup>
Hypothetical Maximally Exposed Individual (Member of Offsite Public)	2.3 x 10 <sup>-5</sup> rem	1.2 x 10 <sup>-8</sup>
General Public (80-km radius population)	2.2 person-rem	1.1 x 10 <sup>-3</sup>

#### 5.6.1.2 Accidents Associated with the Immobilization Alternative

Health effects could result from potential accidents occurring during the implementation of the immobilization alternative. These accidents could be initiated by operational events or natural phenomena. Operational events include human error or the physical failure of components and equipment. Natural phenomena involve an earthquake or other catastrophic event and are equivalent to those for the stabilization actions described in Appendix D.

All of the accident scenarios and frequency of occurrence information described for muffle furnace operations are also generally applicable to immobilization activities. Accidents postulated in association with immobilization activities are:

- Fire or explosion inside the glovebox
- Mishap with equipment located in the cementation glovebox
- Mishap while transporting a drum on a dolly
- Forklift mishap while handling loaded drum(s)
- Vehicle accident while transporting loaded drums from the PFP Facility
- Human error or a malfunction with electro-mechanical equipment used in the cementation glovebox.

The methodology used to estimate the dose received by the PFP Facility workers, other Hanford Site workers, and the public due to an accident would be based on a fire or explosion occurring during immobilization operations. For example, an explosion occurring during a glovebox operation would over-pressurize the glovebox and result in the release of plutonium and americium to the room. This bounding accident event would not be energetic enough to cause the main filtration system to fail and result in an unfiltered release from the PFP Facility into the environment. Based on this methodology, the radiation doses received by the hypothetical maximally exposed PFP Facility worker, Hanford Site worker, and offsite individual are 210 rem, 1.6 x 10<sup>4</sup> rem, and 5.7 x 10<sup>-5</sup> rem, respectively. A detailed discussion of the assumptions and calculations for these estimates is provided in Appendix E.

Health effects from radiation exposure are computed by application of factors relating LCF with the amounts of exposure received. BEIR-V values are used to estimate the effects on PFP Facility and Hanford Site workers and members of the public. The factors are  $4 \times 10^{-4}$  LCF/rem effective dose equivalent for PFP Facility and other Hanford Site workers and  $5 \times 10^{-4}$  LCF/rem effective dose equivalent for members of the general public, which could include babies and children as well as adults (NRC, 1990).

Table 5-15 summarizes the maximally exposed individuals representing the three population groups that would receive the doses and associated LCF risks. Additional details may be found in Appendix E.

**Table 5-15 Estimated Doses and Health Effects from Accident Releases Associated with the Immobilization Alternative**

Hypothetical Maximally Exposed Individual	Dose Received	LCF Probability
PFP Facility Worker	210 rem	$8.4 \times 10^{-2}$
Hanford Site Worker	$1.6 \times 10^{-4}$ rem	$6.4 \times 10^{-8}$
Offsite Individual	$5.7 \times 10^{-5}$ rem	$2.8 \times 10^{-8}$

## 5.6.2 Physical Environment

Impacts of the immobilization alternative on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage, and disposal capacity.

### 5.6.2.1 Air Quality

Implementing the immobilization alternative would result in impacts to air quality. HEPA filters in use at the PFP Facility would minimize the amount of contaminants that would be discharged to the atmosphere. Although most expected air contaminants would be trapped by these filters, some fine particulate matter, referred to as PM<sub>10</sub> (particulates less than 10 microns in size) would be emitted.

The maximum downwind contaminant concentrations resulting from the immobilization alternative and the ambient air standards are provided in Table 5-16. A detailed discussion of the assumptions and calculation method for these estimates is provided in Appendix E.

### 5.6.2.2 Waste Treatment, Storage, and Disposal Capacity

Hanford Site solid waste management facilities that would potentially manage waste generated at the PFP Facility include the Transuranic Waste Storage and Assay Facility, the Central Waste Complex, the Low-Level Burial Grounds, and the Waste Receiving and Processing Facility.



The amount of low-level radioactive, mixed, and dangerous waste that would be generated as compared to the amount of transuranic waste that would be generated is small. It is anticipated that the immobilization alternative would generate approximately 1,600 drums of transuranic waste. It is assumed that drums would be transferred from the PFP Facility to the Transuranic Waste

**Table 5-16 Projected Maximum Ground-Level Concentrations of Particulate Air Contaminants**

<b>Air Contaminant</b>	<b>Maximum Average Concentration<sup>a</sup> (µg/m<sup>3</sup>)</b>	<b>Background Concentration<sup>b</sup> (µg/m<sup>3</sup>)</b>	<b>Ambient Air Standard (µg/m<sup>3</sup>)</b>
PM10 (24-hr)	1.9 x 10 <sup>-9</sup>	81	150
PM10 (Annual)	3.9 x 10 <sup>-10</sup>	27	50

**Notes:**a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data (PNL, 1991)

Storage and Assay Facility for storage. There is currently space for 500 additional drums of waste at this facility (Irwin, 1996). Additional space would become available when existing drums at the facility are transferred to other Hanford Site solid waste management facilities.

### 5.6.3 Transportation

Implementing the immobilization alternative would result in transportation impacts. Over a 6- to 12-month period, up to 90 truck trips would result from the shipment of the immobilized materials from the PFP Facility to Hanford Site solid waste management facilities. This corresponds to an average of 7 to 15 trips per month. These trips would be short in distance (3.2 km [2 mi]) and would be made during off-peak hours. Compared with the volume of vehicular traffic on nearby Hanford Site transport roadways, the additional truck trips would not be expected to adversely impact the existing or future Hanford Site transportation system.

### 5.6.4 Unavoidable Adverse Environmental Impacts

The most common areas of unavoidable environmental impact are to land use and water resources. Immobilizing plutonium-bearing materials would take place in existing facilities and transportation would be on existing roads, and therefore, would not impact these resources.

The immobilization alternative involves those actions necessary to process, package, and deliver the plutonium to a Hanford Site solid waste management facility. Actions and associated environmental impacts for subsequent handling and delivery of the plutonium to the final offsite disposal facility are not considered in this EIS.

Implementation of the immobilization alternative would have the potential for unavoidable adverse impacts in the areas of routine health effects, and accident phenomena. These impacts are discussed in Subsections 5.6.1.1 and 5.6.1.2 of this EIS.

### 5.6.5 Potential Mitigation Measures

Since land use and water resources would not be impacted by the immobilization alternative, no mitigation measures would need to be taken to protect these resources. To protect the workers, the public, and the environment, mitigation measures such as HEPA filtration would be provided.

To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal activities would remain within established requirements, and to ensure that the risk of accidents would be minimized, numerous mitigation measures would be taken in association with the immobilization alternative. These measures include adequate engineered design features for gloveboxes, systems, and components; the development of safety analyses consistent with the process established by DOE; and the implementation of numerous programs that already exist at the Hanford Site. Examples of these programs are as follows:

- Maintenance program - Ensures hardware performs as expected when demanded
- Fire protection program - Mitigates property loss and minimizes human health impacts due to fire
- Radiological controls program - Mitigates routine and accident-related doses
- Industrial hygiene program - Mitigates routine and accident-related chemical exposure
- Occupational safety program - Ensures safe and healthful conditions for workers
- Training program - Minimizes and mitigates adverse impacts to personnel by training them in proper ways to perform their job and to respond during emergency events.





## **5.7 ANTICIPATED IMPACTS OF THE NO ACTION ALTERNATIVE**

Under the no action alternative, the installation and operation of equipment to stabilize, remove, and immobilize plutonium-bearing materials would not take place. Actions would be limited to ongoing maintenance and security activities necessary for the safe and secure management of the PFP Facility. Impacts from the no action alternative are evaluated in the following elements.

- Geology, seismology, and soils
- Water resources and hydrology
- Physical environment
- Ecosystems
- Population and socioeconomics
- Environmental justice and equity
- Transportation
- Land use
- Cultural resources
- Anticipated health effects
- Unavoidable adverse environmental impacts
- Potential mitigation measures
- Irreversible and irretrievable commitments of resources
- Relationship between short-term use and long-term productivity of the environment.

### **5.7.1 Geology, Seismology, and Soils**

No impact to geological resources or soils would be expected from the no action alternative. Because the facilities already exist, there would be no need for Site modification. No leaks or spills are anticipated.

### **5.7.2 Water Resources and Hydrology**

All processes are contained inside the existing facility. Contaminants would not be released to the surface or groundwaters by the no action alternative. No impacts to water resources or hydrology are anticipated.

### **5.7.3 Physical Environment**

Impacts from the no action alternative on the physical environment are examined in terms of the following elements:

- Air quality
- Sound and noise levels
- Waste treatment, storage, and disposal capacity.

#### **5.7.3.1 Air Quality**

No change in existing air quality conditions would result from the no action alternative.

### 5.7.3.2 Sound and Noise Levels

No change in existing sound and noise levels would result from the no action alternative.

### 5.7.3.3 Waste Treatment, Storage, and Disposal Capacity

Units that would potentially manage waste generated at the PFP Facility include the Hanford Site solid waste management facilities the 200 Area Tank Farms (Double-Shell Tank System), and the city of Richland Landfill. Hazardous waste (i.e., not radioactive) would be transported off the Hanford Site to a permitted treatment, storage, or disposal facility. Fluids from the PFP Facility (such as ventilation heating/cooling wastewater, steam condensate, rainwater, and potable water overflow) are currently managed at the 200 Area Treated Effluent Disposal Facility.

The amount of transuranic, radioactive and mixed solid, radioactive and mixed liquid, and nonradioactive nonregulated solid waste that would be generated by the no action alternative (see Table 5-17) would not exceed the design capacities of the waste management units described in Subsection 4.9. Therefore, no additional capacity would be required as a result of the no action alternative.

**Table 5-17 Annual Solid Waste Generation**

Waste Type	Weight (kg)	Volume (m3)
Hazardous	1,360	3.52
Mixed Low-level radioactive	16,600	106
Mixed Transuranic	1,088	6.6
Mixed PCB Low-level radioactive	1,860	9.2
Non-regulated	2,720	5.6
PCB	78	0.74
Low-level radioactive	26,640	205
Transuranic	9,600	75

**Source:** SWIR106, 1995

**Note:** PCB = polychlorinated biphenyl

The volume of noncontact liquid could decrease from current levels due to the reduction of the PFP Facility staff associated with the no action alternative. This decrease in noncontact liquid generated at the PFP Facility could result in a positive impact at the 200 Area Treated Effluent Disposal Facility. The permitted capacity would not be exceeded. Therefore, no additional capacity would be required at the 200 Area Treated Effluent Disposal Facility as a result of

the not action alternative.

#### 5.7.4 Ecosystems

The no action alternative would not involve new construction or modification of the environment. There would be no new biological or ecological impacts.

#### 5.7.5 Population and Socioeconomics

The following section describes the impacts of PFP Facility operations of the no action alternative on employment, income, population, housing, and infrastructure. Socioeconomic impacts associated with this alternative were derived in the same manner as the preferred alternative using the same Study Area. Definitions of terms are used consistently for both alternatives.

##### 5.7.5.1 Local Economy, Employment, and Income

Under the no action alternative, direct PFP Facility employment would drop from its fiscal year 1995 level of 592 full-time equivalents to approximately 492 full-time equivalents in fiscal year 1997, where it would remain indefinitely. This employment reduction would result from the elimination of staff currently involved in interim activities, including sludge removal using muffle furnaces and other minor cleanup tasks, which would cease at the end of fiscal year 1995. The direct impact would therefore be a 17 percent labor force reduction of 100. The cessation of interim activities would also result in a 17 percent reduction in PFP Facility expenditures, from the fiscal year 1995 level of \$80 million to approximately \$67 million in fiscal year 1997.

Table 5-18 shows a summary of the IMPLAN modeling of impacts of the no action alternative on employment, output, and income. Direct changes in PFP Facility employment would result in an associated reduction in secondary employment from 644 full-time equivalents to 535 full-time equivalents. The total impact on Study Area employment would be a loss of 209 full-time equivalents. This translates into a 0.3 percent decrease in total Study Area employment. This Study Area employment impact is estimated to be smaller than the impact on employment from the preferred alternative. Since overall unemployment levels are expected to be relatively unaffected under the preferred alternative, they are not expected to be affected by the no action alternative.

Impacts of the no action alternative on Study Area output result from changes in PFP Facility expenditures. Direct changes in PFP Facility expenditures would lead to a decrease in secondary output from \$34 million in fiscal year 1995 to \$29 million in fiscal year 1996. The total impact on the Study Area would be a \$19 million reduction in output. This would mean an overall 0.3 percent decline in total Study Area output. The total impact of the no action alternative on Study Area output is smaller than what is predicted for the preferred alternative. Since overall economic activity is expected to remain relatively unaffected as a result of the preferred alternative, impacts of the no action alternative are also expected to be negligible.

**Table 5-18 Impacts of the No Action Alternative by Component Fiscal Year 1995 to 1996**

Economic Indicator	FY 95	FY 97	Impact FY 97	Study Area Total	Study Area Impact FY 97 (%)
Employment	.	.	.	.	.

Direct (FTE)	592	492	-100	N/A	N/A
Secondary (FTE)	644	535	-109	N/A	N/A
Total (FTE)	1,236	1,027	-209	79,680	-0.3
Output	.	.	.	.	.
Direct (\$Million)	80	67	-14	N/A	N/A
Secondary (\$Million)	34	29	-5	N/A	N/A
Total (\$Million)	115	95	-19	5,805	-0.3
Income	.	.	.	.	.
Direct (\$Million)	53	44	-9	N/A	N/A
Secondary (\$Million)	19	16	-3	N/A	N/A
Total (\$Million)	72	60	-12	2,728	-0.5

**Sources:** IMPLAN, 1995; Schilling, 1995; WHC, 1995b

**Notes:** FTE = Full-time equivalent

FY = Fiscal year

Direct changes in PFP Facility expenditures would also result in a decrease in secondary income from \$19 million in fiscal year 1995 to \$16 million in fiscal year 1997. The total impact on the Study Area would be a \$12 million expenditure reduction. This translates into an overall 0.5 percent decline in total Study Area income. Again, these impacts are smaller than what is expected under the preferred alternative. Since the preferred alternative is not expected to substantially affect overall personal or household income levels or poverty status in the Study Area, the effects of the no action alternative are also expected to be negligible.

Direct changes in PFP Facility employment and expenditures would be experienced in the government sector, since PFP Facility operations are classified in this sector. Secondary impacts, or changes in the larger economy that result from these direct changes, would be experienced by all sectors in the Study Area economy, as shown in Table 5-19. The no action alternative would have the largest total impacts on employment in the government sector with a 0.8 percent decline followed by trade with a 0.3 percent decline in government employment. In terms of output, the no action alternative would again have the largest total impact on the government and trade sectors with a 1.8 percent decline in government output, followed by trade with a 0.3 percent decline. Income in the government sector would fall by 1.6 percent, while income in the trade sector would fall by 0.3 percent.

#### 5.7.5.2 Demographics

Impacts on population growth in the Study Area resulting from the no action alternative are expected to be consistent with those of the preferred alternative. However, the magnitude of these impacts are expected to be smaller because of the impacts of the no action alternative on Study Area employment, output, and income are smaller in comparison to the preferred alternative.

**Table 5-19 Summary of Total Impacts of the No Action Alternative on Study Area Employment, Output, and Income by Sector**

Sector	Impact on Study Area Employment (%)	Impact on Study Area Output (%)	Impact on Study Area Income (%)
Agriculture, Forestry, Fisheries	0	0	0
Mining	0	0	0
Construction	0	-0.1	-0.1
Manufacturing	0	0	0
Transportation, Communication, Utilities	-0.2	-0.2	-0.2
Trade	-0.3	-0.3	-0.3
Finance, Insurance, Real Estate	-0.2	-0.2	-0.2
Services	-0.2	-0.2	-0.2
Government	-0.8	-1.8	-1.6

**Sources:** IMPLAN, 1995; Schilling, 1995; WHC, 1995b

### 5.7.5.3 Housing

Under the no action alternative, impacts on housing trends in the Study Area would be similar to the preferred alternative. However, these impacts are expected to be smaller in scale since the impacts of the no action alternative on employment and demographics are relatively smaller than the preferred alternative.

### 5.7.5.4 Local Infrastructure

Local infrastructure needs are expected to remain unchanged under the preferred alternative. Since the impacts of the no action alternative on the Study Area economy are projected to be smaller than the preferred alternative, the demand for local infrastructure is not expected to change under the no action alternative.

### 5.7.6 Environmental Justice and Equity

As stated in Subsection 5.7.5, employment and expenditure reductions for the no action alternative will be smaller than those projected for the preferred alternative, resulting in projected impacts on employment, output, and income that are 20 to 30 percent lower than the impacts associated with the preferred alternative. Study Area economic effects are

projected to be relatively small, and are not expected to disproportionately affect low income and minority populations.

Since minimal offsite impacts are projected for the no action alternative, the no action alternative is not expected to substantially affect human health or result in disproportionately high and adverse human health effects.

### **5.7.7 Transportation**

The no action alternative would not result in impacts to the transportation system. In conjunction with the expected Sitewide employment reduction, the no action alternative would result in a reduction of employment at the PFP Facility. Following the completion of interim actions in 1996, employment at the PFP Facility would decline from the current 592 full-time equivalents to approximately 492 full-time equivalents. The reduction in employment at the PFP Facility would result in a reduction of the Hanford Site traffic volumes. The transportation system would not be adversely impacted by the no action alternative.

### **5.7.8 Land Use**

There would be no changes in land use in the 200 West Area. The 200 West Area is dedicated to waste management activities. As a result, the no action alternative would be compatible with existing and planned land uses.

There would be no visual impacts. All existing buildings and facilities are part of the existing environment and the visual landscape.

### **5.7.9 Cultural Resources**

As discussed in Subsection 4.8, several structures located at the PFP Facility have been found to be eligible for the National Register of Historic Places. However, under the no action alternative, these structures will remain intact. Therefore there will not be any adverse impacts as a result of the no action alternative.

### **5.7.10 Anticipated Health Effects**

The following sections present an evaluation of the health effects associated with routine and accident conditions for the no action alternative.

#### **5.7.10.1 Routine**

##### **Gaseous Emissions**

Under no action alternative conditions, minimal releases of radiological constituents to the environment are expected due to the limited nature of the activities that would be conducted and the extensive filtration systems used at the PFP Facility. The expected releases from the PFP 291-Z-1 stack are summarized in Section 3. The total release of plutonium and americium is  $7.7 \times 10^{-10}$  g/sec ( $1.7 \times 10^{-12}$  lb/sec). The resulting exposures to the Hanford Site worker population would be  $7.4 \times 10^{-5}$  person-rem and for the offsite 80-km (50-mi) radius population 0.26 person rem. The



resulting LCF for the Hanford Site workers would be  $2.9 \times 10^{-8}$  and for the offsite population within an 80-km (50-mi) radius would be  $1.3 \times 10^{-4}$ .

### Liquid Waste Stream

Under the no action alternative, approximately  $3.0 \times 10^7$  l/yr ( $7.9 \times 10^6$  gal/yr) of water are expected to be produced and sent to the 200 Area Treated Effluent Disposal Facility. Section 3 discusses the expected concentrations of radionuclides in this waste stream. These levels are below the allowable limits for drinking water. No adverse health effects are expected to the PFP Facility worker, the Hanford Site worker, or the public.

### Solid Waste Stream

The average amount of solid wastes being generated at the PFP Facility in the current shutdown configuration is summarized in Table 5-17. This is representative of the solid wastes that would be generated for the no action alternative.

### Radiation

The annual anticipated PFP Facility worker dose associated with performing activities under the no action alternative will continue at the 1992 to 1994 average level of 53 person-rem. This total person-rem would result in a corresponding LCF of 0.02. Continued application of ALARA principles could result in a reduction of this dose.

#### 5.7.10.2 Accidents Associated with the No Action Alternative

The problems associated with each plutonium inventory group are similar enough that unique scenarios are not required. These problems include the pyrophoric nature of plutonium in certain forms; the generation of hydrogen gas (which presents an explosion and/or fire hazard); the use of containers/packaging materials for applications (such as long-term storage) for which they were not designed; and the ongoing PFP Facility worker radiological dose received while performing surveillance and maintenance functions associated with the plutonium inventory groups.

PFP Unusual Occurrence Reports over the past few years, and the PFP FSAR, provide the best information for potential PFP Facility accident scenarios under the no action alternative. Table 5-20 summarizes the abnormal and accident phenomena that were examined in the PFP FSAR. In general, abnormal phenomena only have the potential to impact PFP Facility workers; whereas, accident phenomena have the potential to significantly affect Hanford Site workers, or the public.

The abnormal events shown in Table 5-20 are credible and in most instances should be categorized as anticipated based on historical events at sites throughout the DOE complex. Contributors to the avoidance of abnormal events are adequate training, well written procedures, and effective preventive and corrective maintenance programs. Appropriate PFP Facility worker response to an abnormal event (i.e., response in accordance with training and abnormal/emergency response procedures) is the most important contributor to minimizing consequences to the PFP Facility workers.

All abnormal events discussed in Appendix C, and their associated frequencies of occurrence, are applicable to the no action alternative.

**Table 5-20 Abnormal and Accident Phenomena from the PFP FSAR**

Abnormal	Accident
Radioisotope-bearing Liquid Spills	Explosions

Radioisotope-bearing Pressurized Liquid Container	Fire
Radioisotope-bearing Powder Spills	Criticality
Radioisotope-bearing Pressurized Powder Container	Seismic Event
Stack Release Resulting from Filter Changes	Strong Wind
Overpressure of RMC Line Pressure Vessel	Aircraft Accident
Ventilation System Upsets	Toxic Chemical Release
Loss of Ventilation	.
Glovebox Glove Breach	.

Unusual Occurrence Reports often provide a better insight into the actual operational problems and abnormal events that are being experienced at a given facility than a Safety Analysis Report. PFP Facility Unusual Occurrence Reports for the past 2.5 years were examined. The following summarizes the more salient findings:

- A mishap occurred on March 17, 1993 at the PFP Facility during HEPA filter changeout activities that resulted in nine workers receiving internal depositions of plutonium (Unusual Occurrence Report RL--WHC-PFP-1993-0018, dated May 17, 1994). The event occurred because a filter holddown bolt broke loose. The maximum committed effective dose equivalent received by any of the nine workers was 990 millirem, with the other eight receiving 250 millirem or less.
- On March 22, 1993, the Manager of the PFP Facility curtailed certain PFP Facility operations and maintenance activities because of the repeated occurrence of events involving inadequate conduct of operations principles (Unusual Occurrence Report RL--WHC-PFP-1993-0022, dated November 16, 1993). Curtailment of activities at the PFP Facility allowed the PFP Facility management team to reassess the conduct of operations practices for work at the PFP Facility, and to develop corrective actions for improvement of operations and maintenance activities based on the results of the assessment.
- On April 26, 1993, there was an event that included the uncontrolled spread of contamination (Unusual Occurrence Report RL--WHC-PFP-1993-0026, dated December 8, 1993). The forklift transport of a package containing radiological materials from Building 234-5Z to the South Canyon Airlock of the PRF resulted in several spots of contamination being detected on the pavement outside of Building 234-5Z and outside the South Canyon Airlock where the pallet had been set down. Three holes were subsequently found in the package, apparently caused by the stress that was induced during the movement of the package. The shoes of two workers were also found to be contaminated.
- On September 18, 1993, a sprinkler head failed in the first floor stairwell of the PRF (Unusual Occurrence Report RL--WHC-PFP-1993-0055, dated October 14, 1993). Two to 3 in (5 to 8 cm) of water were reported on the floor. Inadvertent actuation of a water sprinkler system is undesirable for several reasons. Hazardous situations involving electrical equipment, criticality, and/or the spread of radioactive materials could potentially arise.
- On December 26, 1993, ventilation was lost momentarily (Unusual Occurrence Report RL--WHC-PFP-1993-0065, dated April 11, 1994). A malfunction of uninterruptible power supply #1 resulted in supply and exhaust fans being tripped offline. The steam-turbine-driven exhaust fans started, and within approximately 1.5 hours, normal ventilation equipment was returned to service. When the ventilation system dropped offline, it was announced throughout the PFP Facility that Zone 3 areas were to be evacuated.
- On December 13, 1994, five PFP Facility workers received an internal deposition of plutonium while performing packaging operations. (Unusual Occurrence Report RL--WHC-PFP-1994-0056, dated February 14, 1995 and Leonard, 1996). The direct cause of the event was the use of force by personnel sufficient to tear both bags surrounding a 0.5-l (0.13-gal) polyjar while attempting to place the polyjar into a seismic overpack. The case file indicates that four people received less than 100 millirem (maximum 16 millirem committed effective dose

equivalent), and the fifth worker received 210 millirem committed effective dose.

### **5.7.11 Unavoidable Adverse Environmental Impacts**

The no action alternative would have the potential for unavoidable adverse environmental impacts to health effects under routine and accident phenomena. The concerns discussed in Section 2 of this EIS would not be remedied under the no action alternative. These concerns include the ongoing PFP Facility worker radiological dose received to perform surveillance and maintenance functions associated with the plutonium inventory groups, and the pyrophoric nature of plutonium in certain forms; the generation of hydrogen gas (which presents an explosion and/or fire hazard); the use of containers/packaging materials for applications (such as long-term storage) for which they were not designed. The ongoing, cumulative routine and accident-related health effects risk associated with the no action alternative would eventually exceed the total routine and accident-related health effects risk associated with implementation of the preferred alternative.

### **5.7.12 Potential Mitigation Measures**

Mitigation measures as discussed in this EIS (e.g., HEPA filtration of exhaust pathways) would continue to be provided to ensure that airborne releases to the environment are kept very small during routine operations and minimized during abnormal events and accident conditions.

To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal/routine activities would remain within established requirements, and to ensure that the risk of accidents would be minimized, numerous measures would continue to be taken in association with the no action alternative. These measures include continued implementation of numerous programs that already exist at the Hanford Site. Examples of these programs are discussed in Subsection 5.1.12.

### **5.7.13 Irreversible and Irrecoverable Commitments of Resources**

There would be an irreversible and irretrievable commitment of natural and manmade resources should the no action alternative be chosen. These resources include the following:

- Money
- Full-time equivalents
- Potentially, human life.

For monetary and full-time equivalent considerations, see Subsection 5.7.5. Should the no action alternative be chosen, the ongoing costs associated with that decision would continue to escalate beyond those dollars expended in 1995. As the PFP Facility continues to age, systems would need to be replaced, as necessary, to ensure the safety of the personnel and the materials at the Facility.

Should the no action alternative be chosen, then PFP Facility worker dose will continue at levels similar to that incurred in 1995. A major driver is to lower these doses. Long-term cumulative PFP Facility worker exposure is higher with the no action alternative when compared to stabilization and removal of the material (see Figure 3.5.2-2). The effects on human health due to ongoing exposure to low levels of ionizing radiation are indeterminate. However, under the assumption that all radiation exposure is deleterious to human health, national and international organizations have established dose-to-risk conversion factors, where risk is expressed in terms of LCF. The no action alternative would result in some increase in LCF. Should the no action alternative be chosen, the ongoing LCF associated with that

decision would eventually exceed the LCF associated with implementation of the preferred alternative.

#### **5.7.14 Relationship Between Short-term Use and Long-term Productivity of the Environment**

No new facilities, buildings or structures would be built under the no action alternative. Additionally, land usage and water resources would not be impacted by choosing the no action alternative. All activities proposed under the no action alternative would occur inside existing PFP Facility structures. The relationship between short-term use and long-term productivity of the environment is best addressed in the context of the history and potential future uses of the PFP Facility (and Hanford Site in general). Historical information pertaining to the Hanford Site and the PFP Facility is provided in Section 1 of this EIS. Subsection 5.1.14 of this EIS addresses the process that is currently underway to determine the long-term disposition of weapons-usable fissile materials and potential future uses for the Hanford Site and the PFP Facility specifically.

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## 6.0 CUMULATIVE IMPACTS

A cumulative impact is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time" (40 CFR 1508.7). This section examines the cumulative environmental effects of the preferred alternative along with impacts from past, current, and anticipated future activities at the Hanford Site.

Most of the environmental impacts that have occurred at the Hanford Site were associated with the production of special nuclear materials for national defense. These actions included the construction and operation of nuclear reactors, separation facilities, fabrication facilities, waste disposal areas (burial grounds), waste management tanks, power plants, and laboratories. The production of nuclear materials for weapons has resulted in the generation of waste, contamination, and excess nuclear materials that are stored at the Site.

Potential environmental impacts from the preferred alternative alone are not expected to be of major consequence. However, cumulative impacts in conjunction with other ongoing and planned activities at the Hanford Site could potentially be of concern. These areas of concern include radiological health effects, waste generation, and socioeconomic and transportation impacts.

### 6.1 ONGOING AND ANTICIPATED ACTIVITIES

Current and proposed actions at the Hanford Site involve waste management, remediation of contaminated areas, and the decontamination and decommissioning of onsite facilities. In addition, there are other nuclear facilities at or near the Hanford Site that contribute to radioactive releases in the area. These facilities are a commercial radioactive waste burial site operated on land leased to the state of Washington, a commercial nuclear power plant, a nuclear fuel production plant, a commercial low-activity radioactive waste and compacting facility, and a commercial decontamination facility.

#### 6.1.1 Major Hanford Site Projects

Four major Hanford Site actions, for which EISs have been or are in preparation, are likely to contribute to the overall cumulative impacts on the Hanford Site. They encompass most of the future remedial and decommissioning activities, and the waste and radioactive fuel management on the Hanford Site.

The following is a brief summary of the proposed actions (preferred alternatives) currently being evaluated in these EISs.

##### **Hanford Remedial Action**

The Hanford Remedial Action EIS will provide an assessment of the impacts (primarily from remediation activities) associated with achieving broad classes of future land uses for the Hanford Site. The Hanford Remedial Action EIS will build on the three broad classes of potential future land uses developed by the Hanford Future Site Uses Working Group (restricted, unrestricted, and exclusive future uses).

The Hanford Remedial Action EIS will evaluate the potential environmental consequences associated with sitewide remediation efforts. Once established, future land use designations will guide the process of remediating the Hanford

Site radioactive and hazardous wastes and facilitate the development of a coordinated and cost-effective remediation strategy. However, decisions regarding site-specific remediation technologies and specific activities will not be made in the Hanford Remedial Action EIS. Instead, these decisions will be made through the RCRA and CERCLA process, in accordance with the Hanford Federal Facilities Agreement and Consent Order, also known as the Tri-Party Agreement (Jason, 1996).

### **Tank Waste Remediation System**

The Tank Waste Remediation System would involve actions necessary to retrieve, treat, immobilize, and dispose of stored tank wastes and stored strontium and cesium capsules at the Hanford Site. Over many years, radioactive waste stored in onsite tanks would be transported to process facilities and immobilized for final disposal. Major efforts involving large construction workforces over a period of years, beginning in 1998 would have radiological dose and socioeconomic impacts. The expected operation period would run from 2002 through 2028. The *Tank Waste Remediation System Environmental Impact Statement* was issued in draft in April 1996 (DOE, 1996a).

### **Management of Spent Nuclear Fuel from the K Basins**

The K East and K West Basins are concrete basins constructed in 1951 to temporarily store spent nuclear fuel from the adjacent K East and K West Reactors. Spent nuclear fuel from the N Reactor has been stored in the K East Basin since 1975 and the K West Basin since 1981. The principal environmental and safety concerns are associated with the K East Basin. They arise from the presence of deteriorating spent nuclear fuel, buildup of radioactive sludge on the bottom of the basin, deteriorating concrete with vulnerability to earthquake damage, leakage of contaminated water to the soil below the basins, and the presence of cesium-137 contamination of the concrete at the water line, which, unshielded, can contribute to worker radiation exposure. Conditions in the K West Basin are not as serious because the spent nuclear fuel stored there is in sealed canisters.

The Record of Decision selected the following action to be implemented at the Hanford Site to alleviate these environmental and safety concerns. Spent nuclear fuel from the basin will be removed, vacuum dried, conditioned, and sealed in gas-filled canisters for storage. The canisters will be stored, for up to 40 years, in a Canister Storage Building, being built at Hanford, pending decisions on ultimate disposition. The selected action also includes transfer of the basin sludge to the Hanford Site's 200 Area (Double-Shell Tank System) for management, disposal of non-spent nuclear fuel basin debris in a Low-Level Burial Grounds at the Hanford Site, disposition of the basin water, and deactivation of the basins pending decommissioning.

Should it not be possible to put the sludge into the double-shell tanks, the sludge will either continue to be managed as spent nuclear fuel or disposed of as solid waste (61 FR 10736).

Handling and management of spent nuclear fuel would result in additional human health impacts, generation of waste, an increase in labor force during the construction and management of new facilities, and additional traffic at the Site during peak activities.

### **Disposal of Decommissioned, Defueled Cruiser, OHIO and LOS ANGELES Class Naval Reactor Plants**

Hanford is the preferred site for 100 decommissioned, defueled reactor compartments from U. S. Navy nuclear-powered cruisers and submarines. These reactor compartments would be stored at the Low-Level Waste Burial Grounds in the 200 East Area (USN, 1996).

#### **6.1.2 Potential Future Projects**

In addition to the above major projects, the volume of radioactive waste and impacts associated with construction of new facilities at the Hanford Site could increase if the Hanford Site is selected for the following DOE actions currently being analyzed in NEPA documents:



## **Waste Management of DOE Waste**

The Hanford Site is a potential location for centralized or regionalized management of DOE wastes. The actions would involve construction of treatment and disposal facilities for management of onsite wastes and wastes shipped from other DOE sites. The most adverse impacts at the Hanford Site and vicinity would result from alternatives where treatment and disposal facilities would be constructed for management of Hanford and offsite waste.

## **Storage and Disposition of Weapons-Usable Fissile Materials**

Hanford is a potential site for long-term storage of surplus weapons-usable fissile materials from other sites in the United States or elsewhere. The action may involve constructing a new consolidated storage facility or storing the fissile materials at existing or upgraded facilities.

### **6.1.3 Minor Actions**

In addition to the major actions planned for the Hanford Site, the following activities, currently in progress or anticipated, are likely to contribute to the overall cumulative impacts on the Hanford Site:

- Removal and stabilization of reactive sludges and residues at the PFP Facility
- 222-S radioactive waste line replacement and 219-S secondary containment upgrade
- Activities associated with shutdown and deactivation of the N Reactor facilities
- Final activities associated with the deactivation of PUREX
- Activities associated with the B Plant Accelerated Hazards Reduction Program
- Shipment of waste from 324 Building to the PUREX tunnels
- Proposed Solid Waste Retrieval Complex, Enhanced Radioactive Waste Storage Facility, and associated infrastructure upgrades
- Tank 241-C-106 past-practice sluicing and waste retrieval
- Decontamination and decommissioning of the Waste Incineration Facility (Building 232-Z) and the Plutonium Concentration Facility (Building 233-S)
- Relocation of the Training Reactor Isotopes General Atomics irradiated fuel assemblies from the 300 Area to the 400 Area
- Return and storage of isotope capsules from other DOE and commercial facilities to the Waste Encapsulation and Storage Facility in the 200 Area
- Transportation and storage of low-level radioactive waste from Sandia National Laboratories, New Mexico
- Transfer of irradiated fuel from the Fast Flux Test Facility to the PFP Facility for storage.

## **6.2 POTENTIAL CUMULATIVE IMPACTS**

This section evaluates the impacts from the proposed alternatives as they relate to existing Hanford Site conditions and future actions. The discussion of cumulative impacts is organized as follows:

- Human Health
- Waste Generation
- Population and Socioeconomics
- Transportation

### **6.2.1 Human Health**

The 1994 Hanford Site Environmental Report noted that the potential dose to the hypothetical maximally exposed individual in 1994 from Hanford Site Operations was 0.05 millirem. The potential dose from 1994 operations to the local population within the 80-km (50-mi) radius was 0.6 person-rem. The 1994 average dose to the population within the 80-km (50-mi) radius was 0.002 millirem per person. The current DOE radiation limit for an individual member of the public is 100 millirem/year, and the national average dose from natural sources is 300 millirem/year. During 1994, the maximally exposed individual potentially received 0.05 percent of the DOE dose limit from Hanford Site operations (PNL, 1995).

There is no indication that routine PFP Facility stabilization and removal activities associated with the preferred alternative would add to the overall dose or cumulative impact to the offsite population or Hanford Site worker. Radioactive emissions to the ambient air from Hanford Site activities are limited to an effective dose equivalent to the maximally exposed individual of 10 millirem per year (40 CFR 61). The anticipated routine operational dose for the preferred alternative to the maximally exposed offsite individual would be 1.5 millirem. This would be 15 percent of the allowable airborne emissions. As discussed earlier, this analysis is conservative and actual emissions are expected to be much lower. Other proposed activities at the Hanford Site are projected to be lower than for the preferred alternative.

Routine operations are conservatively predicted to result in 140 person-rem exposure to the population living within 80 km (50 mi) of the PFP Facility. This would result in no predicted LCF to the offsite population. The predicted exposure to offsite individuals from other actual and proposed Hanford Site activities are less than 1 person-rem. Consequently, cumulative radiation impacts to the offsite population are not expected to result in a meaningful environmental impact.

The maximum incremental radiological doses and resulting health effects for the preferred alternative, the no action alternative, and other actions planned at Hanford, are presented in Table 6-1. Although these impacts could be added, it should be noted that the exact location of the facilities for planned actions may change. Also, the location of the maximally exposed individual may be different for the various actions. Therefore, the direct addition of the individual action impacts may be conservative.

The likelihood of occurrence of accidents induced by natural phenomena and external events is common to the facilities and activities at the Hanford Site. Accidents resulting from operations associated with the preferred alternative generally do not possess sufficient energy to disperse radioactive and/or hazardous materials in such a manner as to adversely impact Hanford Site workers, the public, or the environment. The dominant safety concern is for PFP Facility workers. Programs that currently exist at the Hanford Site to prevent and mitigate accidents would be followed.

Based on the above discussion, potential accidents associated with the preferred alternative would marginally add to the collective accident-related risk posed by all facilities and activities at the Hanford Site.

**Table 6-1 Estimated Average Annual Cumulative Radiological Doses and Resulting Health Effects for Normal Operations**

Program	Maximally Exposed Individual Member of the Public	Offsite Population within 80 km		Hanford Site Workforce	
	Total Dose (mrem)	Total Dose (person-rem)	LCF	Total Dose (person-rem)	LCF
PFP EIS No Action <sup>b</sup>	2.9 x 10 <sup>-5</sup>	0.45	2.3 x 10 <sup>-4</sup>	53	0.021

PFP EIS Stabilization and Removal	0.15	14	2 x 10 <sup>-3</sup>	155	0.062
PFP Sludge Stabilization EAc	5.4 x 10 <sup>-5</sup>	5.0 x 10 <sup>-3</sup>	2.5 x 10 <sup>-6</sup>	40	0.016
Tank Waste Remediation Systemd	2.3 x 10 <sup>-4</sup>	22	1.1 x 10 <sup>-2</sup>	455	0.18
Safe Interim Storagee	4.5 x 10 <sup>-7</sup>	0.17	8.5 x 10 <sup>-5</sup>	85	0.034
Spent Nuclear Fuel,g	0.028	1.6	8.0 x 10 <sup>-4</sup>	142	0.057
Waste Managementg	0.45	22	1.1 x 10 <sup>-2</sup>	0.35	1.4 x 10 <sup>-4</sup>
Fissile Materials Storage and Dispositiong	2.6 x 10 <sup>-6</sup>	8.7 x 10 <sup>-5</sup>	4.4 x 10 <sup>-8</sup>	24	9.6 x 10 <sup>-3</sup>
Ongoing Hanford Operationsh	0.050	0.60	3.0 x 10 <sup>-4</sup>	20	8.0 x 10 <sup>-3</sup>

**Notes:** a. Assumes dose rates associated with Record of Decision action if Record of Decision has been issued and preferred alternative if Record of Decision has not been approved

b. Assumes a six-year total duration

c. Assumes a two-year total duration (DOE, 1995b)

d. Assumes a 32-year operational duration (DOE, 1996b)

e. Period of operation expected to be 1996-2000; (DOE,1995c)

f. Assumes impacts associated with K Basins activities are included in spent nuclear fuel estimate

g. Source: DOE, 1996b

h. Source: PNL, 1995

## 6.2.2 Waste Generation

Preferred alternative activities would generate less than 50,000 l (13,000 gal) of liquid waste. This material could be disposed of in the 200 Area Tank Farms. The storage and treatment design capacities for the Double-Shell Tank System is approximately 150,000,000 l (40,000,000 gal). Currently, 640,000 l (170,000 gal) of existing double-shell tank capacity has been allocated for liquid waste generated by the PFP Facility (Koreski and Strode, 1995).

Activities under the preferred alternative would generate up to 8 kg (18 lb) per year of plutonium-bearing materials that could be immobilized and transported to the Hanford Site solid waste management facilities, where space has been allocated for the management of this material.

### 6.2.3 Population and Socioeconomics

Hanford Site employment has declined from over 18,000 in 1994 to less than 14,000 in late 1995 and is expected to remain at about that level through 2004. In addition, non-Hanford Site employment in some sectors is also being reduced. For example, the Washington Public Power Supply System expected to reduce its workforce by 1,300 persons in 1995. The reduction in force now in progress at the Hanford Site and in the private sector has left the surrounding communities with excess housing and educational resources. Between 1996 and 2002, the PFP Facility stabilization and removal activities associated with the preferred alternative would add an average of 62 full-time equivalents to the workforce engaged in Hanford Site activities. After 2002, employment at the PFP Facility is expected to drop to 254 full-time equivalents following completion of the preferred alternative. Major projects (Tank Waste Remediation System and Hanford Remediation Actions) at the Hanford Site may help alleviate some of the impacts of these reductions by increasing employment during the 1996 to 2010 period. Given the uncertain employment situation at the Hanford Site, cumulative socioeconomic impacts of ongoing and anticipated activities are difficult to predict.

### 6.2.4 Transportation

A very large volume of waste, associated with the remediation of past-practice sites at Hanford is expected to be transported to the Environmental Restoration Disposal Facility. In addition, construction and operation of new waste management and nuclear fuel management facilities would involve transportation of wastes, fuel, and construction materials, resulting in increased traffic on Hanford Site roadways. These impacts, when compared to other Site activities, are incrementally and collectively small. The preferred alternative for the PFP Facility is expected to add 81 truck trips over six years or approximately one trip every four weeks. An additional 62 personnel would have to commute to the Site resulting in additional congestion during peak transportation periods. Transportation activities associated with the preferred alternative would result in only incremental increases to the existing traffic load.

#### References:

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

40 CFR 1500, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

61 FR 10736, "Notice of Record of Decision: Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington," *Federal Register*, March 15, 1996.

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## 7.0 STATUTORY AND REGULATORY REQUIREMENTS

This section presents important regulatory requirements associated with the alternatives. Applicable environmental statutes, regulations, and DOE orders are identified. These regulatory requirements establish the guidelines for environmental, safety, and health standards, and specify the required permits and approvals. Both federal and state agencies (primarily EPA and Ecology) have the environmental regulatory authority over the Hanford Site. DOE policy is to fully comply with all applicable environmental requisites. Significant federal and state laws and requirements applicable to the PFP Facility stabilization and removal activities are described briefly in the following subsections and on Table 7-1.

### 7.1 FEDERAL ENVIRONMENTAL LAWS

#### **Atomic Energy Act, as amended (42 U.S.C §2011 et seq.)**

The purpose of the Atomic Energy Act of 1954 is to ensure the proper management of source, special nuclear, and by-product materials. The act authorizes DOE to develop applicable environmental standards for the protection of health or to minimize dangers to life or property. Through a series of orders, DOE has established an extensive system of radiation protection standards and requirements to ensure safe operation of its facilities.

DOE and DOE-contractor radiation protection standards and program requirements for worker protection have been codified under 10 CFR 835 and are implemented by DOE Order 5480.11, Radiation Protection for Occupational Workers.

#### **Clean Air Act, as amended (42 U.S.C §7401 et seq.)**

Enacted in 1970 to improve air quality, the act requires EPA to establish national ambient air quality standards. The state implementation plans, through a permit program, impose these standards on emission sources. State implementation plans also enforce emission limits (new source performance standards) and monitoring requirements on new and modified emission sources. National emission standards for hazardous air pollutants, requiring a permit by EPA (Table 7-1), provide for the control of hazardous air pollutants, including radionuclides from DOE facilities.

#### **Resource Conservation and Recovery Act, as amended (42 U.S.C §6901 et seq.)**

RCRA provides the basic framework for federal regulation of hazardous waste. The act and its implementing regulations (40 CFR 260-282) control the generation, transportation, treatment, storage, and disposal of hazardous and mixed waste (hazardous waste portion only) through a comprehensive "cradle to grave" system of waste management techniques and requirements. Most of the authority to administer the program and permit requirements (except for corrective actions) has been delegated by EPA to the state of Washington.

**Table 7-1 Potential Permits and Approval**

Environmental Media	Permit/Approval	Regulation	Regulatory Agency
Radioactive	Radioactive Air Emissions Program	Chapter	Washington
Air Emissions	(Approval)	246-247	Department of Health

		WAC	
	National Emission Standards for Hazardous Air Pollutants  (Permit)	40 CFR Part 61  Subpart H	EPA
Non- radioactive  Air Emissions	Notice of Construction  New Sources of Air Pollutants (Approval)	Chapters  173-400 and  173-460 WAC	Ecology
	Air Operating Permit  (The existing Sitewide permit application may need modification)	Chapter  173-401 WAC	Ecology
Dangerous Waste Generation, Storage, Treatment, and Disposal	Hanford Facility Dangerous Waste Permit, Resource Conservation and Recovery Act Parts AA-DB	Chapter  173-303 WAC	Ecology
All Media	Cultural Resources Review Clearance	36 CFR 800	Advisory Council on Historic Preservation and State Historic Preservation Officer

### **Emergency Planning and Community Right-to-Know Act of 1986, (42 U.S.C §11001 et seq.)**

This act requires the development of emergency response plans and reporting requirements for chemical spills and other emergency releases. The act also imposes right-to-know reporting requirements covering storage of hazardous materials and releases of specific toxic chemicals.

### **Clean Water Act, as amended (33 U.S.C §1251 et seq.)**

The Clean Water Act sets water quality standards and compliance requirements with provisions of the permits regarding discharge of effluents to the nation's waters. The act requires EPA to impose limitations on pollutant discharges through the National Pollutant Discharge Elimination System permit program (40 CFR 122). Discharges containing radioactive contaminants are regulated under the Clean Water Act by the state. However, the EPA has not delegated authority to the state of Washington to issue such permits at the Hanford Site.

### **Occupational Safety and Health Act, (5 U.S.C §5108)**

This act establishes standards to enhance safe and healthful working conditions in places of employment. DOE facilities emphasize compliance with the regulations and implementation of these standards at the Hanford Site through DOE Orders 3790.1B, Federal Employee Occupational Safety and Health Program; 5483.1A, Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities; and 5480.1B, Environment, Safety, and Health Program for Department of Energy Operations.

### **Toxic Substances Control Act, (15 U.S.C §1 et seq.)**

Toxic Substances Control Act provides for the testing of the long- and short- term effects of chemical substances and

the authority to control the use and disposal of chemical substances as appropriate to prevent an unreasonable risk to human health or the environment. It also imposes strict limitations on the use and disposal of polychlorinated biphenyl (PCB)-contaminated equipment.

### **Hazardous Materials Transport Act, (49 U.S.C §1801 et seq.)**

This act sets the standards for transportation of hazardous waste and material. The transportation of hazardous and radioactive materials and wastes is governed by three agencies: the U.S. Department of Transportation (49 CFR 171 et seq.), the Nuclear Regulatory Commission (10 CFR 71), and EPA (40 CFR 262).

### **Endangered Species Act, (16 U.S.C §1531 et seq.)**

The Endangered Species Act provides for a program for the conservation, protection, restoration, and propagation of selected species of native fish, wildlife, and plants. The act requires consultation with the U.S. Fish and Wildlife Service to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed activities.

### **National Environmental Policy Act (42 U.S.C §4321 et seq.)**

NEPA is designed to ensure that federal agencies consider the environmental consequences of federal actions before they are taken. The requirements specify that if a federal action might have significant effect on the quality of the human environment, the agency involved must prepare an EIS. This EIS has been prepared in compliance with the Council on Environmental Quality's regulations (40 CFR 1500 et seq.) and DOE implementing procedures as codified in 10 CFR Part 1021.

### **National Historic Preservation Act (16 U.S.C §470)**

The National Historic Preservation Act and the implementing regulations of 36 CFR 800 require that, prior to approval of federal activities, agencies should take into account the effect of the undertaking on any district, site, building, structure, or object of significance in American history, architecture, archaeology, or culture. The National Register of Historic Places is a file of resources of national, regional, state, and local significance. When a DOE undertaking is likely to adversely affect an historic property or resource, consultation with the Advisory Council on Historic Preservation would generate a Memorandum of Agreement that would establish stipulations that must be followed. DOE consults with the State Historic Preservation Officer early in this planning to identify concerns that may need mitigative actions prior to such undertaking.

A Memorandum of Agreement between DOE and the Washington State Historic Preservation Officer has been signed and accepted by the Advisory Council on Historic Preservation. The Memorandum of Agreement addresses the measures that would be undertaken by DOE to record, document, and maintain the materials that would be produced (MOA, 1996).

### **American Indian Religious Freedom Act (42 U.S.C §1996)**

Under the American Indian Religious Freedom Act, Native Americans have an inherent right of access to religious sites. DOE has an active program for consultation with Native American groups.

### **Native American Graves Protection and Repatriation Act (25 U.S.C. §3001)**

Under this act, Native American gravesites, human remains, and funerary objects are given special protection. DOE has an active program for consultation with Native American groups.

## **7.2 STATE OF WASHINGTON ENVIRONMENTAL LAWS**



### **Washington Clean Air Act (Chapter 70.94 RCW)**

Under the Washington Clean Air Act, Ecology regulates releases of non-radioactive pollutants. The Washington State Department of Health has overall responsibility for regulating radioactive pollutants to the air. Before a new source of regulated air emissions is established, Ecology must review and approve plans for the construction of the source (Table 7-1). A new radionuclide emission source is similarly subject to a preconstruction review and approval by the Department of Health (Chapter 246-247 WAC). A modification of the Hanford Sitewide air operating permit application (required by the Clean Air Act amendments of 1990) may be required as a result of the PFP Facility stabilization and removal activities.

### **Hazardous Waste Management Act (Chapter 70.105 RCW)**

The Hazardous Waste Management Act and its implementing Dangerous Waste Regulations (Chapter 173-303 WAC) apply to the management of all dangerous wastes at the Hanford Site. The EPA has delegated the RCRA base program to Ecology, the authority regulating hazardous waste in Washington State. The regulations designate waste and specify requirements for transfer, treatment, storage, and disposal of hazardous wastes.

### **Water Pollution Control Act (Chapter 90.48 RCW)**

The Water Pollution Control Act and its implementing regulations (Chapter 173-200 WAC and 173-216 WAC) require that a permit be obtained for any discharge of waste material to the soil column and surface water. The PFP Facility stabilization and removal activities would not require the modification of permits for facilities that treat liquid effluent from the PFP Facility.

### **State Environmental Policy Act (Chapter 43.21C RCW)**

Similar to NEPA, the State Environmental Policy Act is intended to ensure that environmental values are considered by state and local government projects. If DOE proposes a project that needs a state or local permit, it would be considered a private applicant under the State Environmental Policy Act and would be responsible for completing of the environmental checklist. The State Environmental Policy Act rules allow the NEPA environmental assessment or EIS to satisfy the State Environmental Policy Act requirements.

## **7.3 EXECUTIVE AND DOE ORDERS**

Executive orders address issues of national policy and set guidelines for federal agencies to follow. DOE regulations and orders are the regulatory mechanisms used to manage DOE facilities. DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. Relevant executive and DOE orders applicable to the PFP Facility stabilization and removal activities include the following:

#### **Executive Order 12898 (Environmental Justice)**

Executive Order 12898 requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

#### **DOE Order 3790.1B, Federal Employee Occupational Safety and Health Program**

This order sets forth policy for the implementation and administration of the Federal Employee Occupational Safety and Health Program for the DOE.

#### **DOE Order 5400.1, General Environmental Protection Program**

This order establishes environmental protection program requirements, authorities, and responsibilities for DOE operations for ensuring compliance with applicable federal, state, and local environmental protection laws and

regulations as well as internal DOE policies.

### **DOE Order 5400.5, Radiation Protection of the Public and the Environment**

The order sets standards for protection of the public in the vicinity of DOE facilities. The DOE published this rule in 10 CFR 834 in March 1993 promulgating the standards found in the order, but with enhanced emphasis on the ALARA process.

### **DOE Order 451.1, National Environmental Policy Act Compliance Program**

This order establishes the authorities and responsibilities of DOE officials and sets forth internal procedures for implementing NEPA.

### **DOE Order 5480.1B, Environment, Safety, and Health Program for DOE Operations**

This order establishes the Environment, Safety, and Health Program for DOE operations.

### **DOE Order 5480.3, Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes**

The order establishes requirements for the packaging and transportation of hazardous materials, substances, and wastes. It also ensures that each shipment is in compliance with the applicable safety regulations of the U.S. Department of Transportation and follows the applicable packaging standards (10 CFR 71) of the Nuclear Regulatory Commission.

### **DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards**

This order specifies and provides requirements for the applicability of mandatory environmental protection, safety, and health standards applicable to all DOE and DOE-contractor operations.

### **DOE Order 5483.1A, Occupational Safety and Health Program for DOE Contractor Employees at Government-owned, Contractor-operated Facilities**

This order establishes requirements and procedures to provide occupational safety and health protection for DOE contractor employees in government-owned, contractor-operated facilities that is consistent with the protection afforded private industry employees by the occupational safety and health standards promulgated under the Occupational Safety and Health Act.

### **DOE Order 5820.2A, Radioactive Waste Management**

This order establishes policies, guidelines, and minimum requirements for the management of radioactive and mixed waste facilities and contaminated facilities.

### **DOE American Indian Policy**

This policy, dated May 18, 1994, recognizes the special government-to-government relationship between the federal government of the United States and American Indian Tribal governments. It is designed to ensure the rights of sovereign tribal governments are fully respected and that DOE activities affecting Native American Tribal rights or trust resources are implemented in a knowledgeable and sensitive manner respectful of this tribal sovereignty.

## **7.4 HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (TRI-PARTY AGREEMENT)**

The *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement (Ecology, EPA,

and DOE, 1994), governs the cleanup plans for the Hanford Site. It establishes the regulatory framework under which Hanford Site waste management and cleanup must occur, and establishes the applicability of RCRA and CERCLA and their amendments to the Hanford Site. Additionally, the Tri-Party Agreement establishes an action plan for cleanup that identifies priority actions and problems and provides milestones for achieving coordinated cleanup of the Hanford Site.

The Tri-Party Agreement contains one major milestone related to the PFP Facility:

**Milestone M-83-00: Complete Stabilization of Process Areas, and Other PFP Cleanout Actions Resulting from the EIS ROD, Within PFP.** Specific milestones include the following:

- **Milestone M-83-01-T01: Issue Final Environmental Impact Statement Record of Decision** requires completing the Final EIS and all applicable NEPA requirements, including issuance of the Record of Decision by June 1996.
- **Milestone M-83-02: Complete Identified Interim Actions** identifies interim actions that must be completed by December 1998. It notes that additional potential interim actions will be evaluated. Each of the four actions identified to date have been evaluated through the NEPA process, receiving either an Environmental Assessment and its associated Finding of No Significant Impact, or a Categorical Exclusion.

The Tri-Party Agreement contains the following milestones that are indirectly related to the purpose and need for this action:

**M-20-48A: Submit a PFP Part B Permit Application or Closure Plan to EPA and Ecology.** The Record of Decision will determine if a Part B Permit Application is needed for the 241-Z treatment, storage, and disposal Units or if a Closure Plan (or Pre-Closure Work Plan) will be developed. This milestone must be completed by December 1996.

**M-81-00-T03: Complete Transfer of Unirradiated Fuel to the Plutonium Finishing Plant.** Transfer of unirradiated fuel to an appropriate storage area in the PFP must be completed by October 1998.

## 7.5 CONSULTATIONS

The following state, regional, and local agencies and American Indian Tribal Governments were contacted during the preparation of this EIS.

### State Agencies

Oregon Department of Energy

Oregon Department of Environmental Quality

Oregon Hanford Waste Board

Washington State Department of Community, Trade, and Economic Development

Washington State Department of Ecology

Washington State Department of Health

### Regional Agencies

Tri-City Apartment Association

Tri-City Association of Realtors

Tri-City Industrial Development Council

Yakima County Development Association

**Local Agencies and Individuals**

Benton County Assessors's Office

Benton County Auditor's Office

Benton County Clean Air Authority

Franklin County Assessor's Office

Franklin County Auditor's Office

Franklin County Planning Department

Grant County Assessor's Office

Grant County Auditor's Office

Grant County Planning Department

City of Kennewick - Assistant City Manager

City of Kennewick - Auditor's Office

City of Kennewick - Assessor's Office

City of Pasco - Auditor's Office

City of Pasco - Assessor's Office

City of Richland - Mayor

City of Richland - Auditor's Office

City of Richland - Assessor's Office

**Native Americans**

The Nez Perce Tribe

Confederated Tribes of the Umatilla Indian Reservation

Confederated Tribes and Bands of the Yakama Indian Nation

Wanapum People

**References:**

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Fourth Amendment, Washington Department of Ecology, Olympia, Washington, U.S. Environmental Protection Agency, Region 10, Seattle, Washington, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

MOA, 1996, "Memorandum of Agreement Between the U.S. Department of Energy, Richland Operations Office and the Washington State Historic Preservation Officer Submitted to the Advisory Council on Historic Preservation Pursuant to 36 CFR 800.6(a) Regarding the Dismantlement and Removal of the Plutonium Finishing Plant Complex Hanford Site," U.S. Department of Energy, Richland Operations Office, Richland, Washington.





## 8.0 LIST OF PREPARERS

The *PFPP Stabilization EIS* was prepared for DOE by the team of Dames & Moore Inc., MACTEC, and VECTRA GSI under the General Support Services Contract with DOE. Mr. B. F. Burton was the NEPA Document Manager for DOE. Overall project management was provided by Dr. David Guzzetta and Mr. Michael Ciminera of Dames & Moore, Inc. Principal preparers of the EIS sections are identified in Table 8-1.

**Table 8-1 List of Preparers**

Principals		Section	
M. Ciminera		Summary	
M. Ciminera		1.0 Introduction	
D. Ashley	J. Robinson	2.0 Purpose and Need	
D. Ashley	J. Cook	S. Manley	3.0 Description of Alternatives
M. Becker	R. Davis	D. Nguyen	
D. Bruce	C. Kirk	Y. Noorani	
J. Carolla	K. Kjarmo	D. Swanberg	
M. Ciminera	E. Mac Quarrie	A. Tayar	
M. Ciminera	D. Gehrke	V. Miller	4.0 Affected Environment
J. Consort	B. Lewis	N. Peters	
R. Gantenbein	D. Lowery		
D. Ashley	R. Gantenbein	J. Markillie	5.0 Environmental Impacts
M. Ciminera	D. Gehrke	V. Miller	
J. Cook	B. Lewis	D. Nguyen	
J. Consort	D. Lowery	N. Peters	
T. Dart	P. Macbeth	M. Piper	
M. Ciminera	J. Consort	U. Subranmanyam	6.0 Cumulative Impacts
	V. Miller		

J. Cook			
J. Brown	J. Markillie	.	7.0 Statutory and Regulatory Requirements
K. Kimmel	U. Subranmanyam		
M. Hartke	.	.	8.0 List of Preparers
K. Kjarmo	J. Markillie	.	Appendix A -Description of Plutonium Finishing Plant Facility
J. Cook	A. Tayar	.	Appendix B -Engineering Assumptions, Process Flow Diagrams, and Material Balances for Stabilization Alternatives
T. Dart	.	.	Appendix C -Accidents Applicable to All PFP Facility Stabilization EIS Alternatives and Accidents Specifically Applicable to Muffle Furnace Operations
D. Ashley	P. Macbeth	.	Appendix D -Anticipated Health Effects Under Normal and Accident Conditions
J. Cook	E. Mac Quarrie		
J. Cook	J. Markillie	.	Appendix E -The Immobilization Alternative Assumptions and Analysis of Impacts
P. Macbeth	D. Nguyen		
M. Ciminera	V. Miller	.	Appendix F -Public Comments and DOE Responses
C. Parrish			Appendix G -EIS Distribution List

**In addition to the individuals listed in Table 8-1, the following individuals contributed to the overall integration of the document: Vera Miller as the Project Coordinator, Eve Mac Quarrie as the Document Manager, Margaret Hartke as the Lead Technical Editor and Writer, Steve Swenning as the Project Quality Assurance Manager, Christina Parrish in Text Processing and Graphics and Barbara Grothe in Text Processing.**

### **David J. Ashley**

*BS, Chemical Engineering, University of Surrey, United Kingdom 1967*

Mr. Ashley has extensive experience in managing engineering and construction components of nuclear projects. He has over 11 years of DOE-related project work and 17 years of commercial power-generating experience. As part of his work with the environmental restoration of the Hanford Site, Mr. Ashley managed an independent Critical Design Review of a project to remove strontium 90-contaminated sludge from an aging single-shell storage tank. He helped to identify and codify the standards and requirements that apply to the DOE operations for restoring the Hanford Site. Mr. Ashley assisted in developing the programmatic controls for the Hanford Operations section of the national Technology Development Program, including processes for defining work scope, and approving budgets, change control, reporting, and long-range planning.

### **Michael R. Becker**

*Chemical Engineering, Washington State University (Target - Winter 1996)*

Mr. Becker is presently an undergraduate at the Washington State University, majoring in Chemical Engineering. Mr. Becker was the recipient of an Associated Western Universities Fellowship Grant that enabled him during his summer break, to support the *PFPP Stabilization EIS* task by calculating material balances for plutonium stabilization processing and researching plutonium stabilization. Mr. Becker is a national and charter member of the American Institute of Chemical Engineers, and a business fraternity member of the National Engineering Honor Society.

### **Jan L. Brown**

*BS, Engineering Science, Montana College of Mineral Science and Technology, 1986*

*BS, Petroleum Engineering, Montana College of Mineral Science and Technology, 1986*

Ms. Brown has over nine years of engineering and project management experience. Her DOE support includes RCRA and NEPA activities for DOE's Office of Environmental Assurance, Permits and Policy, and Environmental Engineering at the Tank Waste Remediation System. As project manager in support of DOE's Waste Management and Environmental Restoration Program, Ms. Brown supported the development of several EISs. Ms. Brown managed projects for the Buried Waste Program and the Site Characterization Unit of the Environmental Restoration Program, and supported CERCLA remedial investigation tasks.

### **David A. Bruce**

*BS, Chemical Engineering, University of New Mexico, 1965*

Mr. Bruce has 24 years of experience in nuclear fuel reprocessing and radioactive waste management. He has expertise in the areas of planning, design, construction, startup, operation, and troubleshooting of nuclear fuel reprocessing plants, waste management facilities, and plutonium processing facilities. He conducted an overview of Uranium Trioxide Plant operations and performed surveillance of shift operations during the final Uranium Trioxide Plant cleanout run. Mr. Bruce performed technical evaluations of PFP documentation.

### **Jack R. Carolla**

*BS, Mining Engineering, University of Idaho, 1991*

*AS, Civil Engineering Technology, 1976*

Mr. Carolla has 15 years of experience in civil engineering technology. He provides review of construction and environmental procedures in support of the Hanford Site Deactivation and Decommissioning Program of DOE's Environmental Remediation Division. Mr. Carolla conducted project reviews for an extensive wastewater system project, including design review for optimum performance, hydraulic calculations, code conformance, and structural integrity. He also conducted a review for the Hanford Sitewide wastewater collection system. Mr. Carolla wrote an advisory document outlining recommendations for a temporary electrical upgrading to reactor facility structure prior to decommissioning.

### **Mike Ciminera**

*BS, Forest Engineering, State University of New York, Syracuse, NY, 1986*

Mr. Ciminera has more than nine years of experience in environmental engineering, compliance, and management of: waste treatment, storage, and disposal; environmental restoration and management; and facility planning, development, permitting, and construction. This includes extensive experience in project management, technical administration, regulatory compliance, site investigations, and construction management. Mr. Ciminera provides technical expertise for Government Support Services Contract staff in areas involving: RCRA; Clean Air Act; Clean Water Act; Toxic Substance Control Act; Washington State Waste Discharge Permit Program; underground storage tanks; and septic



systems.

## **James Consort**

*MS, Geology, San Diego State University, California, 1979*

*BS, Geology, University of California, Los Angeles, 1976*

Mr. Consort has over 15 years of experience in geological investigations and designs. He provides technical support to DOE at the Hanford Site on CERCLA projects. As a project scientist for several RCRA facilities at the Hanford Site, Mr. Consort evaluated groundwater contamination and contaminant transport associated with potential crib and pond sources. He also managed and implemented a remedial investigation that included monitoring soil and groundwater sampling, geophysical logging, and aquifer testing, and developed structure contour maps based on well data and high-resolution seismic data.

## **John Cook**

*BS, Chemical Engineering, University of Washington, Seattle, 1989*

Mr. Cook is a project engineer with six years of experience providing onsite operations and permitting support to the DOE. He specializes in RCRA facility permitting and compliance and has supported CERCLA, NEPA, and Clean Air Act and Clean Water Act compliance activities. He has developed a methodology by which DOE intends to conduct facility decommissioning and RCRA closure activities as part of the ongoing Tri-Party Agreement. He participated in the development of a comprehensive environmental compliance matrix scoping RCRA, Clean Air Act, and Clean Water Act regulations for the DOE Tank Farm Operations branch at the Hanford Site. Mr. Cook has also performed an Operational Readiness Review of environmental compliance for the Uranium Trioxide nuclear facility at Hanford.

## **Tim Dart**

*ME, Nuclear Engineering, University of Idaho, 1987*

*Officer's Naval Nuclear Power School, Orlando, Florida, 1986*

*BS, Physics, Old Dominion University, 1980*

Mr. Dart, a senior nuclear engineer, has 14 years of experience in the nuclear and risk assessment industries providing special expertise in safety analyses, environmental assessments and EISs, transuranic and mixed waste management, and probabilistic risk assessment. This experience has entailed extensive interaction with the commercial nuclear power industry, the DOE and the U.S. Department of Defense. In the past few years, Mr. Dart has co-authored five Safety Analysis Reports to the requirements of DOE Order 5480.23. Additionally, he was the project manager for a major review and impact assessment of the primary DOE order on waste management (draft DOE Order 5820.2B). Mr. Dart has an extensive knowledge of DOE orders, standards, and notices and a thorough understanding of environmental and waste management compliance issues. Mr. Dart also has several years of probabilistic risk assessments experience and has served as a key or lead technical analyst in the performance of multi-million dollar probabilistic risk assessments.

## **Roger A. Davis**

*MS, Environmental Science and Engineering, Oregon Graduate Institute of Science and Technology, 1994*

*BS, Nuclear Engineering, Oregon State University, 1988*

Mr. Davis combines seven years of practical nuclear engineering experience with the environmental sciences in his

task to support the Hanford Site cleanup of contaminated radioactive materials and enriched plutonium. Mr. Davis' experience includes feasibility studies, remedial alternative evaluations, nuclear systems, and environmental systems involving radionuclides. Mr. Davis has performed analysis and evaluations for sites contaminated with radionuclides in the surface water, groundwater, and soil, as well as evaluated strategies for the cleanup of contaminated groundwater. In the commercial environment, Mr. Davis' tasks included performance of technical reviews for nuclear power plant proposed modifications, preparation of changes to the FSAR, and performance of safety evaluations to ensure the FSAR was valid.

## **Bob Gantenbein**

*BS, Civil Engineering, Oregon State University, 1961*

Mr. Gantenbein is a senior air quality engineer with over 30 years of experience in the areas of environmental, air quality, public health, and water and waste water engineering. Mr. Gantenbein's specialized experience in air quality includes the responsibility for governmental management of a city/county air shed in Albuquerque, New Mexico, design and installation of the first Phoenix, Arizona city/county air monitoring system, industrial air pollution permitting, and industrial source monitoring. He served as the air quality project engineer on the Safe Interim Storage EIS team, a recent Hanford NEPA/State Environmental Policy Act project.

## **Dawn Gehrke**

*MA, Economic Geography and Regional Science, University of Illinois, Urbana-Champaign, Illinois, 1994*

*BA, Economics, University of Illinois, Urbana-Champaign, Illinois, 1990*

Ms. Gehrke assists with the completion of socioeconomic analyses and in the development and implementation of public involvement programs for multi-disciplinary projects related to facility siting studies, water and wastewater issues, energy resources, air quality, and hazardous and solid wastes. Ms. Gehrke is assisting with the socioeconomic analysis for the Navajo Transmission Project EIS. She also serves as the project coordinator and principal public involvement specialist for the public involvement program for the City of Glendale's Project WATERS wastewater reclamation facility siting study. Additionally, Ms. Gehrke serves as the project coordinator of the public information program for the City of Scottsdale's Water Campus reclamation project.

## **David J. Guzzetta, Senior Environmental Scientist, Dames & Moore, Inc.**

*PhD, Environmental Science and Engineering, University of California, Los Angeles, 1986*

*MA, Natural Science, California State University, San Jose, California, 1975*

*BS, Zoology, San Jose State College, San Jose, California, 1969*

Dr. Guzzetta is a senior environmental scientist with over 20 years of experience in the environmental compliance aspects of waste management, energy and resource development, and facility operations. He has worked extensively in program development, technical administration, and project management. His experience includes managing multi-disciplinary and international teams of scientists and engineers in planning and implementing environmental studies, developing compliance strategies, and preparing environmental documents. Dr. Guzzetta has conducted detailed reviews of NEPA documents for the Hanford Site, has developed NEPA guidance for Hanford contractors, and has supported DOE in preparing several EISs.

## **Margaret Hartke**

*MA, Journalism and Mass Communication, University of Wisconsin, Madison, Wisconsin, 1991*

*BA, Biology, University of North Carolina, Chapel Hill, North Carolina, 1984*

Ms. Hartke is a technical writer and editor with 11 years of experience in the areas of science/technical writing and environmental risk communication. Past projects have included editing the Hanford Site Tank 106-C Sluicing Project technical design review, editing/rewriting the Hanford Mission Management Plan which defines the DOE management approach for directing Hanford Site cleanup, and editing/rewriting emergency preparedness documents for the Washington Public Power Supply System. Ms. Hartke has also served as a science writer for the University of Wisconsin-Madison Graduate School where she promoted research and development interactions between the university and private industry.

### **Kay Kimmel**

*BS, Biology and Psychology, University of Tennessee, Martin, 1979*

Ms. Kimmel has over five years of experience providing regulatory compliance services to DOE clients. Her previous experience in an engineering/construction firm and equipment sales also enables her to provide practical solutions. She has overseen three CERCLA operable units from the work scoping phase through remedial investigation/feasibility study stages, and up to the Record of Decision, and has participated in RCRA closure activities. Ms. Kimmel was instrumental in initiating the data quality objective process between DOE, EPA and Washington State regulators to streamline the Remedial Investigation/Feasibility Study process. Because of her CERCLA activities, she is able to provide compliance services in CERCLA, RCRA, National Resource Damage Assessment and NEPA.

### **Carter K. Kirk**

*BS, Health Sciences, George Washington University School of Medicine, 1985*

Mr. Kirk has over ten years of nuclear experience, and is presently assigned as safety engineer/health scientist/safety analyst in support of the DOE multi-contractor Occupational Medical/Health Program. Mr. Kirk provides direct support and oversight to the safety analysis, licensing, and regulatory policy group at Hanford, and is experienced in project and work control, implementation of technical specifications and technical safety requirements, and radiological instrumentation and control systems. Mr. Kirk's non-DOE experience includes serving as radiological engineer for direction of plant health physics operations, senior health physics technician during operations and outages, and radiation health officer in the U.S. Navy.

### **Kevin Kjarmo**

*BS, Environmental Science, BA, Economics, Washington State University, 1993*

Mr. Kjarmo is an environmental scientist with expertise in the areas of environmental law and policy, environmental impact assessment, and pollution prevention planning. Mr. Kjarmo supports the DOE Hanford Tank Waste Remediation System program in NEPA project planning and coordinates with the state of Washington Department of Ecology to meet state of Washington Environmental Policy Act requirements. In addition, Mr. Kjarmo supports the Tank Waste Remediation System Environmental Safety, Quality, and Health program by participating in the development of document review plans, management plans, and operating procedures.

### **Barbara Lewis**

*MS, Water Resources Management, University of Wisconsin-Madison, 1984*

*BA, (Magna cum laude), Economics, Colorado College, 1978*

Ms. Lewis manages public involvement programs and performs socioeconomic analyses for a variety of projects related to infrastructure planning, water and energy resources, and hazardous and solid wastes. Ms. Lewis has provided

support for several EISs including directing the socioeconomic impact assessment for an EIS on alternative transportation corridors through the Tonto National Forest in Arizona. She also managed the public involvement programs for an EIS on a transmission line siting project in Idaho, Nevada, and Utah and for an EIS on a 230 kv transmission line siting in Arizona and New Mexico.

## **Dan Lowery**

*BA, Geography, California State University, Long Beach, California, 1987*

*Hazardous Materials Management Certificate, University of California, Irvine (in progress)*

Mr. Lowery is an environmental scientist with eight years of experience in land use planning and environmental compliance, including NEPA requirements. He has participated in preparing EISs and environmental impact reports, including public works projects, water resources, mixed use development, transportation planning, and hazardous materials management. Mr. Lowery has been responsible for a number of environmental project management and interagency coordination tasks. He has served as project and task manager for environmental impact reports and EISs addressing public health and safety, air and water quality, hazardous material management, hydrology, biology, traffic, geology, electrical energy transmission, and underground tank monitoring.

## **Eve Mac Quarrie**

*BA, Psychology, United States International University, 1973*

Ms. Mac Quarrie has eighteen years of experience in regulatory, litigation, and project management. In support of the DOE, Ms. Mac Quarrie has participated in document review, maintained a database of findings, and provided input to the reports for a DNSFB-mandated Critical Design Review of a project to remove strontium 90-contaminated sludge from an aging underground single-shell storage tank at the Hanford Site. Ms. Mac Quarrie has also provided support to DOE's Technology Development Division creating and maintaining a tracking system for Technical Task Plans and Approved Financial Plan information, coordinating Progress Tracking System reports, tracking program change requests, and facilitating comment resolution on these items with Hanford contractor personnel and other DOE organizations.

## **Paul J. Macbeth**

*MS, Nuclear Physics, Brigham Young University, Provo, UT, 1974*

*BS, Nuclear Physics, Brigham Young University, Provo, UT, 1971*

Mr. Macbeth has over 20 years of experience in the nuclear waste management industry, including assessment of environmental impacts from waste management activities, remediation of uranium mill tailing sites and contaminated federal facilities, waste classification and associated risk assessment, as well as design and operational experience at a commercial nuclear power plant. Mr. Macbeth provides senior-level expertise in radioactive and mixed waste management in review and oversight functions for DOE's Waste Programs Division. His reviews and oversight help ensure compliance with applicable DOE, EPA, State of Washington, Nuclear Regulatory Commission, and Department of Transportation regulatory requirements and guidelines through review.

## **Scott Manley**

*BS, Environmental Science, Washington State University, 1994*

Mr. Manley has extensive experience in bioremediation of groundwater and subsoils. A recipient of the Battelle/WSU Multicultural Fellowship, Mr. Manley conducted multi-faceted research of contaminated groundwater and subsurface soils in conjunction with the Savannah River Integrated Demonstration Project. He also conducted subsoil

bioremediation experiments and subsequent analysis for the DOE-sponsored Cerro Negro Sampling Project.

## **Jeff Markillie**

*BS, Environmental Science, Washington State University, Pullman, 1989*

Mr. Markillie is an environmental scientist with more than six years of professional experience. He provides Clean Air Act, Clean Water Act, and RCRA facility permitting and compliance support to DOE. He has provided management and environmental consulting services to DOE, Department of Navy, and private-sector clients. He specializes in environmental management and operations management including planning, designing, siting, and permitting radioactive, hazardous, and mixed waste treatment, storage, and disposal facilities; analyzing facility operations and support programs for compliance with regulatory requirements; and managing complex marine engineering systems.

## **Vera Miller**

*BS, Biology, University of Oregon, Eugene, Oregon, 1989*

Ms. Miller is an environmental analyst with over six years of experience on environmental permitting projects and with NEPA and CERCLA regulations. Ms. Miller has experience working on EISs, environmental permitting projects, oil spill contingency plans, and environmental monitoring programs. Her NEPA experience includes EISs addressing the safe interim storage of Hanford tank wastes, a combined cycle combustion turbine power plant and associated natural gas pipeline, and the long-term sale of timber. Ms. Miller also supported the Exxon Valdez Biological Effects Monitoring Program where she performed data management and analysis tasks to assess the growth, behavior, and success of pink salmon in Prince William Sound, Alaska after the Exxon Valdez oil spill.

## **Duc M. Nguyen**

*MS, Chemical Engineering, University of Idaho, 1987*

*BS, Chemical Engineering, University of Missouri-Rolla, 1984*

Mr. Nguyen is a chemical engineer with over nine years of engineering and project and program management experience. This experience includes tank waste management, low-level and high-level waste disposal, liquid effluent management, and laboratory waste management and regulatory compliance activities at the Hanford Site. He recently conducted an engineering study to evaluate waste minimization opportunities at the Hanford PFP Facility and to assess design, safety, NEPA, RCRA, and budgetary documentation.

## **Yusuf Noorani**

*B.S. Mechanical Engineering, University of Missouri, 1985*

*B.S. Physics, Chemistry and Mathematics, University of Karachi, 1979*

*Graduate studies, Interdisciplinary Environmental Science, University of Idaho*

Mr. Noorani has over nine years of experience with DOE environmental restoration and waste management. He has extensive experience in all aspects of environmental investigations, permitting, audits, and data management and safety analysis and has participated and coordinated numerous SAR reviews. Mr. Noorani is assigned as a senior environmental engineer on the DOE Hanford Tank Waste Remediation System EIS. In this capacity, he provides technical review and support to DOE in project planning, control, engineering, waste management, and NEPA compliance. Mr. Noorani worked as a low-level waste engineer on the Grout Program at Hanford in support of the Tank Waste Remediation System Program Office.

## **Nanci Peters**

*Business University, Spokane, Washington*

*School of Radiology, Spokane, Washington*

*University of Washington, Sacred Heart Medical Center - Certified Medical Technologist*

Ms. Peters is a community relations specialist with more than 15 years of experience in public and community relations support for DOE programs. She has extensive experience in project management and development, technical administration, regulatory compliance, site investigations, and safety compliance. Currently, Ms. Peters supports the Hanford Cultural Resources Program for DOE and the Indian Nations Program Office. She has provided public relations assistance to the Safe Interim Storage of Hanford Tank Wastes EIS, and supported the Tri-Party Agreement by tracking the management of milestones, including the analysis of milestones for the purpose of identifying current status, potential issues or barriers to success, and recommendations for associated recovery plans.

## **Marie E. Piper**

*BS, Mechanical Engineering, University of New Hampshire, 1986*

Ms. Piper is an air quality expert with ten years of experience in the areas of air quality impact modeling, emission inventory development, regulatory compliance, NEPA analyses, noise impact analysis, and visible emission evaluation. Her representative NEPA project experience includes performing environmental assessment evaluations of the potential air quality impacts associated with several U.S. Navy development projects, performing an air quality impact analysis for a proposed timber harvest in Alaska's Tongass National Forest, and evaluating potential air and noise impacts for the Interstate-5 widening project near Centralia, Washington.

## **John V. (Jack) Robinson**

*M.S. Nuclear Physics, Rensselaer Polytechnic Institute, Troy, NY, 1955*

*B.S. Physics, Canisius College, Buffalo, NY, 1952*

Mr. Robinson has 40 years of experience in programs related to NEPA documentation, nuclear power, nuclear waste, aerospace, and pollution abatement. As Manager of Environmental Programs at the Pacific Northwest Laboratory (PNL) for 12 years, he was responsible for directing NEPA programs at the Hanford Site including EISs for such projects as site defense wastes, double-shell tanks, and decommissioning of production reactors. During the past five years, Mr. Robinson managed coordination of technical input by PNL and Westinghouse Hanford Company for the New Production Reactor EIS prepared by Argonne National Laboratory. He has also assisted in developing a NEPA strategy for the solid waste program at the Hanford Site and a training course for the lead personnel in DOE's Environment, Safety, and Health Progress Assessments.

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## **Avi Tayar**

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## APPENDIX A

# DESCRIPTION OF THE PLUTONIUM FINISHING PLANT

## A.1 INTRODUCTION

The Plutonium Finishing Plant (PFP) Facility (Figure A-1) is comprised of several buildings and is located in the 200 West Area. It occupies approximately 23 hectares (58 acres). The Facility is separated from the rest of the 200 West Area by a double-fenced security enclosure. Personnel having duties and responsibilities associated with the operation of the PFP Facility have security clearances for access to the protected area.

Historically, the PFP Facility was used to conduct diversified plutonium processing, storage, and support operations. Those operations included:

- Special nuclear material handling and storage
- Plutonium recovery
- Plutonium conversion
- Laboratory support
- Waste handling
- Shutdown and operational facility surveillances.

All operations related to the recovery and conversion of plutonium for national defense needs were stopped in 1989.

This appendix provides summary information on the PFP Facility, buildings, operation, design features, and waste management. All information, unless otherwise indicated, was taken from the PFP Final Safety Analysis Report (FSAR)(WHC, 1995). Recent changes in the PFP Facility are not reflected in this FSAR. These changes would not affect impact analyses.

## A.2 BUILDINGS AT THE PFP FACILITY

The following subsections contain brief descriptions of the principal buildings comprising the PFP Facility. The focus of the descriptions is on those buildings that contain plutonium to be stabilized under the proposed alternatives. The descriptions also cover the facilities that are to be used for various stabilization options as well as any auxiliary facilities. Table A-1 lists the major facilities and provides a brief description of each.

### A.2.1 234-5Z BUILDING

The 234-5Z Building (also referred to as the Dash 5 Building) houses the Remote Mechanical A (RMA) and Remote Mechanical C (RMC) plutonium processing lines, an engineering laboratory, development laboratory, and major service and support facilities. The 234-5Z Building also contains plutonium storage and staging areas. These areas were used for interim storage of plutonium pending processing.

[Figure A-1. The PFP Facility](#)

**Table A-1 Major Buildings at the PFP Facility**

Building#	Description
232-Z	Contaminated waste recovery process (Incinerator)

234-5Z	Plutonium Conversion Facility contains RMC and RMA Lines
236-Z	Plutonium Reclamation Facility
241-Z	Liquid waste collection tanks in underground vault(s)
242-Z	Waste Treatment and Americium Facility
291-Z	Exhaust Fan House, Exhaust Air Stack Building, and Compressor and Fan House
291-Z-1	A stack 61 m high, 5 m inside diameter at the bottom, and 4 m inside diameter at the top
296-Z-3	A stack 7.6 m high, which ventilates the 241-Z Building
296-Z-5	An 86-cm diameter, stainless steel stack at 8.4 m above grade, that ventilates the 2736-Z Building
296-Z-6	A 91 cm diameter, stainless steel stack at 4.5 m above grade, that ventilates the 2736-Z Building
2736-Z	Vault for storage of special nuclear material
2736-ZA	Houses an emergency diesel generator to power exhaust ventilation equipment and houses the exhaust fans and filters
2736-ZB	Shipping and receiving operations

**Source:** WHC, 1995

The 234-5Z Building was constructed with noncombustible materials and contains a first floor, duct level, second floor, and roof level. The 234-5Z basement consists mostly of pipe tunnels carrying drain piping to sumps.

The first floor houses the two plutonium processing lines (RMA and RMC Lines) and their control rooms; plutonium scrap stabilization gloveboxes; plutonium storage vaults; the plutonium nitrate feed, blending and storage facilities; the engineering laboratory and development laboratory; the instrument maintenance shops; the building maintenance shops; locker rooms with change facilities and restrooms; and office spaces. The duct level contains most of the service piping, ventilation ducts, and some filterboxes.

The lunchroom, conference room, materials storage room, chemical feed preparation and aqueous make-up rooms, locker rooms with change facilities and restrooms, and office spaces are on the second floor. Also located on the second floor are exhaust air ductwork, including filterboxes and filter rooms, and the fan room. The fan room, located on the northwestern corner of the second floor, houses the ventilation supply fans, the steam inlet and distribution system, air dryers, the distilled water still, air chilling units, and the Vent and Balance Control Room.

The RMC Line was used to produce metallic plutonium from purified plutonium nitrate solution produced at the Plutonium Reclamation Facility (PRF) or from the Plutonium Uranium Extraction Facility (PUREX). It comprises 20 gloveboxes and a control room. Processing equipment is contained in gloveboxes constructed of stainless steel frames and floors, and clear plastic panels on the sides and top. The large, transparent panels provide good visibility for personnel working at the gloveboxes and for viewing from the control room. Spotlights and closed circuit television are provided to aid in viewing. The panels are penetrated by gloveports, entry ports, entry seals, solution transfer lines, and instrument and electrical connectors. Thick panels, water walls, lead-glass, and lead-filled gloves provide neutron and gamma-ray shielding from the gloveboxes. The control room is shielded by concrete, steel water walls, and water-filled viewing windows.

The shutdown RMA Line, which produced plutonium oxide powder, is located to the north of the RMC Line. The equipment in the RMA Line is similar to that for the RMC Line.

Two annexes were built off the main 234-5Z Building. The West Annex is a concrete structure with sheet metal covering. This annex was built to store special nuclear material. The South Annex is a concrete structure that was added to 234-5Z to provide development laboratory office space.

### **A.2.2 236-Z BUILDING**

The 236-Z Building houses the PRF. The building is a four-story structure, surmounted by a two-story penthouse. Its outstanding internal structural feature is a single process equipment cell located near the center of the building.

The PRF was capable of producing a high-purity plutonium nitrate solution from a variety of feed sources, including scrap, by means of continuous solvent extraction process equipment located in the process cell. The product was used as feed to the 234-5Z Building process lines for conversion to plutonium metal. PRF processes, equipment, and services include miscellaneous treatment, slag and crucible dissolution, filtrate concentration, feed preparation, plutonium solvent extraction, product concentration, and waste treatment processes. Central control activities were carried out by operating personnel located on the fourth floor.

The process cell has a 0.60 meter (m) (2 feet [ft]) thick concrete wall between the cell and "access" gloveboxes. "Access" gloveboxes are stainless steel paneled gloveboxes containing glass viewing windows and Hypalon hood gloves. The gloveboxes are located on both sides of the cell on the first two floors and contain process piping, pumps, valves, flowmeters, and other equipment that most frequently require maintenance.

The cell floor is covered with a stainless steel liner extending 45 centimeters (cm) (18 inches [in]) up the side wall. The remaining cell wall and ceiling surfaces are covered with chemical-resistant coatings. Water-filled viewing windows on the third floor have adjacent remote control stations for the cell crane.

A remotely operated overhead crane in the process cell can be used to remove or replace process equipment. Process equipment is fabricated as part of an assembly. The assembly contains supporting equipment, safety bars, and tapered plugs. The plugs fit into the 0.60 m (2 ft) thick concrete wall; the safety bars prevent accidental moving of the tanks. All piping (process, electrical, and instrument) is routed through the plugs. Disconnecting all necessary fittings in the gloved hoods permits removal of equipment. Equipment can be moved by the crane to a special maintenance station at the north end of the process cell. This maintenance area is shielded from the rest of the cell by a 25 cm (10 in) concrete wall. The maintenance station is equipped with a lead-covered stainless steel hood panel and leaded glass windows.

A cluster of five gloveboxes contain the miscellaneous treatment process. The miscellaneous treatment process serves as a small-scale process for recovering plutonium from scrap. Primary equipment includes dissolver pots, hot plates, centrifuges, condensers, and furnaces. Capabilities include receiving and inspection, acid leaching and dissolution, electrolytic dissolution, and distillation and burning of plutonium-bearing organics. Nonleachable solids are also separated and cemented.

Maintenance shop facilities are located on the service (east) side of the building on the ground floor. The second floor of the service side was used as a maintenance glovebox and for ventilation exhaust filters. Building service equipment and electrical switch gear are on the third floor of the service area. The fourth floor was used for chemical preparation and the miscellaneous treatment processes and contains an operating control room, slag and crucible dissolver equipment, and a column room. The column room contains vertical sections of two liquid-liquid extraction columns penetrating the room from above and below. These columns are housed in a glovebox.

### **A.2.3 241-Z BUILDING**

The 241-Z Building is designated as the Waste Treatment Facility. The Facility is used for intermediate storage and neutralization of aqueous wastes. After neutralization, the wastes are pumped to the 200 Area Tank Farms. The building is a buried structure (vault) built of reinforced concrete, with a sheet metal enclosure over the top housing a hoist for removing cell covers.

The building has five separate enclosures or ventilated cells, each containing a tank with a 16,000 liters (l) (4,200 gallons [gal]) working volume used to collect radioactive liquid wastes.

At the southwest corner of the 241-Z vault deck is the equipment for the 241-Z vessel vent and vault ventilation system. The stainless steel 296-Z-3 stack and its associated fans, filters, and controls are also located here on a 4 m (14 ft) by 5 m (18 ft) concrete pad. The stack is a 36 cm (14 in) diameter stainless steel stack standing 7.6 m (25 ft) above grade.

#### **A.2.4 291-Z BUILDING**

The 291-Z Building contains equipment for the main exhaust ventilation system at the PFP Facility. The building is also known as the Exhaust Fan House, Exhaust Air Stack Building, and the Compressor and Fan House. The 291-Z Building contains seven electric exhaust fans and two steam turbine fans which service Buildings 234-5Z, 236-Z, and 242-Z. The building also contains compressors for process air, instrument air, and breathing air, the process vacuum system, and the air sampling vacuum system vacuum, plus a separate exhaust system for removing heat from the 291-Z Building itself.

The PFP main stack (291-Z-1) exhausts filtered process and ventilation air from gloveboxes and hoods in Buildings 234-5Z, 236-Z, and 242-Z, and those rooms which have a potential for contamination.

#### **A.2.5 2736 VAULT BUILDINGS**

The 2736-Z Building consists of four vaults for the storage of special nuclear material, divided by a corridor running the width of the building. Each storage vault is approximately 8.5 by 8.5 m (28 by 28 ft) in size. Vaults 1, 3, and 4 contain storage cubicles while Vault 2 has steel shelves and open floor storage.

Vault 1 cubicles are constructed of precast concrete panels, 20 cm (8 in) thick. Each cubicle has a cross-sectional area 0.3 by 0.6 m (1 by 2 ft) and is approximately 2.4 m (8 ft) tall. There are 68 of these cubicles. The doors of each cubicle are flush with the top of the cubicles and have a 1.3 cm (0.5 in) gap from the bottom of the doors to the floor. A ventilation duct, attached to the top of each cubicle, provides a continuous downward airflow through each cubicle. Thermocouples located in the top of each cubicle permit air temperature monitoring.

Vault 2 contains shelved storage space for 700 items of special nuclear material. Each shelf measures 23 by 23 cm (9 by 9 in) and approximately 30 cm (12 in) deep. Containers are maintained on the shelf by means of a can restraining chain on the front (to load and unload) and a 5 cm (2 in) lip at the bottom of each shelf. In addition, there are 296 spaces in this vault for the storage of fissile material in shipping and storage containers up to the limit allowed by the specifications (approximately 500 grams [g] or 1.1 pounds [lbs]). Ventilation for this vault is provided by supply and exhaust ducts mounted near the ceiling on the east and west walls, respectively.

The cubicles in Vaults 3 and 4 are constructed of precast concrete panels, 20 cm (8 in) thick. Each cubicle has a cross-sectional area 0.3 by 0.6 m (1 by 2 ft) and is approximately 2.4 m (8 ft) tall. There are 68 of these cubicles per vault. Each cubicle has two doors constructed of precast concrete, 23 cm (8 in) thick at the thickest part. The doors, when closed, leave a gap between them to allow for air circulation via natural convection. A 15 cm (6 in) gap between the bottom of each door and the floor also aids ventilation for these vaults, which is provided by supply and exhaust ducts mounted near the ceiling on the east and west walls, respectively.

The 2736-ZA Building stands adjacent to the 2736-Z Building, and houses a backup diesel generator used to power exhaust ventilation equipment. Building 2736-ZA also houses the exhaust fans and filters.

The 2736-ZB Building houses shipping and receiving areas, each providing approximately 93 square meters (m<sup>2</sup>) (1,000 square feet [ft<sup>2</sup>]) of space. Adequate spacing is provided between containers to meet criticality prevention and personnel exposure specifications. Sufficient space is also provided to allow corridor access to the staging areas.



## **A.3 FACILITY OPERATIONS AND DESIGN FEATURES**

This subsection provides information on the following components of the PFP Facility:

- Structural specifications
- Facility containment/confinement features
- Offgas treatment
- Vacuum systems
- Fire protection systems
- Nuclear safety
- Safety communications and alarms
- Emergency electrical power
- Air systems
- Gas systems
- Nonradioactive chemical systems.

### **A.3.1 STRUCTURAL SPECIFICATIONS**

The principal structural design criteria for the construction of the PFP Facility met applicable criteria at the time of construction. The structural specifications establish the basis and engineering design required to maintain the confinement integrity of the major buildings in the PFP Facility.

The natural phenomena hazards that could affect the PFP Facility are earthquake, extreme wind and wind projectiles, and snow loading. Evaluation for the natural phenomena hazard from ashfall is only required for new Safety Class I facilities as described in SDC 4.1, Rev. 11 (DOE, 1989). Therefore, the ashfall loading is not applicable to these facilities. In the structural evaluation, analysis of the roof was performed to verify design adequacy due to live loads, dead loads, and snow loads, which are the normal roof loads.

Based on various studies cited on the PFP FSAR, Buildings 234-5Z, 236-Z, 291-Z, 2736-Z and 2736-ZA, as well as stack 291-Z-1, can withstand a design basis earthquake, extreme wind and wind projectiles, and snow loads. Building 2736-ZB can withstand a design basis earthquake, extreme winds, and snow loads. The cover blocks for Building 241-Z can withstand a design basis earthquake (WHC, 1995).

Most of the seismic qualification analyses for the PFP Facility were performed in accordance with HPS SDC 4.1, Rev. 10 (DOE, 1987), which used a zero period acceleration of 0.25 gravity. Analyses to determine the adequacy of current day design conditions of the PFP Facility buildings and process equipment conclude that all PFP Facility buildings, with the exception of 232-Z, are not expected to structurally fail in the event of a design basis earthquake.

The wind load analyses used the maximum velocity of 40 meters per second (m/sec) (90 miles per hour [mi/hr]) based on the guidelines of SDC 4.1, Rev. 11 (DOE, 1989) (Kennedy, et al., 1990). The structures were all designed to withstand 98 kg/m<sup>2</sup> (20 lb/ft<sup>2</sup>) of normal wind load. The 2736-ZB and 2736-Z Buildings, in addition to the normal wind load, also were designed to withstand tornado wind conditions having a resultant wind speed of 78 m/sec (175 mi/hr) and other associated tornado-generated missiles identified in SDC 4.1, Rev. 7 (DOE, 1974).

The roof loading requirements of the major buildings were based on the Uniform Building Code guidelines at the time of the design. The roofs of all aboveground structures were designed for static vertical live and dead loads, including snow loads.

### **A.3.2 FACILITY CONFINEMENT FEATURES**

Several features were included in the construction of the PFP Facility to ensure confinement of the radioactive materials in the processing areas. Construction features of the process areas in the 234-5Z Building, such as arrangement and piping, ensure the confinement of radioactive materials and reduce personnel exposure.

The arrangement of the areas provide the following features:

- Gloveboxes are connected by an enclosed conveyor so that removal of product from gloveboxes is not required during processing.
- Process steps are combined to reduce transfers, such as a three-tiered glovebox where the material being processed is introduced at the top and progresses by gravity through the precipitator, the calciner, and the fluorinator.
- The main control of process steps is accomplished from a remote operating gallery shielded by water walls.
- Maintenance and operations personnel access is provided through doors from a separate corridor along the back of the rooms housing the gloveboxes.
- Access to all sides of the gloveboxes is provided wherever practicable.

In all cases practicable, piping for radioactive materials is within an encasement that can be monitored for leaks. Also, wherever the fluid transfer pressure will allow, vacuum transfers are used.

### **Facility Ventilation Systems**

The PFP Facility ventilation system includes the following major Facility confinement features:

- The buildings are divided into zones, depending on their potential for contamination, and the zone ambient pressures are controlled so that air flows are from areas of lesser contamination potential to areas having a higher contamination potential, e.g., Zone 1 ---> Zone 3 ---> Zone 4.
- Most of the 234-5Z, 236-Z, and 242-Z Building ventilation systems are a part of a single, large air supply/exhaust once-through system. Building 232-Z has its own air supply system.
- Supply air is filtered (not high efficiency particulate air [HEPA]), washed, and heated or cooled (depending on weather conditions). A small portion of supply air is dehumidified for use in areas requiring dry air.
- Cooling is by evaporation, except for special areas where humidity is a concern or temperature control is critical.
- All air exhausted from potentially contaminated spaces is filtered at least once through HEPA filters.
- Exhaust air from potentially contaminated zones is discharged through a 61-m (200-ft) stack and is continuously monitored for radioactive materials.
- Air is normally supplied near the ceiling and exhausted near the floor to minimize the potential for lofting contamination into the PFP Facility workers' breathing zone.
- All contaminated or potentially contaminated areas are maintained at a negative pressure with respect to ambient pressure.

Ventilation for the PFP Facility is provided by five separate systems. The largest system provides ventilation for the 236-Z, 242-Z, and 234-5Z Buildings. The second system provides ventilation for the 241-Z Waste Retention Building. The remaining three systems provide ventilation for the 2736-Z, 2736-ZB, and the 232-Z Buildings. Ventilation is on a "once through" basis except for small-volume recycling of room air to supply laboratory refrigeration air-conditioning systems and for the 2736-ZB Building, which recycles air from the administration area and from the nondestructive analysis laboratory.

Buildings served by the ventilation systems are zoned as a means of control to ensure confinement of radioactive materials. These zones are identified as Zones 1, 3, and 4. In the 234-5Z, 232-Z, 236-Z, and 241-Z Buildings, Zone 1 is designated as those areas where plutonium contamination would not normally be present. No contaminated materials or personnel wearing protective clothing are allowed in Zone 1 areas.

Zone 3 consists of areas in which radioactive material is stored or handled in contained form, and where there is the potential for contamination to occur.

Zone 4 consists of the inside of hoods, gloveboxes, and process cells, directly exposed to plutonium, and which may be grossly contaminated. Differential pressures are maintained between the zones to ensure that airflow is from the lowest potential contamination areas, to intermediate potential contamination areas, to highest potential contamination areas.

In the 2736-Z complex, zone designations are reversed. Zone 1 is designated as having the highest potential for contamination, and Zone 4 is the clean zone.

Radioactive materials in process areas are confined as close to the point of origin as practicable through the use of HEPA filters installed on the exhaust ducts of hoods and on both the supply and exhaust ducts of gloveboxes. Exhaust ventilation air from Zone 3 areas is filtered via one stage of testable HEPA filtration before discharge to the atmosphere via a stack. Exhaust ventilation air from Zone 4 areas is filtered via two stages of testable HEPA filtration before discharge to the atmosphere via a stack. The HEPA filters (except exhaust filters on gloveboxes) are tested annually with dioctyl phthalate according to specifications. Installed HEPA filters must meet a minimum criterion of 99.95 percent efficiency.

The design of the 234-5Z Building ventilation system combines all the ventilation into one large system. The advantages are considered to be that walls between equal pressure zones in the building do not have to be sealed absolutely tightly and do not require airlocks for access. With one large exhaust system, pressures in different areas in the building remain the same relative to each other if the supply is cut off, which provides a satisfactory emergency condition for the entire building.

Redundant capacity is provided for key features of the ventilation systems (e.g., supply and exhaust fans, HEPA filtration rooms). Two independent 13.8 kilovolt lines supply normal electric power to the PFP Facility. Four supply fans (234-5Z) and four exhaust fans (291-Z) are supplied (through appropriate transformers) from one circuit and four supply fans (234-5Z) and three exhaust fans (291-Z) are supplied from another circuit. Failure of either circuit would therefore not result in failure of the ventilation system. Should one circuit fail, manual switching can be done to power all supply and exhaust fans from the remaining circuit. Two additional ventilation exhaust fans, powered by steam turbines, are installed to provide backup exhaust ventilation on loss of normal electric power.

### **Glovebox Ventilation**

The ventilation of process areas provides ambient air pressures that are lower than any adjoining space so that incidental leakage will flow into the areas. The lowest pressures of all are in the processing gloveboxes.

Filters are provided on the ventilation exhaust outlet from all gloveboxes so that, to the degree practicable, the radioactive particulates can be kept out of the ventilation ductwork and thereby prolong the life of the final filters. Also, all gloveboxes that are supplied air from the room around the glovebox are equipped with HEPA filters on the inlet to the glovebox to reduce the amount of particulate matter that would be carried out of the glovebox to the room in case of a pressure reversal.

### **A.3.3 OFFGAS TREATMENT**

The most extensive treatment given to offgases in the 234-5Z Building is the particulate removal from the ventilation system exhaust. This includes exhaust from contaminated hoods, gloveboxes, and process vessels (E-4 exhaust system) and the exhaust from potentially contaminated rooms around the gloveboxes (E-3 exhaust system). System offgases are treated for physical elimination of fumes, moisture, and particles before discharging to the 291-Z-1 stack.

### **A.3.4 Vacuum Systems**

The process vacuum system provides high capacity vacuum service to the PFP Facility for vacuum transfers of liquids and other high vacuum requirements. It is commonly referred to as the 26-in vacuum because it provides approximately 660 millimeters (mm) of mercury (26 in of mercury) vacuum service. A 10-cm (4-in) diameter stainless steel piping header is routed throughout the first-floor duct level of the 234-5Z Building, with branches serving process areas and the 242-Z and 236-Z Buildings.

The air pulled into this system, in many cases, comes from inside contaminated enclosures and is usually moist from its use as the source of a vacuum transfer of contaminated liquid. Thus, each major branch is equipped with demisters. Seal water is recirculated through coolers and is replaced periodically with fresh water. Liquid effluents, which may

contain trace amounts of contamination, are routed to the 241-Z Building waste tanks for disposal.

The vacuum pump inlet air is filtered through two stages of HEPA filters. The exhaust air is discharged into the 234-5Z Building ventilation system ahead of the final HEPA filter bank.

Air sampling vacuum systems provide the motive force for continuous air monitor units, fixed filter air samplers, and select stack effluent samplers and monitors. These systems provide approximately 430 mm of mercury (17 in of mercury) vacuum service. The source of this vacuum is two vacuum pumps located in the 291-Z machinery room. Piping is provided throughout the 234-5Z, 2736-Z, and 232-Z Buildings. The air is collected and filtered by one stage of HEPA filters before entering the vacuum pumps and discharging via a moisture separator and two outlet HEPA filters to the 291-Z exhaust fan inlet plenum.

### A.3.5 Fire Protection Systems

The fire protection system for the PFP Facility consists of many individual communication and operating systems that inform or provide some action in regard to fires and firefighting. The system also includes compartmentalization and placement of fire barriers to protect against exposure hazard and provide for fire isolation to limit damage and allow personnel departure. The system comprises the following:

- Piping systems, which contain and transport the extinguishing agents
- Fire alarm system, which notifies the Hanford Fire Department and building occupants when triggered
- Heat or products of combustion detection systems that activate an alarm and/or activate a fire extinguishing system
- Automatic sprinkler systems that activate by heat to open and sprinkle water; usually fusible link mechanisms
- Halon suppression systems (particularly in gloveboxes)
- Portable fire extinguishers and magnesium oxide sand
- Supervised valves in the water supply system
- Fire barriers to isolate parts of buildings, thus slowing progress of the fire and reducing damage to such barriers that are vital to personnel safety.

In addition, the PFP Facility buildings are equipped with manual fire alarm pull boxes located strategically throughout the Facility, with the exception of the tunnels.

### A.3.6 Nuclear Safety

A criticality safety program is in place to minimize risk of a criticality incident. Criticality is a state in which a self-sustaining nuclear chain reaction is achieved. The criticality safety program applies to all processing, transfer operations, transport, and storage activities involving fissionable material. The PFP Facility is classified as a fissile material facility and subject to all of the elements of the criticality safety program.

The PFP Facility employs the double contingency principle of criticality safety. That is, criticality prevention shall be based on the double contingency principle that at least two unlikely, independent, and concurrent changes or contingencies must occur before criticality is possible.

The following types of Criticality Safety Control are incorporated into the design, operation, and administration of the PFP Facility, as required, based on criticality safety evaluations:

- **Mass and Piece Count Controls** - Restrictions on the number of units and quantity of fissionable material permitted in individual units or in the total configuration.
- **Volume and Material Compounds and Form Controls** - Restrictions on fissionable material volumes, or container and vessel volumes, as well as the composition and physical state of the material.
- **Geometry Controls** - Dimension and shape restrictions on equipment design provide inherently "geometrically safe," or "geometrically favorable" containers and vessels for fissionable materials. Includes floor areas allowed for leakage accumulations and geometrically favorable drain heights ("criticality drains").

- **Density Controls** - Restrictions on permitted concentrations of fissionable material dissolved or dispersed in another medium.
- **Areal Density Control** - Restrictions on allowed fissionable mass per unit area of a large slab, as for the bottom of a glovebox or floor.
- **Enrichment Controls** - Restrictions on maximum relative fraction of fissionable isotope constituents in total heavy metal (uranium plus plutonium) concentration.
- **Moderation Controls** - Restrictions on allowed range of hydrogenous-material density relative to fissionable material density in moderator/fissionable mixture or on the total amount of moderating materials allowed.
- **Interaction and Reflection Controls** - Restrictions to minimize potential neutron interactions between various units, vessels, containers, and accumulations of fissionable materials, including controls on spacing, arrangement, and/or shielding, as well as restrictions on the composition and/or configuration of reflector materials in proximity to fissionable configurations.
- **Absorber Controls** - Requirements defining need for solution concentration, distributions, minimums, and required permanence of neutron absorbers (such as boron and cadmium) used for criticality safety purposes.
- **Flow and Placement or Displacement Controls** - Requirements for designed features or operational procedures that exclude or restrict the rate of flow of solutions in process pipelines. Requirements for fixtures or barriers that prevent positioning of fissionable units in particular locations or prevent motions of units from designated positions.
- **Chemistry Controls** - Restrictions on concentrations or specifications of the makeup of process chemicals incorporated with the fissionable materials in the processing streams. These controls are to ensure the intended physical and chemical forms of the fissionable material, to prevent material buildup (such as precipitation or internal refluxing in a solvent extraction column), and to ensure control of fissionable material concentration.

Shielding is provided to reduce radiation intensities in occupied spaces during all phases of PFP Facility operation. The activities inside the PFP Facility are designed and controlled to limit personnel radiation exposure.

Minimally and potentially contaminated areas in the Facility are well-defined and appropriately marked. Administrative controls for entrance into the PFP Facility and potentially contaminated areas are enforced by operations supervision. Entrances into zones where high radiation levels or severe contamination levels exist are locked or guarded at all times. Radiation detection instrumentation is provided in all regulated areas. Instrument readings are recorded, and audible and visible alarms are provided at the instrument to alert operators and radiological protection personnel of abnormally high radiation/contamination levels.

Radiation survey instruments are provided at strategic locations throughout the Facility.

### **A.3.7 SAFETY COMMUNICATIONS AND ALARMS**

The role of safety communications and alarm systems in the PFP Facility is to provide audible and/or visual information concerning abnormal conditions. The communication systems provide standard and emergency communication exchanges. Alarm signals are used at the PFP Facility, such as horns, sirens, and gongs, to provide notifications of specific abnormal conditions. All PFP Facility Safety Class systems interface with specific communication and alarm systems.

Safety Class 1 stack alarms are associated with stack continuous air monitor systems. Safety Class 2 alarms are associated with other environmental monitoring, criticality alarm system, and liquid effluent monitoring systems. The Safety Class 3 alarms are for personnel notification in response to fire, evacuation, warning, or radiation protection.

The major components of the system are the fire alarm system, the warning and evacuation alarm system, and the radiation protection alarm system. These systems, are briefly described below:

#### **Fire Alarm System**

The master fire alarm system for the PFP Facility consists of a reliable system that notifies the Fire Department at the 200 Area Fire Station of an alarm at any one of the master fire alarm boxes. Fire alarms are triggered by activation of

a sprinkler system, signals from smoke or heat detectors, and by manual activation of auxiliary alarm boxes (pullboxes) in the building or at master alarm boxes. Any fire alarm activates all fire alarm gongs and notifies the 200 Area Fire Station.

### **Warning and Evacuation Alarm Systems**

Both audible and visual evacuation warning systems are provided in the major buildings. These respond to criticality events, signals from various types of radiation monitors, and other off-standard conditions. They may be activated manually for certain conditions. The warnings provide for evacuation or taking cover as the situation warrants. The "all clear" signal for any evacuation/take cover alarms or signals is passed by voice. This is accomplished via the intercom system or crash alarm phones.

### **Radiation Protection Alarm System**

A variety of radiation protection instrumentation is used throughout the Facility including: portable alpha continuous air monitors, fixed alpha and beta continuous air monitors, portable monitors, and hand/foot monitors. These instruments have alarms which may report locally, centrally, or both. The radiation alarms that are remotely annunciated on the alarm consoles are in Room 221-A of the 234-5Z Building and in Room 631 of the 2736-ZB Building.

### **A.3.8 BACKUP ELECTRICAL POWER AVAILABLE TO THE PFP FACILITY**

Backup electrical power is available for the PFP Facility emergency systems. These emergency systems include monitoring systems, evacuation systems, fire alarm systems, criticality alarm system, security systems, emergency lighting, and building ventilation.

The following backup electrical power sources are available to the PFP Facility:

- Three diesel generators, 325 kilowatts each, in Building 2721-Z, west of Building 2736-ZB, comprise the largest portion of backup electrical power for the PFP Facility.
- A central, 125-volt direct current, stationary battery station to provide continuous direct current power.
- Self-contained, fully automatic, battery operated emergency light packs.

### **A.3.9 AIR SYSTEMS**

Air supply systems are provided for process, instrument, and breathing. These systems are discussed below.

#### **Process Air**

This is a general purpose air supply for use throughout the PFP Facility for air cylinders, aspirators, air tools, etc., and as a backup for the instrument air system.

#### **Instrument Air**

Air is distributed at less than 2.1 kilogram per square centimeter (kg/cm<sup>2</sup>) (30 pounds per square inch [lb/in<sup>2</sup>]) for use in instruments controlling ventilation and process equipment and any place that non-oily, clean, and dry air is required.

#### **Dry Air**

Dry air was supplied to various process gloveboxes by blowers to maintain low moisture content in plutonium products that corrode in moist air or are hygroscopic. Two dry-air generating systems, one electric, one steam, are located in Room 321 of the 234-5Z Building. Flow can be regulated by control valves at each glovebox serviced by the header.

#### **Breathing Air**

Breathing air is provided for use in contaminated or toxic areas where respiratory protection is required. The PFP Facility uses a Portable Cascade Bottle System breathing air system. The Portable Cascade Bottle System utilizes a cart with two compressed air tanks, five outlets, and a pressure demand mask, with the type of mask depending on the nature and location of the work.

### **A.3.10 GAS SYSTEMS**

Nonradioactive gases are supplied from bottle storage facilities located adjacent to the buildings. Gases supplied include a calibration gas for radiation monitors, oxygen, nitrogen, and argon to the laboratories; carbon dioxide for sludge stabilization; and argon to the 2736-ZB repackaging glovebox.

### **A.3.11 NONRADIOACTIVE CHEMICAL SYSTEMS**

Nonradioactive chemical systems consist of storage, transfer, and makeup of chemical solutions used in plutonium processing and laboratory functions. The majority of chemical storage for the PFP Facility is located outside. Inside storage in Building 234-5Z is limited to potassium hydroxide drums, dry and wet chemical storage, and chemical makeup areas. Chemical makeup involves mixing chemicals with other chemicals and/or water to provide solutions or chemical reaction products necessary to run various processes supporting plutonium operations at the PFP Facility.

## **A.4 WASTE STREAM IDENTIFICATION**

Waste streams from the PFP Facility are categorized as gaseous, liquid, or solid wastes.

### **A.4.1 GASEOUS WASTES**

Gaseous waste discharges include both nonradiological and radiological discharges. These systems are discussed below.

#### **Nonradiological Wastes**

Some chemical constituents are contained in the airborne releases from the PFP Facility. While this discharge is primarily ventilation air, other nonradiological effluents are exhausted via the stack. Nonradioactive gaseous releases at the PFP Facility result from the routine use of commercially available products. These products include aerosol, paints and thinners, laboratory chemicals, and products supporting maintenance activities.

#### **Radiological Wastes**

Gaseous effluent streams from the PFP Facility that contain low levels of radioactivity during operations include the following:

- The 291-Z-1 main stack
- The 296-Z-3 stack
- The 296-Z-5 stack
- The 296-Z-6 stack.

The PFP main stack (291-Z-1) exhausts filtered process and ventilation air from gloveboxes and hoods in Building 234-5Z, 236-Z, 232-Z, and 242-Z Buildings, and those rooms which have a potential for contamination.

The 291-Z-1 stack is equipped with an air sampling probe feeding a record sampler and an alpha continuous air monitor with an alarm. The continuous air monitor alarms are connected to annunciator boards that are located in regularly manned areas.

The 296-Z-3 stack exhausts filtered air from the sumps and vessels of the 241-Z Building, the PFP Waste Treatment

Facility. An air sampling probe feeding a record sampler and an alpha continuous air monitor with alarm are located downstream of the exhaust fans.

The 296-Z-5 stack exhausts filtered air from the 2736-ZB Building. The stack is equipped with a sampling probe feeding a record sampler and an alpha continuous air monitor with alarm.

The 296-Z-6 stack exhausts filtered air from the 2736-Z Building (the plutonium storage vaults). The stack has two identical contributing streams. Each stream consists of a filter bank and an exhaust fan. The two streams join at the base of the 296-Z-6 stack. The stack is equipped with a record sampler and two alpha continuous air monitors with alarms (one for each contributing stream).

#### **A.4.2 LIQUID WASTES**

Liquid waste discharge includes sanitary, non-contact, and contact process effluent waste streams.

##### **Sanitary Effluents**

The PFP Facility sanitary sewer systems take liquid waste from bathroom facilities and kitchen sinks and dispose of it through septic tanks to tile fields where it is percolated into the soil. The sanitary sewer system effluents are chemically nonhazardous and are nonradioactive.

##### **Non-contact Process Effluents**

The PFP Facility is one of several Hanford Site facilities permitted by the state of Washington to discharge non-contact treated effluents to the 200 Area Treated Effluent Disposal Facility under State Waste Discharge Permit No. ST-4502 (Ecology, 1995a). The Fact Sheet for the permit identifies for discharge to the Treated Effluent Disposal Facility the following sources of effluent generated by the PFP Facility:

- Ventilation heating/cooling
- Steam condensate
- Cooling water
- Compressed air products
- Process water
- Rainwater
- Potable water overflow.

Prior to discharge, the sources noted above would be treated at the PFP Facility by applying all known, available, and reasonable methods of prevention, control, and treatment prior to its discharge to the environment (Ecology, 1995a). In addition, all known, available, and reasonable methods are required to be applied to reduce the volume of the effluent. The Tri-Party Agreement further requires that the Best Available Technology that is economically achievable be applied to the effluent.

Source controls and end-of-pipe treatment were implemented as Best Available Technology/all known, available, and reasonable treatment methods for the effluent from the PFP Facility (Ecology, 1995a). A closed loop cooling system for three buildings and the replacement of vacuum pumps with waterless pumps has reduced water usage. End-of-pipe treatment includes: an equalization tank, microfiltration to remove suspended solids, carbon absorption to remove organics, bone-char absorption to remove radionuclides, ion exchange to remove cations and anions, and a system of monitoring and sampling effluent water quality before effluents are discharged to the disposal/infiltration ponds of the Treated Effluent Disposal Facility (Ecology, 1995a).

##### **Contact Process Effluents**

Contact effluents are not permitted to be discharged to the Treated Effluent Disposal Facility. The Fact Sheet for State Waste Discharge Permit No. ST-4502 specifies that low-level process wastes produced by stabilizing reactive plutonium scrap mixtures would be transferred to the double-shell tanks for storage (Ecology, 1995a).



The PFP Facility routes all contact effluents to the 241-Z sump tanks for treatment. In the treatment tanks, chemicals are added to adjust the pH of the waste to meet the corrosion protection requirements of the double-shell tank system and to ensure aluminum compounds remain in solution and provide the appropriate percentage of stable solids. Following treatment, the waste is pumped to a collection tank and transferred to the double-shell tank system in the 200 Area Tank Farms for storage. Contact effluents could be routed from tank farms through the 242-A Evaporator for treatment, to the Liquid Effluent Retention Facility for interim storage, to the Effluent Treatment Facility for final treatment, and ultimately to the state-approved land disposal site for disposal. The Effluent Treatment Facility is permitted under State Waste Discharge Permit No. ST-4500 (Ecology, 1995b).

### **A.4.3 SOLID WASTES**

Solid wastes are briefly defined as any discarded material, which may be abandoned, recycled, or considered inherently waste-like.

#### **Nonradiological Wastes**

Nonradiological, nonhazardous solid waste trash is routed to the city of Richland permitted landfill for disposal. Hazardous (non-polychlorinated biphenyl [non-PCB]) solid waste packaged in 55-gallon drums is routed within 90 days of generation to facilities for storage and transfer for disposal, destruction, or recycling. The PCB waste is routed to the Hanford PCB Storage Facility.

#### **Radiological Wastes**

Transuranic wastes are transported to the Transuranic Waste Storage and Assay Facility for storage. Low-level radioactive solid wastes and PCB/absorbed organic wastes are temporarily stored at the PFP Facility for eventual transfer in burial boxes or 55-gallon drums.

#### **Waste Isolation Pilot Plant Certifiable Wastes**

The Waste Isolation Pilot Plant certifiable wastes are transferred from the PFP Facility to the Transuranic Waste Storage and Assay Facility for assay and radiography. Waste that meets the Waste Isolation Pilot Plant requirements is moved to temporary storage for eventual transfer to Waste Isolation Pilot Plant. Waste that does not meet Waste Isolation Pilot Plant requirements is returned to the PFP Facility for repackaging.

#### **Non-Waste Isolation Pilot Plant Certifiable Waste**

The transuranic waste that is known not to meet the Waste Isolation Pilot Plant requirements is temporarily stored at the Central Waste Complex for transfer to 20-year retrievable storage and potential future processing. This waste includes:

- HEPA filters
- Leaded glovebox gloves
- Burial box waste (waste too large to fit in 55-gallon drums).

#### **Low-level Radioactive Solid Waste**

Low-level radioactive nonhazardous waste is transferred to Low-Level Burial Grounds for disposal. Low-level radioactive mixed waste is transferred to storage. Waste is stored and transferred in 55-gallon drums or burial boxes.

#### **References:**

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## ACRONYMS AND ABBREVIATIONS

### ALARA

as low as reasonably achievable

### Am

americium

### C

Celsius; Example: 4·C

### CERCLA

Comprehensive Environmental Response, Compensation and Liability Act of 1980

### Ci

curie

### cm

centimeter

### cm<sup>3</sup>

cubic centimeter

### cm<sup>2</sup>

square centimeter

### CFR

Code of Federal Regulations

### Cs

cesium

### dB

decibel

### dBA

A-weighted sound level

### DNFSB

Defense Nuclear Facilities Safety Board

### DOE

U.S. Department of Energy

### Ecology

Washington State Department of Ecology

### EIS

Environmental Impact Statement

### EPA

Environmental Protection Agency

### F

Fahrenheit; Example: 6·F

### FR

Federal Register

### FSAR

Final Safety Analysis Report

### ft

foot or feet

### ft<sup>2</sup>

square feet

### ft<sup>3</sup>

cubic feet

### g

gram

gal	
	gallon
HEPA	
	high efficiency particulate air (filter)
hr	
	hour
I	
	iodine
in	
	inch
kg	
	kilogram
km	
	kilometer
km <sup>2</sup>	
	square kilometer
l	
	liter
LCF	
	latent cancer fatalities
Leq	
	equivalent sound level
m	
	meter
m <sup>2</sup>	
	square meter
m <sup>3</sup>	
	cubic meter
mi	
	mile
mi <sup>2</sup>	
	square mile
min	
	minute
mm	
	millimeter
NEPA	
	National Environmental Policy Act of 1969
PCB	
	polychlorinated biphenyl
PFP	
	Plutonium Finishing Plant
PM	
	particulate matter/total suspended particulates
PM <sub>10</sub>	
	fine particulate matter
PNL	
	Pacific Northwest Laboratory
PNNL	
	Pacific Northwest National Laboratory (Name changed from PNL to PNNL in fall 1995) Use of PNL vs. PNNL depends on date of citation
ppm	
	parts per million
PRF	

Plutonium Reclamation Facility

Pu  
plutonium

PUREX  
Plutonium Uranium Extraction Facility

RCRA  
Resource Conservation and Recovery Act of 1976

RMA  
Remote Mechanical A (Line)

RMC  
Remote Mechanical C (Line)

sec  
second

Sr  
strontium

Tc  
technetium

U  
uranium

U.S.C  
United States Code

WAC  
Washington Administrative Code

yd  
yard

yd<sup>2</sup>  
square yard

yd<sup>3</sup>  
cubic yard





## APPENDIX B

# ENGINEERING ASSUMPTIONS, PROCESS FLOW DIAGRAMS, AND MATERIAL BALANCES FOR STABILIZATION ALTERNATIVES

## B.1 INTRODUCTION

The process flow diagrams and material balances contained in this appendix provide additional information on the assumptions and calculations used for alternatives presented in this Environmental Impact Statement (EIS). The process flow diagrams identify both major and secondary process operations. Influent and effluent streams are identified and correspond to individual descriptions in the material balances presented in the same section. The material balances are based on a number of assumptions that are listed under the material balance tables.

## B.2 ION EXCHANGE, VERTICAL CALCINATION, AND THERMAL STABILIZATION OF PLUTONIUM-BEARING SOLUTIONS

In this alternative, plutonium-bearing solutions would be stabilized primarily by thermal treatment using a vertical calciner. A similar process was tested at the Plutonium Finishing Plant (PFP) Facility during the 1960s to convert plutonium nitrate solutions to plutonium dioxide powder (Sevigny, et al., 1995). For this application, the feed material would include plutonium nitrate solutions, solutions containing chlorides, caustic solutions, and dissolved plutonium fluoride.

In order to utilize the vertical calcination process, some of the plutonium-bearing solutions would require pretreatment by ion exchange to remove chemical constituents that are not compatible with the vertical calcination process or the process equipment. In addition, the calciner output may require further thermal stabilization in order to meet the requirements of the U.S. Department of Energy (DOE) storage standard.

The combined ion exchange, vertical calciner, thermal treatment process would be capable of processing the entire inventory of plutonium nitrate and chloride solutions. It also would be able to process the plutonium fluoride solids if they are first dissolved and converted to the nitrate form using the ion exchange pretreatment operation.

A flow diagram for the ion exchange of plutonium-bearing solutions is shown in Figure B-1. This is followed by Table B-1, material balance flow sheet for ion exchange. Figure B-2 is a flow diagram of the vertical calcination process. Table B-2 is the material balance for the vertical calcination.

[Figure B-1. Flow Diagram of Ion Exchange of Plutonium-bearing Solutions.](#)

**Table B-1 Ion Exchange Material Balance Flowsheet**

Stream	A	B	C	D	E	F	G	H	I	.	J	K
Description	Blended	Column	Column	Column	Recondition	Ion Exchange	Material	Total	Liquid	or	Solidified	Spent Ion Exchange
.	Feed	Load	Wash	Elute	.	Waste	.	Waste	Waste	.	Waste	Resin
Pu	41.4 g/l	.	.	50 g/l	.	0.019 g/l	50.0 g/l	0.019 g/l	0.013 g/l	.	0.009 g/l	0.0025 g/g
Pu-Total	105.9 kg	1,000 g	.	999 g	.	1.03 g	105.8 kg	0.11 kg	0.11 kg	.	0.11 kg	55 g
U	30.4 g/l	735 g	.	.	.	13.6 g/l	.	13.6 g/l	9.4 g/l	.	6.6 g/l	.
Am	0.2 g/l	5 g	.	.	.	0.09 g/l	.	0.09 g/l	0.06 g/l	.	0.045 g/l	.
HNO3	7.4 M	7.4 M	7 M	0.35 M	7 M	7 M	0.35 M	7 M	pH 14	.	pH 7	.

Cl-	0.1 M	2.4 mole	.	.	.	0.045	.	0.045 M	0.013	.	0.02 M	.
K+	0.2 M	4.8 mole	.	.	.	0.09	.	0.09 M	0.027	.	0.04 M	.
NaOH	.	.	.	.	.	.	.	.	2550 l	.	2113 l	.
Volume	2,560 l	24.2 l	20 l	20 l	10 l	54.2 l	2,118 l	5,734 l	8,284 l	.	10,397 l	40 l
Flow	.	30 l/hr	20 l/hr	7 l/hr	30 l/hr	10.8 l/hr	.	.	.	.	.	.
Cycle time	.	0.8 hr	1 hr	2.9 hr	0.33 hr	5 hr	530 hr	.	.	.	.	.
Resin	.	5,000 g	.	.	.	.	.	.	.	.	.	22 kg

**Note:** See next page for assumptions

### Plutonium-bearing Solution Ion-Exchange Assumptions Associated with Table B-1:

- Feed material processed included all plutonium-bearing solutions noted in the inventory except Plutonium Uranium Extraction (PUREX) Facility nitrate and caustics.
- Plutonium content is estimated as 85 percent weapons grade, and 15 percent fuels grade and americium ingrowth as estimated by Crowe and Szempruch (1994).
- All nitrate solutions are filtered before processing. Solid MnO<sub>2</sub> is removed in this step.
- Valence adjustment of the feed is performed to ensure complete adsorption of the plutonium and minimal carrythrough to the waste stream.
- Americium, uranium (VI), and other metallic impurities do not adsorb well. Some carrythrough in the loading step and the rest are removed in the wash step.
- Typical column operation is to load to 80 percent of capacity, load 3 column volumes per hour, wash 2 column volumes at 2 column volumes per hour, elute 2 column volumes at 0.7 column volumes per hour, and regenerate 1 column at 3 column volumes per hour.
- All but plutonium flow through the waste stream in either the loading or wash step.
- Liquid waste is neutralized with 19 molar NaOH before being transferred to tanks.
- Volume increase due to solidification is approximately 50 percent after neutralization with 19 molar NaOH.
- Spent resin volume is resin only; 50 volume percent increase is assumed for disposal as transuranic mixed waste.
- Plutonium concentration limit in waste is 0.013 g/l and waste concentration can be met by complete elution of the column and occasional rework of wash or depleted feed from the second column.

[Figure B-2. Flow Diagram of the Vertical Calcination.](#)

**Table B-2 Material Balance for Vertical Calcination (g/hr)**

Stream	A	B	C	D	E	F
Description	Feed	PuO <sub>2</sub>	Calciner Offgas	Scrubber Reagent	Scrubber Overflow	Scrubber Offgas
Volume (l/hr)	2	.	.	3.6	7.7	.
Pu(NO <sub>3</sub> ) <sub>4</sub>	287	.	.	.	.	.
PuO <sub>2</sub>	.	160	8.7 x 10 <sup>-4</sup>	.	8.7 x 10 <sup>-4</sup>	4.3 x 10 <sup>-5</sup>
HNO <sub>3</sub>	819	.	.	.	.	.
H <sub>2</sub> O	1,530	.	1,674	2,520	434	.
Air	4,380	.	4,380	.	.	4,380
NO <sub>2</sub>	.	.	704	.	.	35
NO	.	.	0.1	.	.	5.0 x 10 <sup>-3</sup>
O <sub>2</sub>	.	.	189	.	.	189

NaOH	.	.	.	1,440	820	.
NaNO <sub>3</sub>	.	.	.	.	349	.
NaNO <sub>2</sub>	.	.	.	.	283	.

**Assumptions:**

- Feed is blended PUREX nitrate and ion exchange material containing an average of 6.5 molar HNO<sub>3</sub>, 70 g Pu/l.
- Feed rate is 2 l/hr.

**B.3 THERMAL STABILIZATION OF OXIDES, FLUORIDES, AND PROCESS RESIDUES USING A CONTINUOUS FURNACE**

This alternative uses a continuous furnace to thermally stabilize plutonium-bearing oxides, fluorides, and process residues. The objective of this alternative is to produce a resultant plutonium oxide capable of meeting DOE stability requirements for packaging and vault storage.

The oxides and process residues would be loaded continuously into a furnace similar to the continuous fluorinator used in the Remote Mechanical C Line at the PFP Facility. The furnace would operate at 1,000 degrees Centigrade (·C) (1,832 degrees Fahrenheit [·F]) with a continuous air feed. The high-temperature air environment would facilitate conversion of incompletely oxidized plutonium to plutonium dioxide and would also reduce the residual moisture level of the feed solids.

Plutonium fluorides may not be processed through the continuous furnace due to the corrosive nature of the hot hydrogen fluoride gases that would be generated. Plutonium fluorides could be pretreated using an acid dissolution process and blended with the nitrate and chloride solutions. Some of the process residues may also not be amenable to continuous processing due to their size, moisture content, or high organic content (greater than 2 weight percent organic). Hydrolysis is considered to be an appropriate pretreatment measure for high organic-content residues.

A total of 2,417 kilograms (kg) (5,326 pounds [lb]) of plutonium would be stabilized using this alternative. The resultant plutonium dioxide would be tested in accordance with the DOE storage standard (DOE, 1994). Plutonium oxide determined to be acceptable would be packaged using existing packaging capabilities and placed in the vault at the PFP Facility for storage. Plutonium oxide not meeting acceptable standards would be rerun through the continuous furnace. The plutonium oxide could be retrieved and repackaged at a later date to meet the DOE storage standard specifying organic-free containers, when a bagless transfer system becomes available at the Hanford Site.

A block diagram of the continuous thermal stabilization of oxides and process residues is shown in Figure B-3. Tables B-3 and B-4 provide the material balance for these processes.

**B.4 REPACKAGING OF THE METALS AND ALLOYS**

In this alternative, plutonium metals and alloys would be repackaged using methods that do not rely upon organic seals or plastic bags.

A total of 770 kg (1,697 lb) would be stabilized by this alternative. Thermal stabilization of the metals and alloys would not be required to meet the DOE storage standard. Figure B-4 provides a flow diagram of the repackaging alternative for metals and alloys. Table B-5 provides the material balance for this alternative.

[Figure B-3. Flow Diagram for the Continuous Thermal Stabilization of Oxides and Process Residues](#)

**Process Residues**

**Table B-3 Material Balance for the Continuous Thermal Stabilization of Oxides**

Stream	A	B	C	D	E	F
Description	Feed	Air Input	Offgas	Material	Rework	Acceptable PuO <sub>2</sub>
Phase	Solid	Gas	Gas	Solid	Solid	Solid
g/hr	1,200	1,201	1,219	1,182	118	1,064
g Pu/hr	600	.	6	594	59	535
Constituents						



O2	.	280	280	.	.	.
PuO2	680	.	7	673	67	606
H2O	12	.	6	6	<1	5
N2	.	921	921	.	.	.
Misc. Metal Oxides	508	.	5	503	50	453

**Assumptions:**

- 10 percent recycle due to failure to meet loss-on-ignition standard
- Dry air input (relative humidity is estimated to be 50 percent; however, additional moisture content will not affect modeled outcome)
- 1 percent loss-on-ignition for feed oxide - attributable to H2O only
- Average molecular weight of plutonium is 239 g/mole
- 50 percent Pu by weight in the feed
- Air input flow rate 0.02 m3/min
- 1 percent of PuO2 and miscellaneous metal oxides in offgas
- Molecular weight of air is 28.8 g/mole
- Powder pan replaced every hour.

**Table B-4 Material Balance for the Continuous Thermal Stabilization of Residues**

Stream	A	B	C	D	E	F
Description	Feed	Air Input	Offgas	Material	Rework	Acceptable PuO2
Phase	Solid	Gas	Gas	Solid	Solid	Solid
g/hr	1,200	1,201	1,219	1,182	119	1,063
g Pu/hr	240	.	3	237	24	213
Constituents						
O2	.	280	280	.	.	.
PuO2	272	.	3	269	27	242
H2O	12	.	6	6	<1	5
N2	.	921	921	.	.	.
Metal Oxides and Impurities	916	.	9	907	91	816

**Assumptions:**

- 10 percent recycle due to failure to meet loss-on-ignition standard
- Dry air input (relative humidity is estimated to be 50 percent, however additional moisture content will not affect modelled outcome)
- 1 percent loss-on-ignition for feed - attributable to H2O only
- Average molecular weight of plutonium is 239 g/mole
- 20 percent Pu by weight in the feed
- Air input flow rate 0.02 m3/min
- 1 percent of the PuO2 and metal oxides and impurities in offgas
- Molecular weight of air is 28.8 g/mole
- Powder pan replaced every hour

[Figure B-4. Flow Diagram of Repackaging Alternative for Metals and Alloys](#)

**Table B-5 Material Balance for Repackaging Metals and Alloys**

--	--	--	--	--	--	--

Stream	A	B	C	D	E	F
Description	Feed	Oxide Brushings	Brushed Metal	Argon Charge	Offgas	Packaged Material
Phase	Solid	Solid	Solid	Gas	Gas	Solid
g/batch	4,000	266	3,734	50	47	3,737
Constituents	.	.	.	.	.	.
Pu (metal)	2,800	.	2,800	.	.	2,800
PuO2	200	190	10	.	.	10
Alloy (metal)	920	.	920	.	.	920
Alloy oxides	80	76	4	.	.	4
Argon	.	.	.	50	47	3

**Assumptions:**

- 4-kg batches
- Metal and alloys composition:
  - 70 weight percent plutonium
  - 5 weight percent PuO2
  - 23 weight percent alloy
  - 2 weight percent alloy oxides
- Dose rate/isotopic distribution info:
  - Plutonium is 16.7 percent Pu-240
  - 25-year separation age
- Brushing removes 95 percent of PuO2 and alloy oxides
- Argon purge for 0.028 m3/sec for 1 minute
- Inner container volume equates 3 l:
  - 50 percent of volume filled with metal
  - 50 percent filled with argon
- Volume of packaging waste equal to volume of two oversized cans (4-1)

**B.5 PYROLYSIS OF POLYCUBES AND COMBUSTIBLES**

This alternative is a thermal process that separates the plutonium oxides from the polystyrene of the polycubes. The output, stable plutonium oxides, are packaged and returned to the PFP Facility vault.

The pyrolysis process has the capability for processing other combustibles such as rags and polyethylene (Kathios, 1995). This alternative will primarily focus on polycubes, since the majority of the plutonium in this inventory group is contained in these cubes.

A total of 35 kg (77 lb) of plutonium would be stabilized by this alternative (WHC, 1995). The resultant plutonium oxides would be thermally tested in accordance with the DOE storage standard. Material determined to be acceptable would be packaged using existing packaging capabilities and placed in the PFP Facility vault for storage. Material not meeting acceptable standards would be run through the pyrolysis process a second time.

Pyrolysis is a two-step process in which plutonium oxides are separated from polycubes by distillation and subsequent decarbonization. Figure B-5 is a flow diagram of the pyrolysis process. The process described here is essentially the same process previously used in the PFP Facility Glovebox MT-4 (Felt, 1971). Table B-6 provides the material balance for this process.

[Figure B-5. Process Diagram for Pyrolysis of Polycubes and Combustibles.](#)

**Table B-6 Material Balance for Pyrolysis of Polycubes**

Stream	A	B	C	D	E	F	G	H

Description	Feed	Caustic Addition and Rinse	Coating Effluent	Acid Addition	Waste Effluent	Distillation Furnace Feed	Inert Gas Addition	Distillation Furnace Offgas
Phase	Solid	Liquid	Liquid	Liquid	Liquid	Solid	Gas	Gas
g/batch	502	115	117	50	167	500	1,950	359
g Pu/batch	90	.	.	.	.	90	.	.
Constituents	.	.	.	.	.	.	.	.
Polystyrene	398	.	.	.	.	398	.	.
Styrene	.	.	.	.	.	.	.	358
PuO2	102	.	.	.	<0.5	102	.	1
Na+	.	10	10	.	10	.	.	.
Al	2	.	2	.	2	.	.	.
NO3-	.	4	4	30	34	.	.	.
H2O	.	95	95	20	115	.	.	.
H+	.	.	.	<1	<1	.	.	.
N2	.	.	.	.	.	.	1,950	.
O2	.	.	.	.	.	.	.	.
OH-	.	6	6	.	6	.	.	.

**Table B-6 (cont'd) Material Balance for Pyrolysis of Polycubes**

Stream	I	J	K	L	M	N	O	P	Q
Description	Condensate	Immobilized Waste	Condenser Offgas	Granular Activated Carbon Filtered Offgas	Spent Carbon	Decarbonization Furnace Feed	Air Addition	Decarbon. Furnace Offgas	Material
Phase	Liquid	Solid	Gas	Gas	Solid	Solid	Gas	Gas	Solid
g/batch	323	645	1,986	1,950	72	141	4,030	4,072	100
g Pu/batch	.	.	.	.	.	89	.	.	88
Constituents	.	.	.	.	.	.	.	.	.
Polystyrene	.	.	.	.	.	40	.	4	.
Styrene	322	322	36	.	36	.	.	.	.
PuO2	1	1	<0.5	<0.5	<0.5	101	.	1	100
Na+	.	.	.	.	.	.	.	.	.
Al	.	.	.	.	.	.	.	.	.
NO3-	.	.	.	.	.	.	.	.	.
H2O	.	.	.	.	.	.	.	24	.

H+	.	.	.	.	.	.	.	.	.
N2	.	.	.	1,950	.	.	3,184	3,184	.
O2	.	.	.	.	.	.	846	739	.
OH-	.	.	.	.	.	.	.	.	.
CO2	.	.	.	.	.	.	.	111	.
CO	.	.	.	.	.	.	.	9	.
Adsorbent	.	322	.	.	.	.	.	.	.
Carbon	.	.	.	.	36	.	.	.	.

**Note:** See next page for assumptions

**Assumptions for pyrolysis of polycubes and combustibles associated with Table B-6:**

- 500 g batches of polycubes (excluding weight of aluminum) with 18 weight percent plutonium
- Dose rate/isotopic distribution information

a. Plutonium is 18 percent Pu-240

b. 25 year separation age

- Aluminum coating is 0.0004 cm thick and covers two 125 cm<sup>3</sup> cubes
- Nitrogen feed at 0.057 m<sup>3</sup>/min (at 25oC) into the distillation furnace for 30 minutes
- 90 percent of polystyrene is liberated as styrene offgas in the distillation furnace
- Condenser removes 90 weight percent of styrene from distillation furnace offgas
- Mass of adsorbent for immobilization of liquid styrene equal to mass of styrene
- Granulated activated carbon canisters will adsorb 99.99 percent of the organic offgases and will be managed as transuranic mixed waste
- Granulated activated carbon consumption rate is 272 g/hr during distillation
- Air feed at 0.057 m<sup>3</sup>/min (at 25oC) into the decarbonization furnace for 60 minutes
- Decarbonization furnace offgas comprised of 80 percent CO<sub>2</sub>, 10 percent CO, 10 percent styrene monomer.

**B.6 HYDROXIDE PRECIPITATION FOLLOWED BY THERMAL STABILIZATION OF THE PLUTONIUM-BEARING SOLUTIONS**

Under this alternative, plutonium-bearing solutions would be treated by a relatively simple precipitation process. The resultant plutonium precipitate would then be thermally stabilized to an oxide form capable of meeting the DOE storage standard.

Caustic or other hydroxide-forming reagents would be added to the solution, gradually increasing the pH until insoluble plutonium hydroxide is formed. The plutonium hydroxide and other metal impurities, such as nickel, chromium, and iron, would precipitate out and be filtered from solution. The filtered solids would then be thermally processed into a stable oxide form.

Approximately 4,800 liters (l) (1,268 gallons [gal]) containing 338 kg (745 lb) of plutonium would be stabilized by this alternative. The resultant material including americium and other impurities, would be packaged in accordance with the DOE storage standard and placed in the PFP Facility vault for storage.

A flow diagram describing the hydroxide precipitation process is shown in Figure B-6. Table B-7 provides the material balance for this process.

**Table B-7 Hydroxide Precipitation Plutonium-bearing Solutions**

Stream	A	B	C	D
Description	Blended Feed Solution	Magnesium Oxide	Filtrate	Precipitate

Phase	Liquid	Solid	Liquid	Sludge
Pu	99	.	0.02	99
U	23	.	0.050	23
H+	7	.	7	.
Cl-	3	.	3	.
KNO3	13	.	13	.
MnO2	7	.	.	7
Fe, Ni, Cr	<0.5	.	.	<0.5
MgO	.	222	.	.
Mg(NO3)2	.	.	821	.

**Note:** Values expressed in grams per liter of feed solution.

#### Assumptions:

- Batch size is 10 liters (Thompson, 1995)
- Hydroxide Precipitation Decontamination Factor is 5000 for plutonium and 500 for other metals
- Sludge is approximately 15 weight percent liquid
- Filtrate volume increase with respect to feed of up to 50 percent is assumed to account for filter cake washing and feed dilution if necessary.

#### [Figure B-6. Flow Diagram of Hydroxide Precipitation of Plutonium-bearing Solutions](#)

### B.7 BATCH THERMAL STABILIZATION OF OXIDES, FLUORIDES, AND PROCESS RESIDUES

This alternative involves batch thermal stabilization of the plutonium-bearing oxides, fluorides, and process residues. The plutonium-bearing solids are fed into a muffle furnace which is elevated to a temperature of approximately 1,000°C (1,832°F). The high temperature air environment lowers the residual moisture level and facilitates conversion of incompletely oxidized plutonium to plutonium oxides.

Material that meets the DOE storage standard would not require any additional thermal stabilization and would be directly repackaged. The estimated 14-hour throughput would be approximately one 1,200-g (2.7-lb) batch per furnace.

Plutonium fluorides would pose problems in the muffle furnace due to the corrosive nature of fluoride-containing gases that could be liberated. Alternatively, a corrosion control program could be established and the fluorides sent through the muffle furnaces.

Approximately 2,400 kg (5,300 lb) of plutonium would be stabilized by this alternative. The resultant plutonium oxides would be tested in accordance with the DOE storage standard. Material deemed acceptable would be packaged using existing capabilities at Hanford and placed in the PFP Facility vault for storage. Material not meeting acceptable standards would be recycled through the muffle furnace.

A flow diagram of the batch thermal stabilization process using a muffle furnace is shown in Figure B-7. Table B-8 provides the material balance for the muffle furnace of oxides; Table B-9 provides the material balance for the muffle furnace of process residues.

#### [Figure B-7. Flow Diagram for Batch Thermal Stabilization of Oxides and Process Residues](#)

#### Table B-8 Material Balance for the Batch Thermal Stabilization of Oxides

Stream	A	B	C	D	E	F
Description	Feed Batch	Air Input	Offgas	Oxide	Rework	Acceptable Material
Phase	Solid	Gas	Gas	Solid	Solid	Solid
g/batch	1,200	56,420	56,438	1,182	118	1,064
g Pu/batch	600	.	6	594	59	535

Constituents	.	.	.	.	.	.
O2	.	13,165	13,165	.	.	.
PuO2	680	.	7	673	67	606
H2O	12	.	6	6	<1	5
N2	.	43,255	43,255	.	.	.
Miscellaneous Metal Oxides	508	.	5	503	50	453

**Assumptions:**

- 10 percent recycle due to failure to meet loss-on-ignition standard
- Dry air input (relative humidity is estimated to be 50 percent, however additional moisture content will not affect modeled outcome)
- 1 percent loss-on-ignition for feed oxide - attributable to H2O only
- Average molecular weight of plutonium is 239 g/mole
- 14 hour cycle time
- 50 percent plutonium by weight in the feed
- Worker dose will be 110 percent of the total inventory to do rework
- Air input flow rate 0.057 m<sup>3</sup>/min
- 1 percent of PuO<sub>2</sub> and miscellaneous metal oxides in offgas
- Molecular weight of air is 28.8 g/mole.

**Table B-9 Material Balance for Batch Thermal Stabilization of Process Residues**

Stream	A	B	C	D	E	F
Description	Feed Batch	Air Input	Offgas	Oxide	Rework	Accepted Material
Phase	Solid	Gas	Gas	Solid	Solid	Solid
g/batch	1,200	56,420	56,438	1,182	119	1,063
g Pu/batch	240	.	3	237	24	213
Constituents	.	.	.	.	.	.
O2	.	13,165	13,165	.	.	.
PuO2	272	.	3	269	27	242
H2O	12	.	6	6	<1	5
N2	.	43,255	43,255	.	.	.
Metal Oxides and Impurities	916	.	9	907	91	816

**Assumptions:**

- 10 percent recycle due to failure to meet loss-on-ignition standard
- Dry air input (relative humidity is estimated to be 50 percent, however, additional moisture content will not affect modelled outcome)
- 1 percent loss-on-ignition for feed - attributable to H2O only
- Average molecular weight of plutonium is 239 g/mole
- 14-hour cycle time
- 20 percent Pu by weight in the feed
- Worker dose will be 110 percent of the total inventory to do rework
- Air input flow rate 0.057 m<sup>3</sup>/min
- 1 percent of the PuO<sub>2</sub> and metal oxides and impurities in offgas
- Molecular weight of air is 28.8 g/mole

## B.8 BATCH THERMAL STABILIZATION OF THE METALS AND ALLOYS

This alternative involves batch thermal stabilization of the plutonium metals and alloys. The plutonium-bearing solids are fed into a muffle furnace and elevated to a temperature of approximately 1,000·C (1,832·F). The high temperature air environment facilitates conversion of the metal and alloys to metal oxides (i.e., plutonium oxides). The estimated throughput would be approximately one 1,200-g (2.7-lb) batch every 12 hours.

A total of 770 kg (1,698 lb) of plutonium would be stabilized by this alternative. The resultant output would be tested in accordance with the DOE storage standard. It is assumed that the metals and alloys would require two thermal processing cycles to achieve the desired oxide. Oxides not meeting acceptable standards would be cycled through the muffle furnace a third time.

A flow diagram of the batch thermal stabilization using a muffle furnace is shown in Figure B-8. A material balance in this process is provided in Table B-10.

[Figure B-8. Flow Diagram for Batch Thermal Stabilization of Metals and Alloys](#)

**Table B-10 Material Balance for the Batch Thermal Stabilization of Metals and Alloys**

Stream	A	B	C	D
Description	Feed Batch	Air Input	Offgas	Oxide
Phase	Solid	Gas	Gas	Solid
g/batch	1,200	56,420	56,051	1,569
g Pu/batch	900	.	9	891
Constituents	.	.	.	.
O <sub>2</sub>	.	13,165	12,780	.
PuO <sub>2</sub>	10	.	10	1,010
Pu	891	.	.	.
N <sub>2</sub>	.	43,255	43,255	.
Non-Pu alloy material (i.e. aluminum)	299	.	.	.
Non-Pu alloy material oxides	.	.	6	559

### Assumptions:

- Alloy material is predominantly aluminum (25 percent of feed)
- Dry air input (relative humidity is estimated to be 50 percent, however additional moisture content will not affect modeled outcome)
- Average molecular weight of plutonium is 239 g/mole
- 12 hour cycle time
- 75 percent plutonium by weight in the feed
- Worker dose will be 200 percent of the total inventory to do rework
- Air input flow rate 0.057 m<sup>3</sup>/min
- Assume oxide stream is the result of two passes
- 1 percent of oxides (PuO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>) entrained in offgas
- 1 percent of the Pu in the feed is in the form of PuO<sub>2</sub>
- Molecular weight of air is 28.8 g/mole

## B.9 BATCH THERMAL STABILIZATION WITH SECONDARY COMBUSTION OF POLYCYBES AND COMBUSTIBLES

This alternative involves batch thermal stabilization of the plutonium-bearing polycubes and combustibles. Although the thermal stabilization method used for the two types of materials is the same, each type of material would be processed separately. The polycubes and combustibles are fed into a muffle furnace, which is elevated to a temperature of approximately 300·C (572·F). Initially, the furnace is purged with nitrogen gas to maintain an inert environment and prevent combustion of the organic component. At 300·C (572·F), the organic

component of the feed is driven off into a secondary combustion chamber where combustion occurs. The plutonium-bearing material remaining in the muffle furnace is exposed to air and elevated to approximately 1,000·C (1,832·F). The high temperature environment facilitates conversion of incompletely oxidized plutonium to plutonium dioxide. The estimated 14-hour throughput would be approximately one 500-g (1.1-lb) batch per furnace.

The process would result in an offgas containing water vapor, organic combustion products (carbon dioxide and carbon monoxide), residual organic material (styrene monomer), and small quantities of entrained plutonium dioxide. The offgas would be discharged to the environment after appropriate control measures significantly reduce the quantity of entrained solids in the offgas.

A total of 35 kg (77 lb) of plutonium would be stabilized by this alternative. The resultant material would be tested in accordance with the DOE storage standard. Material not meeting the DOE storage standard would be recycled through muffle furnaces.

A flow diagram of the batch thermal stabilization with secondary combustion process is shown in Figure B-9. Tables B-11 and B-12 provide the material balance for this process.

[Figure B-9. Flow Diagram for Batch Thermal Stabilization of Polycubes and Combustibles](#)

**Table B-11 Material Balance for Batch Thermal Stabilization of Polycubes and Combustibles - Aluminum Removal**

Stream	A1	B1	C1	D1	E1
Description	Feed	Caustic Liquid Addition and Rinse	Coating Effluent	Acid Addition	Waste Effluent
Phase	Solid	Liquid	Liquid	Liquid	Liquid
g/batch	502	115	117	50	168
g Pu/batch	90	.	.	.	<0.5
Constituents	.	.	.	.	.
Polystyrene	398	.	.	.	.
PuO2	102	.	.	.	<0.5
Na+	.	10	10	.	10
Al	2	.	2	.	2
NO3-	.	4	4	30	34
H2O	.	95	95	20	115
H+	.	.	.	<1	<1
N2	.	.	.	.	.
O2	.	.	.	.	.
OH-	.	6	6	.	6

**Assumptions:**

- 502 g batches
- 18 weight percent plutonium per batch
- Dose rate/isotopic distribution information

- Plutonium is 18 percent Pu-240

- 25 year separation age

- Aluminum coating is 0.04 mm thick
- 2 polycubes/batch, polycube volume (125 cm<sup>3</sup>)



**Table B-12 Material Balance for Batch Thermal Stabilization of Polycubes and Combustibles-Polystyrene Removal**

Stream	A2	B2	C2	D2	E2	F2	G2	H2	I2
Description	Feed Batch	Inert Gas (N2)	Air Input 1	Furnace Offgas	Air Input 2	Ventilation Gas	Oxide	Rework	Accepted Material
Phase	Solid	Gas	Gas	Gas	Gas	Gas	Solid	Solid	Solid
g/batch	500	16,120	40,300	56,819	56,420	113,239	101	10	91
g Pu/batch	90	.	.	1	.	1	89	9	80
Constituents	.	.	.	.	.	.	.	.	.
O2	.	.	9,403	9,403	13,165	21,513	.	.	.
PuO2	102	.	.	1	.	1	101	10	91
H2O	.	.	.	.	.	251	.	.	.
N2	.	16,120	30,897	47,017	43,255	90,272	.	.	.
CO2	.	.	.	.	.	1,076	.	.	.
CO	.	.	.	.	.	86	.	.	.
Styrene	.	.	.	398	.	40	.	.	.
Polystyrene	398	.	.	.	.	.	.	.	.

Note: See next page for assumptions

#### Assumptions associated with Table B-12:

- 10 percent recycle due to failure to meet 0.5 percent loss-on-ignition standard
- Dry air input (relative humidity is estimated to be 50 percent, however additional moisture content will not affect modeled outcome)
- First 4 hours, N2 is fed into the muffle furnace at 0.057 m3/min 25·C
- Subsequent 10 hours, air is fed into muffle furnace at 0.057 m3/min 25·C
- Average molecular weight of plutonium is 239 g/mole
- 18 percent plutonium by weight in the feed
- Worker dose will be multiplied by 1.1 to account for the need to do rework
- 80 percent of polystyrene combusts to CO2, 10 percent to CO, and 10 percent to styrene monomer
- Assume 20 percent of polystyrene combusts to styrene monomer
- Air feed to combustion chamber (14 hours at 0.057 m3/min 25·C)
- Molecular weight of air is 28.8 g/mole

## B.10 MOLTEN SALT OXIDATION OF POLYCUBES AND COMBUSTIBLES

This alternative is intended to stabilize the inventory of polycubes and combustibles currently stored in the vaults and gloveboxes at the PFP Facility.

Molten salt oxidation is a thermal process in which polycubes and combustibles are oxidized in a bed of molten salt. The output would be an ash containing the plutonium oxides.

Molten salt oxidation technology could potentially be used to process a broad range of wastes, including organic liquids, oils, combustible solids (cellulosic matter, rubber, plastics), aqueous solutions, slurries (process residues), noncombustibles, metals, alloys, and polycubes. As discussed in previous sections, other technologies are preferable for processing liquids, metals, alloys, and oxides. Molten salt oxidation is being considered only for processing polycubes and combustibles at the PFP Facility.

A total of 35 kg (77 lb) of plutonium would be stabilized using this alternative. The resultant ash would be thermally stabilized and subsequently tested in accordance with the DOE storage standard. Figure B-10 provides a block diagram of the molten salt oxidation

process. Table B-13 provides the material balance for this process.

[Figure B-10. Flow Diagram of the Molten Salt Oxidation of Polycubes and Combustibles](#)

**Table B-13 Material Balance for the Molten Salt Oxidation of Polycubes and Combustibles (Processing Rate 350 g/hr)**

Stream	A	B	C	D	E	F	G	H	I	J
Description	Feed of Cubes	Feed of Salt	Melt/"Ash"	Inert	Dissolved Stream	Air Input	Dissolved Substances	"Ash"	Solution	Offgas
Phase	Solid	Solid	"Ash"	Gas	Liquid	Gas	Slurry	Solid	Liquid	Gas
Total g/hr	350	1,060	1,130	8,490	2,650	8,750	3,780	115	3,665	17,521
g Pu/batch	61	.	61	.	.	.	61	61	<0.06	.
Constituents	.	.	.	.	.	.	.	.	.	.
O <sub>2</sub>	.	.	.	.	.	2,040	.	.	.	1,300
PuO <sub>2</sub>	70	.	70	.	.	.	70	70	<0.07	<0.35
H <sub>2</sub> O	.	.	.	.	2,650	.	2,650	45	2,605	175
N <sub>2</sub>	.	.	.	8,490	.	6,710	.	.	.	15,200
CO <sub>2</sub>	.	.	.	.	.	.	.	.	.	758
CO	.	.	.	.	.	.	.	.	.	60
Styrene	280	.	.	.	.	.	.	.	.	28
Na <sub>2</sub> CO <sub>3</sub>	.	1,060	1,060	.	.	.	1,060	.	1,060	.

Note: See next page for assumptions

#### Assumptions associated with Table B-13:

- Production rate of 350 g/hr
- Polycubes contain 80 percent styrene and 20 percent PuO<sub>2</sub>
- Dry air input (relative humidity is estimated to be 50 percent, however, additional moisture content will not affect modeled outcome)
- Average molecular weight of plutonium is 239 g/mole
- The required volumes for salt and water are based on Sevigny, et al. (1995)
- Use a two-stage system for oxidation of polycubes
- Filter solid "ash" stream contains less than 40 percent H<sub>2</sub>O
- N<sub>2</sub> and air input flow rate is 0.11 m<sup>3</sup>/min for each
- Na<sub>2</sub>CO<sub>3</sub> dissolves 100 percent in the water stream
- PuO<sub>2</sub> residual in the liquid stream (Stream I) is less than 0.1 percent
- All polycubes (styrene) dissociates to styrene monomer, where 80 percent combusts to CO<sub>2</sub>, 10 percent to CO, and 10 percent remains as styrene monomer
- Less than 0.5 percent of PuO<sub>2</sub> is in the offgas stream.

#### References:

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## APPENDIX C

# ACCIDENTS APPLICABLE TO STABILIZATION AND REMOVAL EIS ALTERNATIVES

### C.1 INTRODUCTION

This appendix examines potential accident scenarios that are common to each of the alternatives presented in this Environmental Impact Statement (EIS) and scenarios that are specifically applicable to alternatives that involve operation of a muffle furnace. Accident-related preventive and mitigative features are addressed. Aspects of institutional and organizational safety at the Hanford Site are also discussed. Extensive analyses of accidents associated with activities at the Plutonium Finishing Plant (PFP) Facility have been conducted by the Department of Energy's (DOE) maintenance and operations contractor. These analyses were used during the development of accidents postulated in this appendix, and are cited throughout this appendix as appropriate.

Implementation of any of the alternatives discussed in this EIS would be subject to numerous federal and state requirements, including DOE orders. Any major additions or modifications to the PFP Facility would be required to comply with applicable design criteria from DOE Order 6430.1A, General Design Criteria (DOE, 1989). The 5400 Series of DOE Orders would also be applicable. The 5400 Series addresses "Environmental Quality and Impact." Compliance with these DOE Orders aids in ensuring that adequate accident-related preventive and mitigative measures would be considered during the design and operation of alternatives discussed in this EIS. Furthermore, operations would not be allowed to begin until appropriate safety documentation had been approved. *The PFP Final Safety Analysis Report* (FSAR) has been recently updated (WHC, 1995). Throughout this appendix, this reference will be referred to as the PFP FSAR.

The majority of the PFP Facility is decades old, and therefore there is more potential for unknown and/or unforeseen hazards than in newer facilities. (In this EIS, a hazard should be understood as a source of danger, with the potential to cause illness, injury, or death to personnel [including the public] or damage to an operation or to the environment.) As stated in the "Lessons Learned" portion of a 1994 PFP Facility Unusual Occurrence Report:

"PFP is an aging plant. Although the plant has extensive preventive maintenance and in-service inspection programs, some equipment not currently covered by those programs may present potential hazards. Consequently, more conservative assessments of risk to workers and appropriate protective measures are needed when work is performed on equipment that has been in service for many years or on equipment that may otherwise exhibit unexpected deterioration" (Unusual Occurrence Report RL--WHC-PFP-1993-0018, May 17, 1994).

However, these hazards, along with those that have been identified in PFP Facility safety-related documentation, generally possess insufficient energy to disperse radioactive and/or chemically hazardous materials in such a manner as to adversely impact Hanford Site workers or the public. The dominant risk and safety concern associated with the alternatives discussed in this EIS is for the PFP Facility workers. Nevertheless, a few plausible severe events that could impact Hanford Site workers and the public can be postulated. Only one of these severe events is evaluated in this EIS for its health effects on the public and Hanford Site workers.

Regarding PFP Facility workers, it is recognized that those who work at the PFP Facility accept some risk of exposure to radioactive and other hazardous materials (greater than that accepted by the public) due to the nature of the materials managed, handled, and stored at the PFP Facility. Nevertheless, it is incumbent upon DOE and the maintenance and operations contractor of the Hanford Site to ensure that the PFP Facility is operated in a manner that minimizes the risk to PFP Facility workers and limits exposures to hazardous materials to far below levels permitted by federal or state regulations and relevant DOE Orders and notices as is reasonably achievable. Workers are protected primarily through engineered barriers, proper training, procedures, programs (e.g., industrial hygiene and radiological control programs)

and other administrative controls.

Design basis accidents are those accidents that are postulated for the purpose of establishing functional requirements for structures, systems, and components that make a significant safety-related contribution. Beyond design basis accidents are accident scenarios with frequencies below the acceptable threshold frequency (i.e., less than or equal to  $1 \times 10^{-6}$  per year for operational or external event accidents, or below the site-specific designated return frequency for natural phenomena events such as earthquakes), but which would result in potentially greater consequences than the design basis accidents. Normally, beyond design basis accidents are not analyzed to the same level of detail as design basis accidents, since the intent is that an evaluation be performed that provides insight into the magnitude of the consequences of beyond design basis accidents. Beyond design basis accidents are not evaluated primarily for the purpose of providing assurance of public health and safety, but rather are evaluated to serve as a contributing basis for cost-benefit considerations and, for National Environmental Policy Act of 1969 (NEPA) purposes, to "inform an agency (and the public) in making reasonable choices among alternatives" (DOE, 1993). To provide this insight into the residual risk associated with the alternatives addressed in this EIS, select beyond design basis accidents are examined in this EIS.

The design and operation of alternatives discussed in this EIS would provide for defense-in-depth for public and worker safety during normal, off-normal, and accident conditions. Defense-in-depth, as an approach to facility safety, has extensive precedent in nuclear safety philosophy. Defense-in-depth entails the concept that layers of defense are provided against the release of radiological and hazardous materials such that no one layer by itself, no matter how good, is completely relied upon. This philosophy is a fundamental approach to hazard control for nonreactor nuclear facilities, even though nonreactor nuclear facilities generally do not possess the same magnitude of accident potential as that associated with nuclear power plants. The primary layers of defense for activities at the PFP Facility would be as follows:

- Passive containment/confinement barriers
- Limited inventory involved at any given time in any given activity/process
- Limited energy sources available to interact with and disperse radiological and/or hazardous materials
- Active confinement barriers
- Alarms and monitors
- Personnel training
- Administrative controls.

## **C.2 GENERAL INFORMATION AND OVERVIEW OF ACCIDENT PHENOMENA**

The words "anticipated," "unlikely," "extremely unlikely," and "incredible" are defined quantitatively as shown in Table C-1. DOE guidance on development of NEPA documents states that accidents with a frequency of occurrence between  $1 \times 10^{-6}$  to  $1 \times 10^{-7}$  per year shall be examined to the degree that events within this range "inform an agency (and the public) in making reasonable choices among alternatives" (DOE, 1993). The same DOE guidance also states that a range of accidents that are reasonably foreseeable should be examined, and that "reasonably foreseeable has no precise definition." It is indeterminate whether accidents with a frequency of occurrence of less than or equal to  $1 \times 10^{-6}$  per year are reasonably foreseeable, and in this EIS, such accidents are not reasonably foreseeable. There is a relatively long-standing precedent in the nuclear industry to consider accidents with a frequency of occurrence of less than or equal to  $1 \times 10^{-6}$  per year as "incredible." Nevertheless, events which could (but not necessarily) be placed in the  $1 \times 10^{-6}$  to  $1 \times 10^{-7}$  per year range are addressed in this EIS. These include the beyond design basis earthquake and aircraft crash events. (The beyond design basis earthquake has no specific annual frequency associated with it. It must merely be less than the annual frequency associated with the design basis earthquake. Regarding an aircraft crash, the PFP FSAR calculates that an aircraft accident involving the PFP Facility has an annual frequency of occurrence of  $1.28 \times 10^{-8}$ . However, because of data uncertainties involved in the calculations, this value could be in error by at least a factor of 10.) Other events that could conceivably be placed in the  $1 \times 10^{-6}$  to  $1 \times 10^{-7}$  per year range could be postulated (e.g., meteorite strike, lava encroachment, and an operational accident due to multiple human errors), but they are not considered to "inform an agency (and the public) in making reasonable choices among alternatives." (DOE, 1993).

**Table C-1 Accident Nomenclature**

Accident Term	Estimated Annual Frequency of Occurrence	Description
Anticipated	1 to 0.01	Accidents that may occur once or more during the lifetime of the facility
Unlikely	0.01 to $1 \times 10^{-4}$	Accidents that may occur at some time during the lifetime of the facility  Natural phenomena of this probability class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
Extremely Unlikely	$1 \times 10^{-4}$ to $1 \times 10^{-6}$	Accidents that will probably not occur during the lifecycle of the facility
Incredible	$<1 \times 10^{-6}$	Accidents that are not credible and that are not reasonably foreseeable

Three categories for initiating an accident scenario are often examined in the performance of a safety analysis: natural phenomena, external events, and operational events. Each category can result in different types of accidents (e.g., fires, spills, and explosions).

Events discussed in this section and frequency of occurrence information are summarized in Table C-2. These events are applicable to the PFP Facility in general and are applicable to each of the alternatives presented in this EIS.

**Table C-2 Summary of Accident Scenarios Common to Each Alternative**

Accident Scenario	Frequency of Occurrence and Basis for the Frequency Selected
Greater than sustained 145 km/hr straight wind and/or greater missile than that associated with 145 km/hr wind, resulting in an unknown extent of structural damage to PFP Facility buildings and structures. (Buildings and structures are often capable of withstanding significantly higher winds than expected because of conservative design and construction practices.) As discussed in the text, key PFP Facility buildings and structures have been analyzed and found to be capable of withstanding both the wind forces and the standard missile assumed to be associated with a 145 km/hr.	Unlikely. Straight wind gust of 145 km/hr (90 mph) was measured at the Tri-Cities Airport in January 1990. Kennedy, et al. 1990, recommend that a high hazard facility at the Hanford Site be able to withstand a 145 km/hr straight wind, which has an associated annual return frequency of $1 \times 10^{-4}$ .)
Greater than 0.25 gravity peak horizontal ground acceleration earthquake, resulting in significant structural damage to PFP Facility buildings and structures. Because of the substantial uncertainties and modeling limitations involved in seismic analysis, and because of recent data points regarding the ability of structures to withstand earthquakes (e.g., the Northridge earthquake in California and the Kobe, Japan earthquake), it is a good assumption that significant structural damage, including possibly complete collapse, would occur from a greater than a 0.25 gravity earthquake. As discussed in the text, key PFP Facility buildings and the 291-Z-1 stack have been analyzed and found to be capable of	Extremely unlikely. Coats and Murray (1984), indicate that a 0.25 gravity earthquake has an associated annual frequency of occurrence of $4 \times 10^{-5}$ (extrapolated).

withstanding a 0.25 gravity earthquake.	
External flooding sufficient to challenge the safety and security of PFP Facility operations.	Unlikely. The PFP Facility is sited above the projected 1,000-year flood and the flood that would result from the instantaneous destruction of 50 percent of the Grand Coulee Dam analyzed by the U.S. Army Corp of Engineers.
Aircraft accident involving the PFP Facility.	Incredible. Based on analysis provided in PFP FSAR.
An accident at the PFP Facility, induced by an accident on nearby transportation routes or an accident at another nearby facility, that results in the uncontrolled release of radiological or hazardous materials from the PFP Facility.	Extremely unlikely to possibly incredible, based on proximity of transportation and other facilities.
Criticality anywhere in the PFP Facility.	Extremely unlikely. Lessons learned about criticality from DOE incidents have been rigorously applied so that the annual frequency of occurrence of criticality is very low. See extensive criticality discussion provided in text.

## C.2.1 NATURAL PHENOMENA

Accident scenarios induced by seismic events and high winds, including tornadoes, have been the natural-phenomena-induced accidents that have received the most attention in the performance of safety analyses. As documented in the PFP FSAR, these are the natural phenomena of primary concern for the PFP Facility. In many safety studies, flooding also receives extensive analysis. Regarding natural phenomena in general, the PFP FSAR states the following:

The PFP structure has been analyzed and was found to functionally meet or exceed the [Nuclear Regulatory Commission] Regulatory Guide 3.39 elements involving natural phenomena. Near incredible scenarios combining the [Design Basis Earthquake] DBE with worse case operational upsets result in little radiological impact to the onsite [Hanford Site worker] or offsite population.

### C.2.1.1 Winds

Phenomena such as hurricanes and tornadoes are inconsistent with the region, and therefore, in accordance with established natural phenomena hazard guidance for the Hanford Site, their potential impacts were not evaluated. High straight winds are the dominant wind-related concern for the Hanford Site. The PFP FSAR states the following:

The primary buildings and some of the auxiliary buildings of the PFP Facility were analyzed for potential damage by the design basis, 90 mi/h wind delineated in the Hanford Standard Architectural-Civil Design Criteria SDC-4.1. The 234-5Z and 236-Z Buildings and the 291-Z-1 stack were analyzed and found to be capable of withstanding both the wind forces and the standard missile assumed to be associated with the wind. Buildings 242-Z, 291-Z, 2736-Z, 2736-ZB and the 291-Z/234-5Z stack manifold were also shown to withstand both wind and missile forces.

DOE guidance (and the PFP FSAR) indicates that the annual frequency of occurrence for a sustained 145 kilometers

per hour (km/hr) (90 miles per hour [mi/hr]) wind at the Hanford Site is in the extremely unlikely range. Based on the fact that a straight wind gust of 145 km/hr (90 mi/hr) was measured at the Tri-Cities Airport in January 1990, it is considered more appropriate to categorize as unlikely such a wind at the Hanford Site.

At the PFP Facility, there is a 26,000-liter (l) (7,000-gallon [gal]) outside holding tank for nitric acid. The PFP FSAR performs a conservative consequence analysis of the release of nitric acid (induced by high wind generated missiles) and determines that the consequences, to onsite and offsite receptors, are very small, and well below established criteria.

### C.2.1.2 Earthquakes

The following excerpt from the PFP FSAR summarizes the original seismic design criteria for the PFP Facility:

Original seismic design criteria for PFP facilities were based on [Uniform Building Code] UBC requirements applicable at the time of construction or modification. The 234-5Z, 241-Z, 2902-Z, and 291-Z Buildings were designed in 1947 in accordance with the UBC of 1946 (UBC did not include seismic criteria). The 232-Z, 236-Z, and 242-Z Buildings were designed in 1959 and 1960 in accordance with applicable Hanford Plant Standards (HPS SDC 4.1) and the UBC of 1958 and 1961. The 2736-Z Building was designed in 1969 in accordance with Hanford Standards (HPS SDC 4.1), general criteria for the storage of plutonium (ARH-1226), and the UBC of 1967. The 2736-ZB complex was designed in 1979 in accordance with the ERDA 6301, Hanford Standards (HPS SDC 4.1) and the UBC of 1976. Facility additions and alterations since June 1981 have been designed in accordance with DOE Order 6430, 6430.1, or 6430.1A, *General Design Criteria*, as applicable, DOE Order 5480 series, and Hanford Standards (HPS SDC 4.1).

Current criteria require all Safety Class 1 and 2 structures, systems, and components (i.e., the most important/highest level of safety-related structures, systems, and components) to have the ability to withstand the potential earthquake events applicable to the site or be fail-safe.

Based on DOE Order 6430.1A (which invokes Kennedy, et al., 1990, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, which in turn invokes Coates and Murray, 1984, *National Phenomena Hazards Modeling Project: Seismic Hazard Models for DOE Sites* [Coats and Murray, 1984]), the current design basis earthquake for high hazard facilities (such as the PFP Facility) at the Hanford Site has a maximum horizontal ground acceleration of 0.17 gravity and an associated frequency of occurrence of  $2 \times 10^{-4}$  per year. The current maintenance and operations contractor for the Hanford Site uses a slightly more stringent criteria, namely a 0.20 gravity earthquake which, according to Coats and Murray, has an associated annual frequency of occurrence of  $1 \times 10^{-4}$ . As discussed in Appendix A, several key buildings and the 291-Z-1 stack have had seismic evaluations performed on them. These buildings include the 234-5Z Building and 236-Z Building. The results of these evaluations show that these buildings and the 291-Z-1 stack can withstand a 0.25 gravity peak horizontal ground acceleration earthquake, with a concurrent 0.17 gravity peak vertical ground acceleration. Coats and Murray indicate that this magnitude of an earthquake has associated with it an annual frequency of occurrence of  $4 \times 10^{-5}$  (extrapolated).

Table 9.2.4-1 of the PFP FSAR lists 156 gloveboxes and hoods throughout Buildings 234-5Z and 236-Z. The subject table states the maximum plutonium allowed (in grams) in each glovebox or hood per criticality prevention specifications, and states whether the given glovebox or hood is seismically qualified. Only 20 of the 156 gloveboxes and hoods are seismically qualified. These 20 are as follows:

- Glovebox HC-4 in Room 166 in 234-5Z
- Glovebox HC-227T in Room 227 in 234-5Z
- Gloveboxes HC-7, HC-9B, and HC-11 in Room 228-A in 234-5Z
- Gloveboxes HC-15A,-B,-C in Room 228-B in 234-5Z
- Glovebox HC-18BS in Room 228-C in 234-5Z
- Gloveboxes H-9D, H-9E, and HA-7A in Room 235-A in 234-5Z
- Gloveboxes HA-20MB and HA-23S in Room 235-B in 234-5Z



- Glovebox HA-22B in Room 236-A in 234-5Z
- Glovebox (first floor) and Glovebox (second floor) in East corridor of 236-Z
- Glovebox (first floor) and Glovebox (second floor) in West corridor of 236-Z
- Glovebox (for slag and crucible charging) in Room 43 of 236-Z.

This information is incorporated into the accident-related discussions that are provided in this EIS.

### **C.2.1.3 Flooding**

Regarding flooding at the PFP Facility, the PFP FSAR states the following:

The PFP site, 500 ft above mean sea level (MSL), is 75 ft above the probable maximum flood (PMF). This PMF is a combination of the most severe meteorological and hydrological conditions hypothesized for the region. The PFP is sited above the projected 1,000-yr flood and the instantaneous destruction of 50 percent of the Grand Coulee Dam analyzed by the U.S. Army Corp of Engineers. The studies and analyses made of the surface hydrology conclude that flooding scenarios of the PFP are not credible. Surface flooding is a possibility, but adequate drainage reduces any potential for damage. The failure of the elevated tank could cause localized flooding but not impact the PFP. Flooding would not impact the plant containment envelope.

Therefore, flooding that potentially significantly impacts the PFP Facility is unlikely.

## **C.2.2 EXTERNAL EVENTS**

External events include the crashing of aircraft and energetic events (i.e., accidents) at facilities or along transportation routes located in the vicinity of the Facility. The PFP FSAR performs a rigorous analysis of the likelihood of any type of aircraft accident involving the PFP Facility, and concludes that an aircraft accident involving the PFP Facility is incredible. An examination of transportation routes and facilities around the PFP Facility, as documented in Chapter 2 of the PFP FSAR, revealed no sources that could provide the necessary energy to cause an accident scenario more severe than those postulated in this EIS. There are no nearby industrial, military, or transportation facilities, other than those on the Hanford Site controlled by DOE, to impact or be impacted by the PFP Facility. The closest onsite facility to the PFP Facility is the 274-WA Building, located 0.6 km (0.4 mi) to the north northwest. The U.S. Army Yakima Firing Range boundary is about 29 km (18 mi) northwest of PFP Facility. Live firing conducted has no impact on the Hanford Site. At 4 km (2.5 mi) from the PFP Facility, State Route 240 is the closest transportation route to the PFP Facility. State Route 240 crosses the Hanford Site. This road, along with other Site roads, are used for the commercial transport of fuel and common hazardous chemicals. Though not methodically evaluated, an accident at the PFP Facility, induced by an accident on nearby transportation routes or an accident at another facility, that results in the uncontrolled release of radiological or hazardous materials from the PFP Facility is extremely unlikely, and possibly incredible.

## **C.2.3 OPERATIONAL EVENTS**

Operational accidents presented in this appendix and elsewhere in this EIS were gleaned from a review of pertinent safety and environmental documentation (e.g., the PFP FSAR and applicable environmental assessments), and, for the muffle furnace and vertical calciner, direct observation of the hardware and scrutiny of their design attributes and operating environment. Discussions with knowledgeable Hanford Site personnel were also conducted to gain their insights into potential accident phenomena. Additionally, Unusual Occurrence Reports associated with the PFP Facility over the past two and a half years were reviewed so that historical PFP Facility accident phenomena could be incorporated into this EIS as appropriate. (Unusual Occurrence Reports for the PFP Facility are available at the DOE public reading room in Richland, Washington.) A detailed hazards and operability study for muffle furnace operations was also used to support the development of accident scenarios (WHC, 1991).

## **C.2.4 CRITICALITY**

Theoretically, criticality could occur at the PFP Facility due to an external event, natural phenomena, or operational mishap. One of the factors that affects the potential to cause a criticality event is the form/constitution of the plutonium (e.g., powder, metal, alloy, solution). Nevertheless, for each of the alternatives presented in this EIS, criticality is extremely unlikely based on the extensive evaluation of criticality presented in the PFP FSAR. A review of historical records of the six major DOE sites (i.e., Hanford, Idaho Falls, Rocky Flats, Los Alamos, Oak Ridge, and Savannah River) reveals that in the approximately 40 year history of these sites there were six criticalities involving chemical processing. (Other criticality accidents happened with test reactors or test critical assemblies for research purposes.) Of these six events, five took place through 1964, with the last one in 1978 at Idaho Falls. Thus, overall, raw data indicates the annual likelihood of any one site experiencing a non-reactor related criticality would be six in 240 site-years, or 0.025 per year. However, each site has had several process operations or activities over the past 40 years that have had the potential for criticality. Historical information would indicate that criticality is unlikely on a per process operation or per activity basis. Coupling this fact with: 1) the type and scale of stabilization activities discussed in this EIS; 2) the relatively limited duration of these activities; and 3) the extensive measures that have been put in place by DOE since 1978 to ensure that criticalities never occur again, it is reasonable to categorize criticality as extremely unlikely.

Formal safety documentation would be required to be developed prior to implementation of any of the alternatives presented in this EIS to demonstrate that the risk of a criticality is acceptable. Risk, as used here, is meant to connote the frequency of occurrence of an accident scenario multiplied by the consequences (i.e., human health effects) of such an accident scenario. It is beyond the scope of this EIS to formally demonstrate that the risk of a criticality associated with each alternative meets established guidelines for acceptable levels of risk. Criticality analyses of similar previous activities and current activities (such as the analyses contained in the PFP FSAR) indicate that the alternatives presented in this EIS could be performed within established levels of acceptable risk.

The following discussion on criticality is predominantly from the PFP FSAR.

The conditions for a criticality would most likely occur during an off-normal condition when personnel would be trying to cope with the obvious problem and in the process create another. Training and a variety of administrative controls, as well as good design, would be used to minimize the chance of such a situation. Training classes would emphasize (and currently do emphasize) that off-normal situations have been involved in the criticalities that did occur.

No detailed scenarios are presented for criticality in the PFP Facility. The parameters that determine criticality are multiple and exist as continua, so deciding on a particular set of errors at any of dozens of locations is exhausting. For example, in a typical solution system the variable parameters could be plutonium mass, plutonium concentration, nitrate ion concentration, moderation, and reflection. Criticality safety would be achieved (and is currently achieved) by limiting the extreme end of each parameter and not by trying to limit all the ways that the parameter could be varied. An extensive system of design controls is in place to reduce the probability that personnel could create a criticality in either a dry or liquid system. Before any configuration changes can be made, the design must be reviewed for criticality considerations by a specialist in criticality evaluation. Work control plans ensure that modification or maintenance is done properly and checked before use.

#### **C.2.4.1 Metals**

Plutonium metal exists in the PFP Facility in amounts that could go critical without a moderator (e.g., in the Remote Mechanical C Line [RMC] gloveboxes during repackaging operations). This could only happen if a person were to willfully neglect or bypass pertinent operational and control-related safety constraints. Security concerns require two people in attendance when handling Category-1 material. Therefore, a criticality involving plutonium metal would take willful misconduct by two people. As bare metal, only a compact stacked, three dimensional array of plutonium buttons would reach criticality. A bare array of plutonium metal would lose reactivity by heat-related mechanisms, since the metal density decreases as it is heated. Expansion of the metal could cause a fissile system to shut down. Another possible shutdown of a metal system would be from melting.

#### **C.2.4.2 Powders**

Currently, no criticality scenario exists in the PFP Facility involving dry plutonium fluoride or plutonium oxide powder under the conditions of only nominal neutron reflection found in the dry air gloveboxes. Plutonium oxide in a spherical configuration at a density of 3 grams per cubic centimeter (g/cm<sup>3</sup>) (0.11 pounds per cubic inch [lb/in<sup>3</sup>]) has a critical mass of 140 kilograms (kg) (309 lb). Typical plutonium fluoride powders have bulk densities closer to 2 g/cm<sup>3</sup> (0.07 lb/in<sup>3</sup>), which means a spherical critical mass would require 290 kg (639 lb). Criticality safety limits are based on the addition of moderating and reflecting materials not normally encountered. For example, addition of water to an array of fissile material makes a profound difference in the mass required to achieve criticality. A spherical plutonium oxide-water mixture with the same 3 g/cm<sup>3</sup> (0.11 lb/in<sup>3</sup>) density as the dry material discussed above has a critical mass of only 18 kg (40 lb). Given full water reflection and the same type and arrangement of material, the critical mass goes down to only 12 kg (26 lb). Critical mass and spacing limits are often based on an assumption of a mass or spacing violation concurrent with glovebox flooding or the presence of other moderating materials, such as finely divided polyethylene. Twenty-one different combinations of spacing, moderation, reflection, and mass involving plutonium fluoride powder were examined in order to establish bounding conditions. The only two arrangements with a keff(1) greater than one involve: 1) a stacked array of three powder pans containing 2,500 g (5.5 lbs) plutonium as plutonium fluoride (keff = 1.0082); and 2) a powder pan of the same material with two stacked metal buttons in the middle (keff = 1.0701). To achieve the degree of moderation modeled, a conservatively high density was assumed for the powder as there is not enough space left in a powder pan of normal density powder to fit the required amount of moderating material. The PFP FSAR goes on to state that a simple spill or spacing error with dry powder that could result in a criticality is not credible. If enough loose, dry powder could be found in a process to achieve criticality, shutdown would occur when the interstitial air heated and expanded rapidly. The powder would be widely scattered. A stacked array of cans filled with powder, if possible to assemble, would react similarly. Cans would swell and possibly burst from heated air, and very quickly perturb the critical array.

#### C.2.4.3 Liquids

Regarding a criticality event involving liquids, the majority of vessels in the PFP Facility are constructed in a manner to maximize criticality safety. Gloveboxes cannot be of a critically safe geometry should they become flooded with water, but by enforcing strict administrative controls on mass, spacing, and the chemical or physical form of materials, the results of an accidental flooding are minimized and criticality prevented. Existing gloveboxes are, and new gloveboxes would be, equipped with drains and protected from plugging with large mesh screens, to minimize the probability of flooding. However, simultaneous breakdown of several controls and flooding could result in a criticality. Mitigating features exist in the event of a liquid criticality. In solutions, micro-bubble formation from radiolytic breakdown of the water molecules quickly lowers the density of the solution. In both solutions and in mixed solid and water systems, heat generated through the fission process can cause evaporation that may then lead to system shutdown. Nearly instantaneous formation of steam could, in some circumstances, be expected to physically disrupt the fissile materials into a nonreactive geometry. The same design features that prevent criticality, such as small size and mechanical spacing, work to limit the extent of super criticality and the duration of phenomena such as the pulsing that took place in Recuplex in 1962.

During day-to-day work, a set of general limits would address such items as the size and location of containers or potential containers even on the outside of a glovebox, or the use of plastic sheeting for covers or drapes. The number and size of cleaning rags would carefully be controlled as a pile of saturated rags may approach an unfavorable shape and could draw solution by absorption. Existing gloveboxes are, and new gloveboxes would be, equipped with special drains that reduce the probability of deep accumulations of liquid occurring. The size of each drain is (would be) specified in relation to the potential for liquid flow and each drain is (would be) equipped with a large, coarse screen to prevent plugging. Some drains flow liquid onto the room floor, and while such an event can cause a radiological problem, it does prevent formation of a critical system.

The volume of containers, both individual and total, would be specified for each glovebox to reduce the probability of accumulating excess liquid. In addition to process container volumes, there would be specifications that describe non-containers. At times in the past, hardware was brought into gloveboxes or hoods for purposes other than liquid handling which, in case of an accident, could become containers. For example, years ago a metal box or a quart ice cream carton were commonly used to store tools. Now such containers must have a specified number, size, and arrangement

of holes near the bottom. Personnel are taught that even a section of pipe set on end could contain liquid if the liquid was introduced faster than it would leak away.

#### C.2.4.4 Example of Seismic-induced Criticality Evaluation

Areas in which a seismically induced criticality is conceivable would be those that already contain a critical mass that is separated into several subcritical masses during operation. As stated in the PFP FSAR, there are currently only a few active gloveboxes in which previously determined critical configurations for plutonium metals, powders, and solutions are even potentially satisfied (assuming that the only plutonium present is that related to normal operations and within established operational limitations). Currently, two of the locations where there are quantities of materials in excess of a critically safe mass (if all the material in the form allowed in the glovebox were to somehow be gathered into the optimum configuration and reflected) are Gloveboxes HC-21A and HC-21C. To support sludge stabilization activities that were addressed in a previous NEPA document (DOE, 1994), two muffle furnaces are currently active in Glovebox HC-21C. To concretely illustrate the point made previously that formal safety documentation would be required to be developed prior to implementation of any of the alternatives presented in this EIS, the following excerpts from the PFP FSAR regarding seismically induced criticality in Gloveboxes HC-21A and HC-21C are provided.

The [Criticality Prevention Specifications] CPSs for each of these two gloveboxes have been revised. The limits are a maximum total glovebox inventory of 5 kg plutonium as slightly moderated material plus a 2.0 l limit on the volume of individual containers and 10 in. minimum spacing between containers (no total volume limit). No free liquids are allowed in either glovebox, and there are no liquid pipelines into them.

HC-21A and HC-21C are both seismically nonqualified due to neither of their table-stands being anchored to the floor. Thus, during a DBE these gloveboxes are assumed to topple, freely tumbling containers, and dumping their contents if open. Although no restriction is set on hydrogen/plutonium ratio for the materials present, it is not plausible that sludges in containers introduced will have hydrogen/plutonium values of more than 50, as this enters the realm of solutions (500 grams/l). At this dilution, a criticality with 5 kg of plutonium nominally reflected requires a 10-l, perfectly spherical configuration (Carter et al., 1969, graph III.A.9(100.4). Production of the optimum geometry by the seismic motions is not credible.

Therefore, as a single contingency effect, a seismically induced criticality in gloveboxes HC-21C and HC-21A is not credible. Extra faulted conditions can be postulated to produce criticality, such as extensive glovebox overbatching or the entrance of water from exterior sources. The latter would depend on the probability of box windows breaking in conjunction with fire sprinkler activation, providing the breakage does not produce drainage paths.

### C.3 MUFFLE FURNACE

Accident scenarios postulated for muffle furnace operations have been developed primarily from: 1) direct observation of current muffle furnace operations at the PFP Facility; 2) discussions with PFP Facility supervisory and muffle furnace operations personnel; 3) review of the muffle furnace hazard and operability study (WHC, 1991); and 4) review of Chapter 9 (i.e., the accident analysis chapter) of the PFP FSAR.

Muffle furnace operations are discussed in this EIS as a potential method of stabilizing multiple forms of plutonium (e.g., oxides, fluorides, residues, metals, polycubes). Though the health effects of a given accident scenario involving each of these forms may vary due to the intrinsic physical and chemical properties of a given form, the fundamental hardware and operational steps would be essentially the same, as would be potential preventive and mitigative measures. Accidents scenarios have not been developed for muffle furnace operations that are unique to a given form.

A detailed hazard and operability study for muffle furnace operations was also used to support the development of accident scenarios (WHC, 1991). In this study, each major piece of equipment was considered a node, and the piping and instrument lines connecting the equipment were also designated as nodes. Pertinent process parameters such as flow, pressure, fluid level, and temperature were chosen, and a series of questions was asked about each parameter. Each question concerned an abnormal condition of the parameter (e.g., "no flow"). The hazard and operability study team, based on design knowledge and operational experience, postulated the cause(s) and effects of the abnormal

process condition. From this information, a qualitative estimate of the consequences of the abnormal condition was obtained. The study concluded that there are two events associated with muffle furnace operations with the potential for significant onsite and/or offsite consequences. One event involves a chemical reaction that results in "an abnormally high flow of flammable gases creating an explosion hazard" in the offgas system. The other event is an "explosion or combustion of flammable gases or activation of the [halon] fire suppression system causes pressurization of the glovebox."

In addition to the events previously shown in Table C-2, the following three general types of accident phenomena are postulated for muffle furnace operations:

- Explosion and/or fire
- Loss of ventilation not due to explosion or fire
- Breach/bypass of radiological material confinement or contamination control barrier(s) not due to explosion or fire.

Frequency of occurrence information for specific scenarios associated with each of these types of accident phenomena are summarized in Table C-3. Other accident scenarios could be postulated, but their consequences would likely be small and limited to PFP Facility workers.

### C.3.1 EXPLOSION AND/OR FIRE

Various mechanisms for an explosion and/or fire can be postulated. In certain forms, plutonium is pyrophoric. The pyrophoric nature of plutonium has exhibited itself more than once at the PFP Facility. Some other potential causes of a fire include spontaneous ignition of non-pyrophoric materials, electrical shorts, uncontrolled temperature excursion of a muffle furnace; and contact of combustible materials (e.g., glovebox gloves or cleaning rags) with hot equipment.

**Table C-3 Summary of Muffle Furnace Accident Scenario Frequencies**

ACCIDENT SCENARIO	FREQUENCY OF OCCURRENCE AND BASIS FOR THE FREQUENCY SELECTED
<b>EXPLOSION AND/OR FIRE:</b>	.
Fire not involving radiological materials	Anticipated. Historical events at DOE and other industrial facilities.
Fire involving radiological materials but releases maintained within confinement barriers	Anticipated. Historical events at DOE facilities, including the PFP Facility.
Explosion and/or fire involving radiological materials with releases impacting PFP Facility workers, but not escaping to the environment unfiltered	Anticipated. Historical events at DOE facilities, including the PFP Facility.
Explosion and/or fire involving radiological materials leads to unfiltered releases from the facility, potentially impacting the environment and health of Hanford Site workers and the public	Extremely unlikely. Based on extremely limited explosion and fire energy sources.
<b>LOSS OF VENTILATION NOT DUE TO EXPLOSION OR FIRE</b>	.
Loss of offsite power coupled with failure of the two steam turbine driven exhaust fans, potentially resulting in the exposure of PFP Facility workers to airborne radioactive materials. (Backup alternating current power, i.e., diesel generator alternating current power, is not provided	Unlikely. Frequency of loss of offsite power events and failure rate data for turbine driven equipment.

for the seven electrical exhaust fans in Building 291-Z.)	
Moderately severe earthquake (i.e., the currently DOE specified earthquake for moderate and low hazard facilities at the Hanford Site, 0.12 gravity, which is essentially the maintenance and operations contractor design specification [0.129 gravity] for Safety Class 2 and 3 structures, systems and components, which includes most ventilation equipment), potentially resulting in the exposure of PFP Facility workers to airborne radioactive materials	Unlikely. 0.12 gravity is the DOE Order 6430.1A earthquake design requirement for moderate and low hazard facilities at Hanford, which has an associated annual return frequency of $1 \times 10^{-3}$ .
<b>BREACH/BYPASS OF RADIOLOGICAL MATERIAL CONFINEMENT OR CONTAMINATION CONTROL BARRIER(S) NOT DUE TO EXPLOSION OR FIRE</b>	.
Breach/bypass of all HEPA filters in an exhaust pathway to atmosphere not due to explosion or fire, potentially impacting the environment and health of Hanford Site workers and the public	Unlikely. Historical event. Ductwork downstream of the final stage of PFP Facility HEPA filtration is contaminated, and an explosion or fire was not the cause. Credit is taken for stringent measures that are currently in place to prevent such releases in the future.
Contaminated wound associated with glovebox activities	Anticipated. Historical events at DOE facilities, including Hanford.
Hardware failure or human error associated with HEPA filter replacement bagout operations results in PFP Facility worker skin contamination and/or inhalation of radiological materials	Anticipated. Historical events at DOE facilities, including recent event at the PFP Facility.
Hardware failure or human error associated with the transfer of radiological materials into and out of gloveboxes results in PFP Facility worker skin contamination and/or inhalation of radiological materials	Anticipated. Historical events at DOE facilities.
Hardware failure or human error associated with handling and packaging radiological materials results in PFP Facility worker skin contamination and/or inhalation of radiological materials	Anticipated. Historical events at DOE facilities, including recent event at the PFP Facility.
Substantial earthquake causes spill/release of radiological materials, resulting in PFP Facility worker skin contamination and/or inhalation of radiological materials	Unlikely. 0.09 gravity is the DOE Order 6430.1A earthquake design requirement for "general use" facilities at Hanford, which has an associated annual return frequency of $2 \times 10^{-3}$ .

Various mechanisms for causing an explosion (and possibly fire) are conceivable, including: improper feed materials (type and/or quantity); unexpected chemical reactions; excessive hydrogen generation from batteries and subsequent accumulation to detonable levels; and a propane gas cylinder mishap. Administrative controls would make the introduction of improper feed materials (sufficient to result in an explosion) a remote possibility. The current level of understanding of chemistry, coupled with the level of characterization of elements and chemicals that would be processed in a muffle furnace, would also make unexpected chemical reactions a remote possibility. Improper feed materials and unexpected chemical reactions are the dominant mechanisms for generating flammable or explosive gases in the muffle furnace offgas system. This situation is extremely unlikely, especially in consideration of offgas to offgas system volumetric flowrate ratios, and that an ignition source is also required. The "muffle furnace with secondary combustion chamber" alternative for stabilizing polycubes and combustibles presents an exception. For this alternative, concentrations of organics in the offgas stream would need to be diligently controlled to prevent a

flammable gas hazard from developing. As discussed in Section 3 of this EIS, various measures would be taken to prevent flammable gas concentrations from occurring, including the use of an inert purge gas.

Batteries are located in well ventilated areas, and administrative controls (e.g., periodic inspection and testing) aid in ensuring that a hydrogen deflagration or detonation is unlikely or extremely unlikely. The following excerpt from the PFP FSAR is provided regarding propane gas usage at the PFP Facility:

The types and quantities of flammable gases used at the PFP were reviewed and nominal 465-g (16.4-oz) containers of liquid propane gas (LPG) were found to present the greatest risk. Propane is used on an as-needed basis at the PFP Facility for a variety of activities which require relatively high temperatures. Examples U.S. Department of Transportation (DOT) and the Compressed Gas Association of applications requiring propane include: soldering, heating planchets in a laboratory setting, igniting the flashpoint analyzer in the Analytical Laboratory, and making repairs to the [Heating, Ventilation, and Air Conditioning] HVAC system. Liquid propane gas containers used in the PFP Facility are restricted to small, commercially available cylinders of 465-g (16.4-oz) capacity which meet requirements established by the (CGA). Federal requirements are found in 49 CFR 173 and 49 CFR 178.65. Applicable national consensus standards are found in CGA Standard S1.1-89 (CGA 1989). Testing of propane cylinders by Underwriter's Laboratory (UL), in accordance with test procedure 147A, *Nonrefillable (Disposal) Type Fuel Gas Cylinder Assemblies* (UL 1992), provides added assurance that the cylinders meet or exceed applicable DOT and CGA requirements.

In a minor fire, a small breach of confinement is not in itself enough to cause a loss of radioactive material from the glovebox because of the negative pressure that can be maintained within the glovebox. In a large fire, filter clogging combined with the pressure of combustion gases would likely result in the spread of radioactive particles outside the glovebox. The following excerpt from the PFP FSAR for Glovebox MT-5 is provided because it contains meaningful insight into fire-related operational problems, and to demonstrate the fire resistance of gloves (which is discussed in Subsection C.3.1.1).

Glovebox MT-5 is located in room 41 of Building 236-Z. Plutonium compounds and plutonium-bearing residues containing less than 20 wt percent organic are transferred to this glovebox and dissolved in nitric acid (HNO<sub>3</sub>) to form aqueous plutonium nitrate feed to the solvent extraction process. In the past, small flameups have occurred in glovebox MT-5. These flameups have scorched several gloves and in some instances required the gloves be pierced and fire extinguishers used to extinguish the flameup. This has resulted in the release of small amounts of radioactive material into room 41. A large-scale fire in glovebox MT-5 would have greater consequences but is deemed extremely unlikely, if not incredible, because of the small volume, form, and arrangement of combustible materials within the glovebox.

In consideration of the above discussion of explosions and fires, and in consideration of historical information pertaining to Hanford Site operations in general, an explosion and/or fire event associated with muffle furnace operations is anticipated. It is important to examine the preventive and mitigative measures that would be in place to limit the propagation and potential consequences of an explosion and/or fire.

#### **C.3.1.1 Available Combustible Materials**

Quantities of combustible materials are very limited in gloveboxes (and would be for muffle furnace operations), and throughout PFP Facility processing areas in general. The number of rags allowed in a glovebox would be administratively controlled. Small quantities of other combustibles (e.g., wood and paper), which are generally associated with support and cleanup activities as opposed to facilitating the main process, could also be located in a glovebox. Nevertheless, it is emphasized that based on current PFP Facility operational practices, it is not probable that a fire of sufficient intensity and/or duration could breach a glovebox. Other combustible materials in PFP Facility processing and laboratory areas, but outside of gloveboxes, include system documentation and procedures, speaker boxes with wood casings, and a few cardboard boxes. Wooden high efficiency particulate air (HEPA) filter casings are treated with a fire retardant. Process and laboratory areas are overwhelmingly comprised of non-combustible materials (e.g., steel and concrete), and it is difficult to envision a scenario where more than a very localized fire could occur.

Generally, the materials of construction for a glovebox are steel, synthetic rubber-based gloves, and one or more of the

following transparent materials: plastic (Lexan); plexiglass; leaded-glass; safety glass; or polycarbonate. These see-through materials are nominally approximately 0.63 to 1.3 cm (0.25 to 0.5 in) thick. Plexiglass supports combustion, but would not be associated with muffle furnace operations. Polycarbonate and Lexan are self-extinguishing. Gloves (located in the gloveports of gloveboxes) would likely be made of hypalon. Hypalon is an elastomer made by substituting chlorine and sulfonyl chloride groups into polyethylene. Hypalon, because of its chlorine content, is inherently more resistant to burning than are exclusively hydrocarbon polymers. In laboratory tests, hypalon will ignite and burn slowly as long as an outside source of flame is present, but will stop burning when the flame is removed. Natural rubber and many other synthetics, under the same conditions, will keep burning. The heat resistance of hypalon is well documented by reports from users of many end products. Hypalon also features outstanding abrasion resistance, and resistance to ozone or oxidizing chemicals.

### C.3.1.2 Detection, Suppression, and Mitigation

As discussed in Appendix A to this EIS, substantial fire detection and suppression capabilities exist at the PFP Facility. The PFP FSAR provides an extensive description of PFP Facility fire detection and suppression systems. Key elements of the PFP Facility fire protection system include:

- Piping systems that contain and transport the extinguishing agents
- Fire alarm system, which notifies the fire department when triggered
- Heat or products of combustion detector systems that activate an alarm and/or activate a water system or Halon system
- Automatic sprinkler systems that activate by heat to open and sprinkle water; usually fusible link mechanisms
- Halon suppression systems (in some gloveboxes)
- Supervised valves in the water supply system
- Fire barriers to isolate parts of buildings, thus slowing progress of fire and reducing damage. Such barriers are also vital to life safety.

Any room/area containing a glovebox used to support muffle furnace operations would have a fire protection (sprinkler) system. Several types of sprinkler systems are employed in PFP Facility building locations. They include wet pipe, dry pipe, preaction, pressurized water can (limited supply for hoods and gloveboxes), and deluge systems. The sprinkler systems are schedule designed rather than hydraulically designed, which provides more conservatism. Foam systems are not used in PFP Facility sprinkler systems. The Hanford Fire Department, which provides separate and reliable backup to all PFP Facility fire protection systems, is located only 5.6 km (3.5 mi) from the Facility. Response to any fire alarm can be made in a timely manner. Additionally, PFP Facility workers would be trained to fight a fire in the incipient stages if reasonable from a health and safety perspective (e.g., combat a small trash can fire, but not a piece of on-fire plutonium metal located outside of a glovebox). Select PFP Facility personnel would receive special training in fighting incipient fires.

Operator(s) would be located nearby (i.e., within a few feet) of a glovebox that contains an operating muffle furnace. From that location, operator(s) would monitor a control panel that: 1) allows for selection of a predetermined heatup and cooldown sequence; 2) provides a readout of the existing muffle furnace temperature; 3) alarms (audible and visual) if certain parameters are exceeded; and 4) provides for manually preventing actuation of the glovebox halon system. Parameters that would be alarmed (and may be made to automatically shutdown the furnace) would be high glovebox temperature, high furnace temperature, and excessive temperature deviation from pre-programmed values. High glovebox temperature for current muffle furnace operations is set at 70 degrees Celcius (·C) (158 degrees Fahrenheit [·F]). The furnace door would be interlocked such that an open door de-energizes the furnace. The setpoint for actuation of the glovebox Halon system for current muffle furnace operations is 93·C (199.4·F). Actual insertion of Halon into the glovebox is delayed for a short while to give the operator a moment to evaluate the situation and make a determination as to whether Halon insertion should be allowed to proceed automatically. Abnormal and/or accident event response procedures would be made available in the immediate area, with response training provided. Given these fire prevention, detection, and suppression factors, muffle furnace glovebox operations are not a likely location for a fire that results in PFP Facility workers, Hanford Site workers, or the public being exposed to radiological materials.



Nevertheless, an explosion and/or fire involving radiological materials with releases impacting (if only to a very minor extent) PFP Facility workers, but not escaping to the environment unfiltered, is anticipated. This categorization is based on other activities that would be associated with muffle furnace operations where a fire could occur (e.g., transportation to and from the furnace, furnace material preparatory activities, staging areas for subsequent furnace feeds, laboratory activities associated with "loss on ignition" testing, etc.). The anticipated categorization is also based on historical fire-related events at DOE facilities, including the PFP Facility.

PFP Facility offgas and heating, ventilation and air conditioning systems are described in Appendix A to this EIS. The PFP FSAR provides an extensive description of these systems. These systems are very important for protecting the health of Hanford Site workers and the public, as they are designed and intended to provide HEPA filtration of airborne radioactive particulates during normal and accident conditions. (Obviously, some extreme events such as a large deflagration in heating, ventilation and air conditioning ducting, or a severe seismic event could defeat the HEPA filtration function.) PFP Facility workers are protected primarily through proper training, procedures, programs (e.g., industrial hygiene, radiological control, and emergency preparedness programs) and other administrative controls. The following excerpt from the PFP FSAR summarizes the important safety aspect of the ventilation function.

Within the 234-5Z, 232-Z, 236-Z, 241-Z, and 242-Z Buildings, Zone 1 is designated as those areas where plutonium contamination would not normally be present (e.g., office areas, lunchroom, certain maintenance shops, hallways, etc.). No contaminated materials or personnel wearing protective clothing are allowed in Zone 1 areas. Zones 3, 3A, and 3B (collectively referred to as Zone 3) consist of areas in which radioactivity (e.g., plutonium) is stored or handled in contained form, and where there is potential for contamination to occur (e.g., rooms in which hoods and gloveboxes are located). Zone 4 consists of the inside of hoods, gloveboxes, and process cells, directly exposed to plutonium, and which may be grossly contaminated. The [Differential Pressures] DPs are maintained between the zones to assure that airflow is from the lowest potential contamination areas, to intermediate potential contamination areas, to highest potential contamination areas, (Zone 1 ---> Zone 3 ---> Zone 4).

Zone 3 and Zone 4 exhaust pathways are HEPA filtered. Any radioactive particulate materials escaping Zone 4 would be HEPA filtered by Zone 3 equipment.

### **C.3.2 LOSS OF VENTILATION NOT DUE TO EXPLOSION OR FIRE**

The main hazard posed by the loss of ventilation is caused by the loss of differential pressure zones. Airborne contamination that could migrate to areas occupied by PFP Facility workers (e.g., from Zone 4 areas to Zone 3 areas) would generally be tortuous/restricted. Airborne contamination would be minimal during a loss of ventilation because all process related activities would be promptly terminated. All but essential and/or emergency response personnel would likely be evacuated from the PFP Facility, and those remaining would likely be required to wear respirators. The situation would be somewhat exacerbated by the fact supply air pathways to Zones 1 and 3 are not HEPA filtered should backflow occur through these pathways. However, Zone 4 area supply and exhaust ventilation system pathways are HEPA filtered, and the "stack effect" would contribute to air flow out of the building occurring through normal exhaust air pathways.

#### **C.3.2.1 Loss of Normal Electrical Power and Failure of Steam Driven Exhaust Fans**

Loss of offsite power is anticipated, and for purposes of this analysis, it is assumed to occur once a year. *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs* (EG&G, 1990) provides a recommended failure rate of 0.03 per demand for turbine driven pumps. Using this failure rate for the steam turbine driven exhaust fans, and neglecting common cause failure mechanisms (which would result in a larger likelihood of both pumps not operating when demanded), the failure rate for both pumps failing on demand is  $9 \times 10^{-4}$ . Loss of ventilation due to this scenario is unlikely.

#### **C.3.2.2 Moderately Severe Earthquake**

During a moderately severe earthquake, the ventilation function could be lost due to various electrical or mechanical

faults/failures. Additionally, the PFP FSAR states that redundant systems (one automatic, one manual) are in place to shut down the electric fans in the event of an earthquake of a magnitude greater than or equal to 0.07 gravity horizontal. Exhaust fans in Building 291-Z and other ventilation support equipment have not been designed to (and are not likely capable of) withstanding the currently specified design basis earthquake for high hazard facilities, which has an annual frequency of occurrence of  $2 \times 10^{-4}$ . The PFP FSAR states the following:

Detailed accident analyses for the PFP have not identified any scenario where continued operation of the 234-5Z ventilation system is essential to prevent an airborne release of plutonium that is unacceptable. Therefore, a temporary loss of ventilation is acceptable. This finding permits most ventilation equipment to be assigned to either Safety Class 2 or 3. The exception is that when the ventilation system is operating, the final filters and stack detection systems are Safety Class 1.

At the Hanford Site, Safety Class 2 and 3 equipment are designed to withstand an earthquake with a horizontal acceleration of 0.129 gravity. (Safety Class 2 must withstand dynamic loadings, while Safety Class 3 must withstand static loadings.) Kennedy, et al. show that, for the Hanford Site, such an earthquake has an annual frequency of occurrence of  $1 \times 10^{-3}$ . This scenario is considered unlikely.

### **C.3.3 BREACH/BYPASS OF RADIOLOGICAL BARRIER(S) NOT DUE TO EXPLOSION OR FIRE**

Several scenarios that involve the breach/bypass of radiological material confinement or contamination control barrier(s), not due to an explosion or fire, can be postulated. Nearly all of the following scenarios were developed from DOE historical events, and some were taken from relatively recent PFP Facility events.

#### **C.3.3.1 Breach/Bypass of All HEPA Filters in an Exhaust Pathway to Atmosphere**

Some theoretical ways of breaching/bypassing one or more HEPA filters are as follows:

- Improper sealing/seating of the filter in its housing structure. (This is unlikely since PFP Facility exhaust system HEPA filters are tested after installation to ensure their filtration efficiency is as expected.)
- Random failure of the filter, even though design conditions for the operating environment of the filter have not been exceeded.
- Excessive differential pressure across the filter, possibly due to failure to replace the filters in a timely manner after high differential pressure is recognized.
- Chemical attack.

Regarding chemical attack, the PFP FSAR states the following:

There is an historical occurrence of [hydrogen fluoride] HF gas leaks from the fluorinator into the middle section of glovebox HC-9B. On one occasion, the entire filter chain from the glovebox HC-9B, through filterbox 9B to filterbox 9AB, was completely destroyed. Subsequently, an improved offgas system was installed. Hydrogen fluoride resistant filters were installed, an improved hydrofluorinator offgas system was constructed, a dual HF detector system was installed, and a frequent filter testing program was instituted under [Operational Safety Requirement] OSR control. Use of RMC line has been discontinued, the supply of HF has been disconnected from the building, and all of the HF has been removed from the PFP Facility so the potential for chemical attack of the filters by HF no longer exists.

The differential pressure across HEPA filter trains are monitored and alarmed for both high differential pressure conditions (indicating clogging of the filter) and excessively low differential pressure (indicating a breach/bypass of the filter). Also, radiological monitoring equipment is installed downstream of the HEPA filters and alarm upon detection of radiological materials above predetermined levels. In consideration of these facts, it is unlikely that an unfiltered release to the environment would occur, especially for a prolonged period of time (e.g., for more than 10 minutes).

#### **C.3.3.2 Contaminated Wound Associated with Glovebox Activities**

The potential exists for an operator to tear a glove during handling operations in a glovebox. Gloveboxes are a proven method of handling alpha contaminated materials and have been used at DOE facilities like Hanford for decades. Features would be provided that would aid the operator in handling the materials and reduce the chance of a glove tear. Operators would likely be required to monitor their hands and arms for radioactive contamination each time they exit the glovebox gloves. They would wear surgical type gloves inside the glovebox gloves to minimize the potential of skin contamination if the glovebox gloves should develop a hole. Breaches of glove integrity are anticipated events. However, contaminated wounds occur in only a small fraction of glove integrity violations. A Hanford Site specific study documents 12 contaminated wounds associated with glovebox operations that occurred from 1972 through 1986 (Sudmann, 1992). Because of several factors, it is difficult to calculate for muffle furnace operations an accurate yearly frequency for such wounds. Based on the subject Hanford Site specific study, they are anticipated events. Historical accidents involving a contaminated wound have nearly always resulted in a very small radiological dose (i.e., committed effective dose equivalent) to the affected worker.

### **C.3.3.3 HEPA Filter Changeout Mishap**

HEPA filters must be periodically replaced, usually when the loading on them results in higher-than-desired differential pressure. (Excessively high differential pressure can breach a filter.) Muffle furnace activities could lead to more frequent HEPA filter changeouts. Several events have occurred over the decades at DOE facilities that involve the loss of radiological control during HEPA filter changeout activities. These events sometimes result in skin contamination and/or the internal deposition of radiological materials. For example, a mishap occurred on March 17, 1993 at the PFP Facility during HEPA filter changeout activities that resulted in nine workers receiving internal depositions of plutonium (Unusual Occurrence Report RL-- WHC-PFP-1993-0018, dated May 17, 1994). The maximum committed effective dose equivalent received by any of the nine workers was 990 millirem, with the other eight receiving 250 millirem or less. Hardware failure(s) and/or human error(s) associated with HEPA filter replacement, and resulting in a PFP Facility worker incurring skin contamination and/or the internal deposition of radiological materials, are anticipated.

### **C.3.3.4 Bag or Bagless Transfer Operations Into and Out of Gloveboxes**

To support muffle furnace operations, numerous transfers of radiological materials into and out of gloveboxes would be required. Bag or bagless methods may be employed, depending on the particular transfer taking place. DOE requirements mandate the need for bagless operations if long term (i.e., greater than 50-year) plutonium storage configurations are desired. Bag methods have been employed for many years at DOE sites, and have been relatively effective from a risk and safety perspective. However, events involving skin contamination and/or the internal deposition of radiological materials have occurred. The Savannah River DOE site has introduced a bagless transfer system that uses a hollow plug insert as discussed in Section 3 of this EIS. This system or some modification thereof would be used as appropriate. Because of the history of events associated with bag-in and bag-out activities, and because of the novelty of bagless operations, an event resulting in a PFP Facility worker incurring skin contamination and/or the internal deposition of radiological materials is anticipated.

### **C.3.3.5 Handling and Packaging Mishap**

To support muffle furnace operations, extensive handling and packaging of radiological materials (external to a glovebox) would be required. As recently as December 13, 1994, four PFP Facility workers received an internal deposition of plutonium while performing packaging operations (Unusual Occurrence Report RL--WHC-PFP-1994-0056, dated February 14, 1995). The direct cause of the subject event was the use of force by personnel sufficient to tear both bags surrounding a polyjar while attempting to place the polyjar into a seismic overpack. (A polyjar is a plutonium storage container, and the one involved in the subject event was a 0.5 l polyjar.) Preliminary assessments indicate that the committed effective dose equivalent for each of the four affected workers will be less than 100 millirem. Hardware failure(s) and/or human error(s) associated with the handling and packaging of radiological materials, and resulting in a PFP Facility worker incurring skin contamination and/or the internal deposition of radiological materials, are anticipated.

### C.3.3.6 Substantial Earthquake

Gloveboxes HC-21A and HC-21C are not seismically qualified. Neither of their table-stands are anchored to the floor. Thus, during a substantial earthquake these gloveboxes could topple, freely tumbling containers, and dumping their contents if open. The exact magnitude of earthquake that would topple these gloveboxes or otherwise disperse materials contained in them has not been determined. Kennedy, et al. specify a 0.09 gravity horizontal acceleration earthquake, with an annual return frequency of  $2 \times 10^{-3}$ , for "general use" facilities at the Hanford Site. It is assumed that this magnitude of an earthquake could topple the subject gloveboxes or otherwise disperse materials contained in them, thereby potentially impacting the PFP Facility workers. This scenario is unlikely. As indicated previously, a larger magnitude earthquake (e.g., a 0.12 gravity earthquake with an associated annual frequency of occurrence of  $1 \times 10^{-3}$ ) would be required to potentially create unfiltered pathway(s) to the environment, thereby potentially impacting the environment and health of onsite personnel and the public.

### C.3.4 SUMMARY

The accident analysis of muffle furnace operations at the PFP Facility would seem to validate the position that the dominant risk and safety concern is for the PFP Facility workers. The three most credible scenarios for impacting the environment and health of Hanford Site workers and the public are the following:

- A moderately severe earthquake that provides an unfiltered pathway for releases
- An explosion and/or fire, in or around the exhaust pathway from muffle furnace operations, of sufficient magnitude to create an unfiltered pathway for releases
- Chemical attack, random hardware failure, and/or human error lead to a breach/bypass of all HEPA filters in an exhaust pathway.

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(1)  $k_{eff}$  is a multiplication factor for criticality. If  $k_{eff}$  is equal to or greater than 1, a criticality situation potentially exists.





## APPENDIX D

# ANTICIPATED HEALTH EFFECTS UNDER NORMAL AND ACCIDENT CONDITIONS

## D.1 INTRODUCTION

This appendix provides background information on the analysis basis used to quantify the potential causes and magnitudes of the health effects from radiation exposure that could result from implementing the alternatives identified in this Environmental Impact Statement (EIS). Radiation exposure could occur to individuals and collective populations in three groups, via two pathways, and under two different conditions. These are:

- Individuals and Populations - Plutonium Finishing Plant (PFP) Facility worker, Hanford Site worker, and the public
- Pathways - Internal (inhalation) and external (direct radiation)
- Conditions - Routine operations and accidents.

Each of these is discussed in the subsections that follow. Because of the low emissions from the PFP Facility during implementation of the alternatives, compared to routine industrial releases, potential health effects resulting from other sources, such as chemicals and common industrial-type accidents, are not included in this analysis.

The methods used to estimate these health effects are also explained. These methods are intended to conservatively bound the anticipated magnitudes of potential health effects and provide a consistent means for comparisons among the alternatives. They should not be interpreted as predictive of the actual future expected effects, which would likely be lower than those presented.

## D.2 BACKGROUND

The analysis of health effects caused by radiation for the *PFP Stabilization EIS* is governed by the radionuclides present, the type of radiation emitted, and the route of entry into the body. These factors are analyzed to determine the potential health effects from exposure to radiation for both normal and accident conditions at the PFP Facility.

The health effects associated with plutonium and other transuranic materials are caused by the absorption in body tissues of energy from spontaneous nuclear transformations. These transformations are referred to as radioactive decay. As a result of the radioactive decay process, one element is usually transformed into another. This newly formed element is called a decay product and possesses physical and chemical properties different from those of its parent. The decay product may also be radioactive, undergoing successive radioactive decay steps until a stable element is produced. Americium-241 (Am-241) is included in this EIS because the decay of plutonium-241 (Pu-241) produces Am-241. Energy absorption in living organisms from radioactive decay can damage cells and the genetic material they contain, possibly causing health effects in the organism, depending on the type and amount of radioactivity involved.

Each distinct radioactive form of a particular element is referred to as a radionuclide. A characteristic unique to each radionuclide is its radioactive half-life, defined as the time required for one half of the atoms in a given quantity of the radionuclide to decay. Half-lives can range from fractions of a second to millions of years, depending on the particular radionuclide. It is generally accepted that a radionuclide can be considered to have completely decayed after 10 of its half-lives have passed.

Different types of radiation are released during radioactive decay, depending on the radionuclide. The principle types

of radiation emitted during radioactive decay are alpha particles, beta particles, gamma rays, and neutrons. Each type of radiation differs in its physical characteristics and in its ability to inflict damage to biological tissue.

Although highly energetic, alpha particles are the least penetrating type of radiation because of their electrical charge and relatively large mass. They will not penetrate a sheet of paper or the outer layer of human skin. They pose primarily an internal radiation hazard. That is, they may be very harmful if inhaled, ingested or otherwise admitted into the body (such as through a cut in the skin) because of their high energy and the difficulty in removing them. Alpha particles have the potential for causing cellular damage over time.

Beta particles are a more penetrating type of radiation than alpha particles. Unlike alpha particles, some beta particles can penetrate the skin. Like alpha particles, they can also cause serious effects if they are inhaled or ingested. Beta particles are thus both an external and internal radiation hazard.

Gamma rays and neutrons are very penetrating and are of concern because they can expose individuals from a distance through layers of intervening material, posing an external radiation hazard, potentially damaging organs of the body. They also are hazardous if taken into the body.

As shown in Table D-1, the radionuclides found at the PFP Facility that are important to this analysis are the plutonium isotopes Pu-238 through Pu-242, and Am-241. All of these isotopes are alpha particle emitters, although Pu-241 decays predominantly by beta emission to Am-241. Gamma ray emissions also accompany most of these alpha decay events, and spontaneous fission creates neutron radiation as well.

**Table D-1 Radionuclides of Concern**

Radionuclide	Half-life (years)
Pu-238	87.4
Pu-239	2.41 x 10 <sup>4</sup>
Pu-240	6.54 x 10 <sup>3</sup>
Pu-241	144
Pu-242	3.76 x 10 <sup>5</sup>
Am-241	432

**Source:** Eckerman and Jeffrey, 1993

### Exposures to PFP Facility Workers

Because the applicable radionuclides are all alpha emitters, the dominant health concern resulting from exposure to them is internal exposure (WHC, 1995a). The most probable route of entry to the body from PFP Facility events is through inhalation. This pathway is applicable to the relatively small routine operational releases from processing the plutonium-bearing materials and releases that could occur during accident conditions, such as drops, spills, fires, or explosions. However, during routine operations, PFP Facility workers would be protected from anticipated inhalation hazards by engineering controls, barriers, and personal protective devices, as appropriate. Conversely, direct external exposure to the gamma and neutron radiation from large amounts of plutonium is a concern. Direct external exposure is the only radiation hazard evaluated for PFP Facility workers under routine conditions in this EIS.

Under accident conditions routine worker protective devices are assumed to fail and lead to inhalation exposures. Because accidents are short-term events and resultant contamination can be cleaned up and controlled, use of the inhalation pathway to represent the magnitude of anticipated health effects to the PFP Facility workers in this EIS is

appropriate.

## **Exposures to Hanford Site Workers and the Public**

All exposures to Hanford Site workers and to the offsite public from routine releases or accidents depend on airborne emissions and transport of radionuclides away from the PFP Facility. Both of these groups are shielded from the large quantities of plutonium-bearing material by the thick concrete walls at the PFP Facility and are far enough away from the direct gamma and neutron radiation to be unaffected by it. Therefore, the inhalation pathway is the exposure pathway evaluated for these individuals and populations. Following an accidental release of radioactivity, much of the released activity could be cleaned up and controlled after it has been deposited on the ground, minimizing potential long-term impacts to ground and surface waters. The airborne materials initially dispersed during the accident may, however, be inhaled by downwind individuals. Thus, inhalation is also the exposure pathway bounding the accident consequences.

## **Health Effects from Ionizing Radiation Exposure**

Health effects from exposure to ionizing radiation depend on many complex and interrelated factors, including the total amount of radiation absorbed, the rate at which the exposure is received, the type and energy of radiation, and many specific body, cellular, and tissue response factors. To estimate potential health effects, extensive studies have been conducted by international scientific bodies on exposed populations to determine the likely results from exposures received. The complex factors involved in radiation damage to living organisms may include latency periods before effects from the exposure are observed, cellular damage repair mechanisms, and probabilistic likelihoods of localized cellular damage resulting in significant observable effects.

The International Commission on Radiological Protection has integrated the results of a vast body of scientific evidence on potential effects from exposure to ionizing radiation into a dose/response model specifically for predicting future effects from radiation doses (ICRP, 1991). The most important health effect from exposure to ionizing radiation is the potential for cancer to arise as a result of damage to the genetic material of a living cell. The probability of a cancer resulting from radiation is modeled to increase with increasing dose in a proportional manner, with no threshold for effects. The severity of the cancer is not affected by the dose received. This kind of effect is called "stochastic," meaning "of a random or statistical nature." Based on the body of evidence and models used, the International Commission on Radiological Protection has determined the corresponding cancer fatality probability coefficients relating dose received and resultant future latent cancer fatalities (LCF). These values for relating doses received and effects are  $4 \times 10^{-4}$  statistically predicted LCF per rem of dose absorbed by workers, and  $5 \times 10^{-4}$  LCF per rem of dose absorbed by members of the general public. In a statistical sense, the number of exposed individuals who receive a given dose (the exposed population) does not affect the fatality probability coefficients. That is, a given dose will result in a predicted number of fatalities whether the dose is received by one individual (rem) or a large population of individuals, each receiving smaller total doses (person-rem). Fatalities affect only individuals in the population (i.e., only whole integer numbers of people can die). The LCF probability coefficients and resultant predicted affects per exposure must, therefore, be interpreted as statistical predictions. The non-integer values are reported to allow comparisons among the alternatives.

## **Inhalation Model**

To quantify the dose received from exposure to airborne contaminants, the International Commission on Radiological Protection has developed a dosimetric model for the respiratory system, giving characteristics of the "standard man" for dose consequence modeling purposes (ICRP, 1975). The dosimetric lung model is used to relate the inhalation of radioactive materials, assumed to be aerosols (finely divided airborne particles of respirable size), to the dose received. The exposure of individuals to radioactive materials is controlled by evaluating and limiting the effective dose equivalent that could be received over a 50-year working-lifetime. The dosimetric lung model focuses on the target organs and determines the committed dose equivalent based on rates of elimination from body tissues, the number of nuclear transformations in the remaining source over the 50 years following intake of the radionuclide, and the amount of radiation received in other surrounding organs.

This model provides a basis for the dose conversion factors used to calculate the inhalation doses that may be received



during implementation of the alternatives evaluated in this EIS. The dose conversion factors used in this EIS are those provided in Federal Guidance Report No. 11 (Eckerman, et al., 1988). These factors relate the amount of plutonium inhaled in grams to the resulting 50-year committed effective dose equivalent in rem. That is, the dose is the total that will be received over a 50-year period following the intake into the body through inhalation during one year. Throughout this EIS, the inhalation doses are referred to in units of rem, meaning 50-year committed effective dose equivalents. The bounding (highest) dose factors for plutonium (lung retention Class W) are used to simplify the calculations and ensure that the projected consequences are bounding. See Table D-2 for the listing of the dose factors, isotopic weight percentages, and weighted dose conversion factors for each of the four inventory groups used to represent the plutonium-bearing materials in this EIS.

Applicable dispersion factors for quantification of routine and accident releases were taken from the PFP Final Safety Analysis Report (FSAR) (WHC, 1995a).

### **D.3 NORMAL CONDITION EXPOSURES FROM STABILIZATION OPERATIONS**

Exposures to radiation would result from normal operational activities for all of the alternatives evaluated in this EIS, including the no action alternative. The PFP Facility workers would be subject to direct external radiation exposures from proximity to the plutonium source material. They would be protected from inhalation hazards by engineered barriers, monitoring, and personal protective devices during routine operations. Routine releases of small quantities of plutonium from the PFP Facility stack during operations could contribute to doses to Hanford Site workers and the public. Potential exposures to each of these population groups are addressed in the following subsections.

#### **D.3.1 DIRECT RADIATION EXPOSURES TO PFP FACILITY WORKERS FROM ROUTINE OPERATIONS**

The actual external radiation doses that could be received by the PFP Facility workers during implementation of the alternatives described in this EIS would be affected by the length of time each individual is exposed to the plutonium source, its strength, their distance and shielding from the source, and the ambient radiation levels in the area. To facilitate a systematic comparison of the possible exposures to PFP Facility workers for the alternatives evaluated in this EIS, the exposure assessment presented in Subsection D.6 was prepared by analyzing personnel exposures received during an actual plutonium sludge stabilization program at the PFP Facility. The actual data were extrapolated to estimate exposures during each of the stabilization alternatives. The extrapolation was based on the physical characteristics of the materials being processed and the technologies involved, as described in the following paragraphs.

A sludge stabilization program was begun in 1994. Plutonium-bearing sludges were thermally stabilized in batches using muffle furnaces located in Rooms 230-A and 230-B of Building 234-5Z. Exposure to PFP Facility workers was measured using individual dosimetry. These data were used to estimate total exposure during the stabilization alternatives, as follows:

- The total exposure received by operators, laboratory technicians, managers, and radiological control technicians for the period of April, May, and June 1995 was 3 person-rem for processing sludge containing about 16 kilograms (kg) (35 pounds [lb]) of plutonium (WHC, 1995b)
- An average ambient background dose per shift was estimated based on assumptions of a standard crew, estimated average time spent in the process location, and typical ambient radiation levels in Rooms 230-A and 230-B.
- The ambient dose contribution was subtracted from the total exposure. The remaining exposure was attributed to the handling and processing of the plutonium sludges.

#### **Table D-2 Source Term Compositions and Inhalation Dose Conversion Factors for Inventory Groups**

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Isotope	Specific Activity	Inhalation Dose Factor	Nitrates and Chlorides		Oxides		Metals and Alloys		Polycubes and Combustibles	
	Ci/g	rem/g	wt%	DCF (rem/g)	wt%	DCF (rem/g)	wt%	DCF (rem/g)	wt%	DCF (rem/g)
Pu-238	1.71 x 10 <sup>-1</sup>	6.71 x 10 <sup>+9</sup>	2.02 x 10 <sup>-2</sup>	1.36 x 10 <sup>+6</sup>	2.33 x 10 <sup>-1</sup>	1.56 x 10 <sup>+7</sup>	5.60 x 10 <sup>-2</sup>	3.76 x 10 <sup>+6</sup>	1.61 x 10 <sup>-1</sup>	1.08 x 10 <sup>+7</sup>
Pu-239	6.21 x 10 <sup>-2</sup>	2.66 x 10 <sup>+7</sup>	9.23 x 10 <sup>+1</sup>	2.46 x 10 <sup>+7</sup>	7.85 x 10 <sup>+1</sup>	2.09 x 10 <sup>+7</sup>	8.02 x 10 <sup>+1</sup>	2.13 x 10 <sup>+7</sup>	8.05 x 10 <sup>+1</sup>	2.14 x 10 <sup>+7</sup>
Pu-240	2.28 x 10 <sup>-1</sup>	9.73 x 10 <sup>+7</sup>	6.84	6.66 x 10 <sup>+6</sup>	1.65 x 10 <sup>+1</sup>	1.61 x 10 <sup>+7</sup>	1.64 x 10 <sup>+1</sup>	1.60 x 10 <sup>+7</sup>	1.69 x 10 <sup>+1</sup>	1.64 x 10 <sup>+7</sup>
Pu-241	1.03 x 10 <sup>+2</sup>	8.50 x 10 <sup>+8</sup>	3.19 x 10 <sup>-1</sup>	2.71 x 10 <sup>+6</sup>	1.40	1.19 x 10 <sup>+7</sup>	1.02	8.67 x 10 <sup>+6</sup>	1.10	9.35 x 10 <sup>+6</sup>
Pu-242	3.92 x 10 <sup>-3</sup>	1.61 x 10 <sup>+6</sup>	5.01 x 10 <sup>-2</sup>	8.07 x 10 <sup>+2</sup>	6.71 x 10 <sup>-1</sup>	1.08 x 10 <sup>+4</sup>	5.90 x 10 <sup>-1</sup>	9.50 x 10 <sup>+3</sup>	5.70 x 10 <sup>-1</sup>	9.18 x 10 <sup>+3</sup>
Am-241	3.43	1.52 x 10 <sup>+9</sup>	4.98 x 10 <sup>-1</sup>	7.57 x 10 <sup>+6</sup>	2.72	4.13 x 10 <sup>+7</sup>	1.68	2.55 x 10 <sup>+7</sup>	7.56 x 10 <sup>-1</sup>	1.15 x 10 <sup>+7</sup>
Totals			1.00 x 10 <sup>+2</sup>	4.28 x 10 <sup>+7</sup>	1.00 x 10 <sup>+2</sup>	1.06 x 10 <sup>+8</sup>	9.99 x 10 <sup>+1</sup>	7.53 x 10 <sup>+7</sup>	1.00 x 10 <sup>+2</sup>	6.95 x 10 <sup>+7</sup>

**Notes:**a. Inhalation dose conversion factors from Eckerman, et al., 1988.

Ci =curies

g =grams

wt% =weight percent

DCF =dose conversion factor

The foregoing steps resulted in a unit exposure factor of 0.053 millirem per gram of plutonium processed. The unit exposure factor was adjusted to correct for differing isotopic compositions of the four inventory groups. This was accomplished separately for both the neutron and gamma radiation contributions to the total dose rate per gram of material handled. For alternatives involving multiple processes, the unit exposure factor was adjusted to reflect the additional handling steps. A total exposure attributed to the plutonium source was calculated by applying the adjusted unit exposure factor (millirem per gram [millirem/g]) to the quantity of plutonium to be processed in the given inventory group presented in Section 3 of this EIS. Ambient background exposure was calculated by applying the average ambient dose rate to the total person-hours required to process the inventory group. Additional exposure was added to each process to account for handling activities following processing that were not included in the personnel exposure totals used to calculate the unit exposure factor. The total exposure for a particular alternative was calculated by summing the contributions from the source, ambient background, and additional handling activities.

Table D-3 provides a summary of estimated personnel exposure resulting from the extrapolated analysis discussed above. The assumptions and supporting documentation for this summary are included in Subsection D.6. The calculation for batch thermal stabilization of oxides, fluorides, and process residues was used to establish unit exposure rates since this process is most similar to the sludge stabilization process actually performed. The results of this calculation were extrapolated to the other alternatives as shown in Subsection D.6.

The external direct radiation exposure assessment presented here was accomplished using a number of assumptions to simplify the analysis. Therefore, the calculated exposure values should be considered only as bounding the anticipated results under the conditions assumed. The actual doses received are anticipated to be significantly lower than those presented, based on the administrative requirements and engineering controls imposed during actual processing. While the calculated exposures provide only conservative estimates of total dose, they can be used to compare the relative exposure from each of the alternatives because the simplifying assumptions were applied consistently to each alternative.

### D.3.2 RADIATION EXPOSURES TO HANFORD SITE WORKERS AND THE PUBLIC FROM ROUTINE OPERATIONS

As described in Sections 3 and 5 of this EIS, conservative estimates of the airborne releases from each of the stabilization process steps have been estimated for purposes of comparing alternatives and bounding the anticipated consequences of stabilization activities at the PFP Facility. These releases from the plutonium stabilization processes will be filtered through the main PFP Facility ventilation system before being released to the atmosphere through the main exhaust stack. After discharge from the stack, atmospheric dispersion will affect the concentrations of released activity. The applicable dispersion factors for quantifying the concentrations of radioactivity at the receptor locations were calculated using the 1983 to 1987 historical data collected at the Hanford Meteorological Station, as described in Subsections 3.3.4 and 8.6.2 of the PFP FSAR (WHC, 1995a). The elevated release dispersion factors used in this EIS for routine release are tabulated in Table D-4.

**Table D-3 Summary of Personnel Exposure Estimates**

Alternative	Inventory (kg Pu)	Total Emissions (g PuO <sub>2</sub> ) <sup>a</sup>	Total Exposure (Person-rem) <sup>b</sup>	LCF <sub>c</sub>
Preferred Alternative	.	.	.	.
Plutonium-bearing Solutions Ion Exchange/Vertical Calciner/Thermal Stabilization	337.4	0.037	86	0.034
Oxides, Fluorides and Process Residues Thermal Stabilization Using a Continuous Furnace	2417	0.27	450	0.18
Metals and Alloys Repackaging	770	0.0049	180	0.072
Polycubes and Combustibles Pyrolysis	35	0.0053	15	0.0060
<b>Total for Preferred Alternative</b>	.	.	<b>730</b>	<b>0.29</b>
Plutonium-bearing Solutions Alternative	.	.	.	.
Hydroxide Precipitation with Thermal Stabilization	337.4	0.037	85	0.034

Oxides, Fluorides, and Process Residues Alternative	.	.	.	.
Batch Thermal Stabilization	2417	0.27	640	0.26
Metals and Alloys Alternative	.	.	.	.
Batch Thermal Stabilization	770	0.17	320	0.13
Polycubes and Combustible Alternatives	.	.	.	.
Batch Thermal Stabilization with Secondary Combustion Chamber	35	0.064	29	0.012
Molten Salt Oxidation	35	0.038	19	0.0076

**Notes:** a. Total projected emissions from the PFP Facility stack during routine operations (see Appendix B)

b. Total exposure does not include exposure associated with future repackaging to meet the DOE storage standard (DOE, 1994a)

c. One person-rem is equivalent to  $4 \times 10^{-4}$  LCF for PFP Facility and Hanford Site workers (ICRP, 1991)

**Table D-4 Atmospheric Dispersion Factors for Routine Releases from the Main PFP Facility Stack**

200 foot elevated release C/Q (sec/m <sup>3</sup> )	.	.	.	.	.	.	.	.
Sector	1	2	3	4	5	6	7	8
Ring 1	1.51 x 10 <sup>-7</sup>	9.78 x 10 <sup>-8</sup>	8.52 x 10 <sup>-8</sup>	6.96 x 10 <sup>-8</sup>	8.66 x 10 <sup>-8</sup>	9.38 x 10 <sup>-8</sup>	5.74 x 10 <sup>-8</sup>	4.42 x 10 <sup>-8</sup>
Ring 2	8.97 x 10 <sup>-8</sup>	5.69 x 10 <sup>-8</sup>	4.49 x 10 <sup>-8</sup>	3.85 x 10 <sup>-8</sup>	5.35 x 10 <sup>-8</sup>	4.91 x 10 <sup>-8</sup>	4.88 x 10 <sup>-8</sup>	3.61 x 10 <sup>-8</sup>
Ring 3	6.52 x 10 <sup>-8</sup>	4.05 x 10 <sup>-8</sup>	3.17 x 10 <sup>-8</sup>	2.78 x 10 <sup>-8</sup>	4.02 x 10 <sup>-8</sup>	3.87 x 10 <sup>-8</sup>	3.97 x 10 <sup>-8</sup>	3.08 x 10 <sup>-8</sup>
Ring 4	4.87 x 10 <sup>-8</sup>	2.98 x 10 <sup>-8</sup>	2.33 x 10 <sup>-8</sup>	2.08 x 10 <sup>-8</sup>	3.06 x 10 <sup>-8</sup>	3.00 x 10 <sup>-8</sup>	3.15 x 10 <sup>-8</sup>	2.51 x 10 <sup>-8</sup>
Ring 5	3.82 x 10 <sup>-8</sup>	2.32 x 10 <sup>-8</sup>	1.82 x 10 <sup>-8</sup>	1.63 x 10 <sup>-8</sup>	2.43 x 10 <sup>-8</sup>	2.40 x 10 <sup>-8</sup>	2.57 x 10 <sup>-8</sup>	2.08 x 10 <sup>-8</sup>
Ring 6	2.23 x 10 <sup>-8</sup>	1.33 x 10 <sup>-8</sup>	1.05 x 10 <sup>-8</sup>	9.51 x 10 <sup>-8</sup>	1.45 x 10 <sup>-8</sup>	1.44 x 10 <sup>-8</sup>	1.60 x 10 <sup>-8</sup>	1.32 x 10 <sup>-8</sup>
Ring 7	1.01 x 10 <sup>-8</sup>	5.92 x 10 <sup>-9</sup>	4.71 x 10 <sup>-9</sup>	4.32 x 10 <sup>-9</sup>	6.69 x 10 <sup>-9</sup>	6.70 x 10 <sup>-9</sup>	7.69 x 10 <sup>-9</sup>	6.53 x 10 <sup>-9</sup>
Ring 8	5.52 x	3.21 x	2.56 x	2.36 x	3.68 x	3.69 x	4.32 x	3.71 x

	10-9	10-9	10-9	10-9	10-9	10-9	10-9	10-9
Ring 9	3.68 x 10-9	2.13 x 10-9	1.71 x 10-9	1.58 x 10-9	2.47 x 10-9	2.47 x 10-9	2.92 x 10-9	2.53 x 10-9
Ring 10	2.71 x 10-9	1.57 x 10-9	1.26 x 10-9	1.17 x 10-9	1.83 x 10-9	1.82 x 10-9	2.17 x 10-9	1.88 x 10-9
200 foot elevated release C/Q (sec/m3)	.	.	.	.	.	.	.	.
Sector	9	10	11	12	13	14	15	16
Ring 1	4.84 x 10-8	3.70 x 10-8	4.76 x 10-8	4.90 x 10-8	5.67 x 10-8	6.44 x 10-8	1.09 x 10-7	1.01 x 10-7
Ring 2	4.21 x 10-8	2.86 x 10-8	3.51 x 10-8	4.49 x 10-8	7.31 x 10-8	9.10 x 10-8	1.04 x 10-7	7.48 x 10-8
Ring 3	3.66 x 10-8	2.48 x 10-8	3.08 x 10-8	4.09 x 10-8	6.98 x 10-8	8.27 x 10-8	8.61 x 10-8	5.77 x 10-8
Ring 4	3.01 x 10-8	2.05 x 10-8	2.57 x 10-8	3.48 x 10-8	6.02 x 10-8	6.89 x 10-8	6.89 x 10-8	4.46 x 10-8
Ring 5	2.51 x 10-8	1.75 x 10-8	2.17 x 10-8	2.97 x 10-8	5.17 x 10-8	5.78 x 10-8	5.64 x 10-8	3.58 x 10-8
Ring 6	1.61 x 10-8	1.13 x 10-8	1.44 x 10-8	2.01 x 10-8	3.50 x 10-8	3.75 x 10-8	3.54 x 10-8	2.18 x 10-8
Ring 7	8.01 x 10-9	5.75 x 10-9	7.35 x 10-9	1.05 x 10-8	1.82 x 10-8	1.87 x 10-8	1.72 x 10-8	1.03 x 10-8
Ring 8	4.56 x 10-9	3.32 x 10-9	4.26 x 10-9	6.12 x 10-9	1.06 x 10-8	1.07 x 10-8	9.69 x 10-9	5.77 x 10-9
Ring 9	3.11 x 10-9	2.28 x 10-9	2.93 x 10-9	4.23 x 10-9	7.34 x 10-9	7.27 x 10-9	6.57 x 10-9	3.90 x 10-9
Ring 10	2.32 x 10-9	1.71 x 10-9	2.20 x 10-9	3.19 x 10-9	5.52 x 10-9	5.43 x 10-9	4.89 x 10-9	2.89 x 10-9

**Source:** Table 3-8, PFP FSAR (WHC, 1995a)

**Notes:** sec/m3 = seconds per cubic meter

The population distribution in an 80-kilometer (km) (50-mile [mi]) radius around the PFP Facility is coupled with the atmospheric dispersion factors to calculate a population dose from the routine releases projected. The population distribution projected in the PFP FSAR for the year 1997 and used in this EIS is shown in Figure D-1 and tabulated in Table D-5. The total population within 80 km (50 mi) of the PFP Facility in 1997 is projected to be 352,514. Tables D-6 and D-7 show the details concerning the sectors and rings used in this analysis.

**Table D-5 Projected 1997 Resident Population Distribution in 16 Compass Sectors and 10**

## Radial Rings to 50 Miles Around the PFP Facility

Population distribution (persons/segment)	.	.	.	.	.	.	.	.
Sector	1	2	3	4	5	6	7	8
Ring 1	0	0	0	0	0	0	0	0
Ring 2	0	0	0	0	0	0	0	0
Ring 3	0	0	0	0	0	0	0	0
Ring 4	0	0	0	0	0	0	0	0
Ring 5	0	0	0	0	0	0	0	0
Ring 6	0	0	0	5	33	0	0	0
Ring 7	1,580	936	1,230	1,900	670	459	574	254
Ring 8	1,540	5,460	20,500	5,240	981	829	412	472
Ring 9	202	674	2,260	15,600	7,110	861	510	894
Ring 10	1,860	133	475	4,730	81,300	2,930	1,500	4,680
Population distribution	.	.	.	.	.	.	.	.
Sector	9	10	11	12	13	14	15	16
Ring 1	0	0	0	0	0	0	0	0
Ring 2	0	0	0	0	0	0	0	0
Ring 3	0	0	0	0	0	0	0	0
Ring 4	0	0	0	0	0	0	0	0
Ring 5	0	0	0	0	0	0	0	0
Ring 6	0	0	0	0	0	0	0	0
Ring 7	180	95	271	243	352	293	6,990	2,070
Ring 8	1,160	678	6,130	799	1,370	1,420	50,300	13,600
Ring 9	798	5,740	3,060	2,450	1,720	238	52,200	2,810
Ring 10	2,020	15,300	616	450	608	674	3,590	5,400

Source: Figure 3-6b, PFP FSAR (WHC, 1995a)

.	.	.	.	.	.	Total
Ring km	0-16	16-32	32-48	48-64	64-80	0-80

mi						
	(0-10)	(10-20)	(20-30)	(30-40)	(40-50)	(0-50)
Population	38	18,098	110,898	97,164	126,316	352,514

[Figure D-1. Projected Distribution of Population within an 80-km \(50-mi\) Radius \(from Figure 3-6b, PFP FSAR \[WHC, 1995a\]\)](#)

**Table D-6 Ring Distances from the PFP Facility for the 16 Directional Sectors**

Ring Number	Location (mi)	Ring midpoint (mi)	(km)
1	0.0 - 1.0	0.5	0.81
2	1.0 - 2.0	1.5	2.4
3	2.0 - 3.0	2.5	4.0
4	3.0 - 4.0	3.5	5.6
5	4.0 - 5.0	4.5	7.2
6	5.0 - 10.0	7.5	12.0
7	10.0 - 20.0	15.0	24.0
8	20.0 - 30.0	25.0	40.0
9	30.0 - 40.0	35.0	56.0
10	40.0 - 50.0	45.0	72.0

Source: Table 3-6, PFP FSAR (WHC, 1995a)

**Table D-7 Midpoints of 16 Sectors, Each 22.5° Wide**

Sector number	Sector midpoint Degrees	Compass
1	180.0	S
2	202.5	SSW
3	225.0	SW
4	247.5	WSW
5	270.0	W

6	292.5	WNW
7	315.0	NW
8	337.5	NNW
9	0.0	N
10	22.5	NNE
11	45.0	NE
12	67.5	ENE
13	90.0	E
14	112.5	ESE
15	135.0	SE
16	157.5	SSE

**Source:** Table 3-7, PFP FSAR (WHC, 1995a)

The locations that would give the highest potential doses for onsite and site-boundary receptors have been calculated in the PFP FSAR for annual average meteorological conditions and routine releases to ensure that no population group would be likely to receive doses greater than those presented. For the elevated releases (releases from the PFP Facility stack), the 272-WA Facility located 0.63 km (0.39 miles) west-northwest of the PFP Facility has the highest annual average dispersion factor (least dispersion) and was used as the representative location of exposed Hanford Site workers. The C/Q value there is  $9.38 \times 10^{-8}$  seconds per cubic meter (sec/m<sup>3</sup>) (WHC, 1995a). To represent the magnitude of doses that could be received by this population group, it was assumed that five Hanford Site workers would spend an entire year at that worst location with no respiratory protective devices.

The maximally exposed offsite individual is hypothetically assumed to reside for the entire year at the location of the highest dispersion factor at the boundary. For the elevated release, this point is located 25 km (16 mi) east of the PFP Facility. The C/Q value there is  $1.75 \times 10^{-8}$  sec/m<sup>3</sup> (WHC, 1995a).

The basic equation for calculating the population dose is:

$$PD = \sum_i Q_i \times (C/Q)_i \times ABR \times DCF \times (AP)_i$$

where:

PD = Population Dose in person-rem (Effective Dose Equivalent) for the population being evaluated. The 80-km (50-mi) radius population dose presented in this EIS is the sum of the population doses for each of the 160 segments (16 compass sectors times 10 radial rings out to 80 km [50 mi]) within 80 km (50 mi) of the PFP Facility.

Q = The total quantity of plutonium in grams released by the various alternative processes, as described in Section 3 and Appendix B of this EIS.

(C/Q)<sub>i</sub> = The atmospheric dispersion factor at the "ith" location in sec/m<sup>3</sup>.

ABR = The average annual breathing rate of  $2.66 \times 10^{-4}$  m<sup>3</sup>/sec, based on the recommendations of the International Commission Radiological Protection.



DCF = The dose conversion factor for the isotopic mix of radionuclides released from the stack.

(AP)<sub>i</sub> = The applicable population at the location being evaluated.

The population doses presented are conservative because the estimated releases from each of the stabilization processes were purposely selected from the upper end of their expected ranges to ensure that the consequences presented bound the actual anticipated values. Table D-8 shows the results of the population dose calculation by segment for stabilization of the plutonium-bearing solutions. This distribution is typical of that obtained for all of the alternatives evaluated, although the magnitudes are scaled to match the actual quantities estimated to be released.

**Table D-8 Population Dose Distribution for Stabilization of Plutonium-bearing Solutions at the PFP Facility**

Population dose(person-rem/segment)Elevated Release	.	.	.	.	.	.	.	.	.
Sector	1	2	3	4	5	6	7	8	9
Ring 1	0	0	0	0	0	0	0	0	0
Ring 2	0	0	0	0	0	0	0	0	0
Ring 3	0	0	0	0	0	0	0	0	0
Ring 4	0	0	0	0	0	0	0	0	0
Ring 5	0	0	0	0	0	0	0	0	0
Ring 6	0	0	0	2.0 x 10 <sup>-4</sup>	2.0 x 10 <sup>-4</sup>	0	0	0	0
Ring 7	6.8 x 10 <sup>-3</sup>	2.3 x 10 <sup>-3</sup>	2.4 x 10 <sup>-3</sup>	3.5 x 10 <sup>-3</sup>	1.9 x 10 <sup>-3</sup>	1.3 x 10 <sup>-3</sup>	1.9 x 10 <sup>-3</sup>	7.0 x 10 <sup>-4</sup>	6.1 x 10 <sup>-4</sup>
Ring 8	3.6 x 10 <sup>-3</sup>	7.4 x 10 <sup>-3</sup>	2.2 x 10 <sup>-2</sup>	5.2 x 10 <sup>-3</sup>	1.5 x 10 <sup>-3</sup>	1.3 x 10 <sup>-3</sup>	7.5 x 10 <sup>-4</sup>	7.4 x 10 <sup>-4</sup>	2.2 x 10 <sup>-3</sup>
Ring 9	3.1 x 10 <sup>-4</sup>	6.1 x 10 <sup>-4</sup>	1.6 x 10 <sup>-3</sup>	1.0 x 10 <sup>-2</sup>	7.4 x 10 <sup>-3</sup>	9.0 x 10 <sup>-4</sup>	6.3 x 10 <sup>-4</sup>	9.6 x 10 <sup>-4</sup>	1.0 x 10 <sup>-3</sup>
Ring 10	2.1 x 10 <sup>-3</sup>	8.8 x 10 <sup>-5</sup>	2.5 x 10 <sup>-4</sup>	2.3 x 10 <sup>-3</sup>	6.3 x 10 <sup>-2</sup>	2.3 x 10 <sup>-3</sup>	1.4 x 10 <sup>-3</sup>	3.7 x 10 <sup>-3</sup>	2.0 x 10 <sup>-3</sup>
Totals	1.3 x 10 <sup>-2</sup>	1.0 x 10 <sup>-2</sup>	2.6 x 10 <sup>-2</sup>	2.2 x 10 <sup>-2</sup>	7.4 x 10 <sup>-2</sup>	5.7 x 10 <sup>-3</sup>	4.6 x 10 <sup>-3</sup>	6.1 x 10 <sup>-3</sup>	5.9 x 10 <sup>-3</sup>
Population dose	.	.	.	.	.	.	.	.	.
Sector	10	11	12	13	14	15	16	Totals by Ring	.
Ring 1	0	0	0	0	0	0	0	0 (person-rem)	.
Ring 2	0	0	0	0	0	0	0	0 (person-	.

								rem)	
Ring 3	0	0	0	0	0	0	0	0 (person-rem)	.
Ring 4	0	0	0	0	0	0	0	0 (person-rem)	.
Ring 5	0	0	0	0	0	0	0	0 (person-rem)	.
Ring 6	0	0	0	0	0	0	0	4.0 x 10 <sup>-4</sup> (person-rem)	.
Ring 7	2.3 x 10 <sup>-4</sup>	8.4 x 10 <sup>-4</sup>	1.1 x 10 <sup>-3</sup>	2.7 x 10 <sup>-3</sup>	2.3 x 10 <sup>-3</sup>	5.1 x 10 <sup>-2</sup>	9.0 x 10 <sup>-3</sup>	8.8 x 10 <sup>-2</sup> (person-rem)	.
Ring 8	9.5 x 10 <sup>-4</sup>	1.1 x 10 <sup>-2</sup>	2.1 x 10 <sup>-3</sup>	6.2 x 10 <sup>-3</sup>	6.4 x 10 <sup>-3</sup>	2.1 x 10 <sup>-1</sup>	3.3 x 10 <sup>-2</sup>	3.1 x 10 <sup>-1</sup> (person-rem)	.
Ring 9	5.5 x 10 <sup>-3</sup>	3.8 x 10 <sup>-3</sup>	4.4 x 10 <sup>-3</sup>	5.3 x 10 <sup>-3</sup>	7.3 x 10 <sup>-4</sup>	1.4 x 10 <sup>-1</sup>	4.6 x 10 <sup>-3</sup>	1.9 x 10 <sup>-1</sup> (person-rem)	.
Ring 10	1.1 x 10 <sup>-2</sup>	5.7 x 10 <sup>-4</sup>	6.1 x 10 <sup>-4</sup>	1.4 x 10 <sup>-3</sup>	1.5 x 10 <sup>-3</sup>	7.4 x 10 <sup>-3</sup>	6.6 x 10 <sup>-3</sup>	1.1 x 10 <sup>-1</sup> (person-rem)	.
Totals	1.8 x 10 <sup>-2</sup>	1.6 x 10 <sup>-2</sup>	8.1 x 10 <sup>-3</sup>	1.6 x 10 <sup>-2</sup>	1.1 x 10 <sup>-2</sup>	4.1 x 10 <sup>-1</sup>	5.3 x 10 <sup>-2</sup>	7.0 x 10 <sup>-1</sup> (person-rem)	.

Table D-9 presents a summary of the results of the maximum individuals and population dose calculations for each of the four preferred alternative inventory groups.

**Table D-9 Summary of Population Doses for Preferred Stabilization Alternatives**

Receptor(s)	Solutions	Oxides	Metals	Polycubes	Totals
Hanford Site worker population dose (5 workers) (person-rem)	2.0 x 10 <sup>-4</sup>	3.6 x 10 <sup>-3</sup>	4.6 x 10 <sup>-5</sup>	4.6 x 10 <sup>-5</sup>	3.9 x 10 <sup>-3</sup>
Maximum Site Boundary Individual (rem)	7.4 x 10 <sup>-6</sup>	1.3 x 10 <sup>-4</sup>	1.7 x 10 <sup>-6</sup>	1.7 x 10 <sup>-6</sup>	1.5 x 10 <sup>-4</sup>
80-km radium population dose (person-rem)	7.0 x 10 <sup>-1</sup>	1.3 x 10 <sup>1</sup>	1.6 x 10 <sup>-1</sup>	1.6 x 10 <sup>-1</sup>	1.4 x 10 <sup>1</sup>
Hanford Site worker (LCF)	7.9 x 10 <sup>-8</sup>	1.4 x 10 <sup>-6</sup>	1.9 x 10 <sup>-8</sup>	1.8 x 10 <sup>-8</sup>	1.6 x 10 <sup>-6</sup>
Public (LCF)	3.5 x 10 <sup>-4</sup>	6.4 x 10 <sup>-3</sup>	8.2 x 10 <sup>-5</sup>	8.1 x 10 <sup>-5</sup>	6.9 x 10 <sup>-3</sup>

#### D.4 NORMAL CONDITION EXPOSURE FROM REMOVAL OPERATIONS

Radiation exposure to PFP Facility workers during plutonium removal activities is estimated for the purpose of comparison among the alternatives. To simplify the estimating process, because no directly applicable data from actual removal activities are available, a number of assumptions regarding dose rate and productivity have been made. The doses calculated based on these assumptions are expected to be conservative. The actual doses to these PFP Facility workers are expected to be much lower.

The actual dose is affected by the radiation source, the amount of time each individual is exposed to the source, the distance and shielding from the source, and the ambient radiation level in the working area. To quantify the magnitudes of exposures that may be involved, radiation exposure is estimated for the removal of readily retrievable plutonium from the ductwork, piping, gloveboxes, and Plutonium Reclamation Facility (PRF) canyon based on conservative estimates of actual conditions that may be encountered during removal activities. A summary of the total PFP Facility worker dose estimates for the removal of readily retrievable plutonium is shown in Table D-10.

Because the routine removal activities themselves do not involve any high energy sources (such as explosives, steam, high temperature, compressed gases) that could widely disperse the plutonium being removed, it is postulated that all releases will be confined inside the PFP Facility. Airborne releases from normal removal operation will be filtered through the Facility high efficiency particulate air (HEPA) filters before discharge, reducing the activities and any resultant exposures to levels orders of magnitude below those of concern. Therefore, no impacts are postulated to any Hanford Site workers or the public from routine removal activities. Any exposures from routine releases from stabilization of removed plutonium-bearing materials will be bounded by those presented for the stabilization alternatives and are not separately calculated.

**Table D-10 PFP Facility Worker Doses From the Removal of Plutonium in the PFP Facility**

Activities	Routine PFP Facility Worker Dose (person-rem)
Plutonium Removal from the E-4 Ventilation System Ductwork	130
Plutonium Removal from the Process Vacuum System Piping	56
Plutonium Removal from the Gloveboxes	5.1
Plutonium Removal from the PRF Canyon	1.0
Thermal Stabilization of Removed Plutonium	7.9
Total	200

#### **D.4.1 DOSE RECEIVED DURING REMOVAL OF HOLD-UP MATERIAL FROM DUCTWORK**

Approximately 6 kg (13 lb) of plutonium is contained in about 1,200 meters (m) (3,960 feet [ft]) of the E-4 exhaust system ductwork (WHC, 1995a). The bulk of the plutonium is held up in about 100 m (330 ft) of ducting. Ductwork remediation in fiscal year 1996 is expected to account for removal of about 4 kg (8.8 lb) of plutonium (DOE, 1994b). The remainder of the plutonium (about 2 kg or 4.4 lb) is held up in about 70 m (230 ft) of ducting. A "reasonable" scenario for removing the plutonium would be:

- a. Using non-destructive assay probes to characterize the ducts.
- b. Using mechanical and circular saws to cut the ducts into 0.75 m (2.5 ft) sections and moving the duct sections to a maintenance glovebox for plutonium removal.
- c. Using a scraper to remove plutonium from each duct section.

- d. Using a wiping or washing method to decontaminate the duct sections.

The total PFP Facility worker dose during these steps is calculated by assuming that:

- The dose received by the workers while performing characterization is negligible because the duration is expected to be short and probes may be used remotely by attaching them to long extension handles.
- A crew of four will perform the work. The two operators would receive dose from the source. The crew lead and the health physics technician would receive only ambient dose.
- It takes six hours to set up the greenhouse for cutting.
- Two segments may be cut per greenhouse set-up.
- Segmenting is performed at the rate of one section for every three hours (or two segments per shift, accounting for shift transitions). This duration includes the time it takes to set up cutting equipment, make the cut, and package the segment in a shielded drum.
- During segmenting, the crew lead and the health physics technician are assumed to receive exposure at an ambient dose rate of <2 millirem per hour (millirem/hr). The operators are assumed to receive exposure at a bounding dose rate of less than 100 millirem/hr. If shielding and other means can not achieve a dose rate of less than 100 millirem/hr, then remote cutting methods would be used.
- The dose received while transporting the drum to the maintenance glovebox is minimal because the distance is not very long and the drums would be shielded, if necessary.
- Scraping to remove plutonium and decontaminating duct sections are performed at the rate of two hours per segment.
- During plutonium removal and decontamination, the crew lead and the health physics technician are assumed to receive exposure at an ambient dose rate of 2 millirem/hr. The two operators are assumed to receive exposure at the rate of 40 millirem/hr. This rate is based on past radiation surveys of plutonium handling gloveboxes (WHC, 1995c).

Based on these estimates and assumptions, the total PFP Facility worker dose expected to be incurred during the removal of readily retrievable plutonium from the ductwork is calculated to be 130 person-rem.

#### **D.4.2 DOSE RECEIVED DURING REMOVAL OF HOLD-UP MATERIAL FROM PIPING**

Because the piping and ductwork are similar in shape, the removal process and assumptions for the removal of 4.3 kg (9.5 lb) of plutonium from the 30 m (98 ft) of piping (WHC, 1995a) would be similar to those for the ductwork. The total dose incurred for the removal of plutonium from the piping is estimated to be 56 person-rem.

#### **D.4.3 DOSE RECEIVED DURING REMOVAL OF HOLD-UP MATERIAL FROM GLOVEBOXES**

Approximately 31 kg (68 lb) of plutonium is held up in over 150 gloveboxes and hoods in the PFP Facility (WHC, 1995a). An inventory of the plutonium indicates that over 90 percent of the total plutonium held up is associated with 25 gloveboxes. Removal actions would be focused on these 25 gloveboxes to maximize plutonium recovery while minimizing personnel exposures and costs. A "reasonable" scenario for removing the plutonium would be:

- a. Using non-destructive assay probes to characterize the gloveboxes.
- b. Using a scraper or wire brush to remove plutonium.
- c. Using a wiping or washing method to decontaminate the equipment used for removal.

The PFP Facility worker dose received during these steps is calculated by assuming that:

- The dose received by the workers during characterization is negligible because the duration is expected to be short.
- A crew of four will perform the work. One operator would receive a dose from the source (approximately 40 millirem/hr). The other three crew members would receive only an ambient dose (less than 2 millirem/hr). These

- values are based on a past radiation survey of the gloveboxes and the surrounding areas (WHC, 1995c).
- Based on process knowledge and visual observation, most of the plutonium is determined to be on the floor of the gloveboxes. The total floor area for all gloveboxes is estimated at 110 square meters (m<sup>2</sup>) (1,200 square feet [ft<sup>2</sup>]).
- Removal rate is estimated at 1 m<sup>2</sup>/hr (11 ft<sup>2</sup>/hr). This is reasonable for using a scraping tool.

Based on these estimates and assumptions, the total PFP Facility worker dose expected to be incurred during the removal of readily retrievable plutonium from the gloveboxes is calculated to be 5.1 person-rem.

#### **D.4.4 DOSE RECEIVED DURING REMOVAL OF HOLD-UP MATERIAL FROM PRF CANYON**

Over the years, approximately 12.5 kg (27.5 lb) of plutonium has accumulated on the PRF canyon floor (WHC, 1995a). The high radiation level in the canyon may prohibit personnel entry into the canyon to perform work in the future. Thus, remote technologies are considered applicable for the removal of this plutonium. A "reasonable" scenario for removing the plutonium would be:

a. Using the mobile automated characterization system for characterization of the canyon floor.

b. Using laser ablation and vacuum units mounted on a robotics system such as the Dual-Arm Work Module/Selective Equipment Removal System/Rosie (Red Zone Robotics, Inc.) to move equipment currently on the floor of the canyon, remove and collect the deposited plutonium using the vacuum, and self-decontaminate the removal equipment.

The workers (a crew of four) would remain outside the canyon during this operation and therefore would experience only ambient dose rates (<2 millirem/hr).

The PFP Facility worker dose received during plutonium removal and equipment decontamination is calculated by assuming that:

- It takes two weeks to set up the robotics systems prior to placing them in the canyon.
- The total surface area of the canyon floor includes the floor area of 15.8 x 9.8 m (52 x 32 ft) and the surface area of the floor grids of 0.9 x 0.9 x 0.1 m deep (3 x 3 x 0.3 ft).
- The total surface area of the removal equipment requiring self-decontamination is based on the largest piece of equipment, Rosie, 2 x 2.9 x 1.1 m (6.5 x 9.5 x 3.5 ft). The surface areas of the other equipment are expected to be less than that of Rosie.
- Based on past experience with lasers, the removal rate is expected to be 0.2 to 0.4 m<sup>2</sup> (2 to 4 ft<sup>2</sup>) per hour (WHC, 1992).

Based on these estimates and assumptions, the total PFP Facility worker dose expected to be incurred during the removal of readily retrievable plutonium from the PRF canyon floor is estimated to be approximately 1 person-rem.

#### **D.4.5 DOSE RECEIVED DURING STABILIZATION OF THE REMOVED HOLD-UP MATERIAL**

It is assumed that the removed plutonium would be stabilized using a thermal stabilization method. The PFP Facility worker dose incurred during the stabilization is calculated using the following assumptions:

- The total plutonium hold-up to be removed from the ductwork, piping, gloveboxes, and PRF canyon is 42 kg (92 lb). The overall removal efficiency is assumed to be 90 percent.
- Previous calculations of worker exposure during thermal stabilization indicate that 0.19 person-rem is incurred for every kilogram (kg) (2.2 lbs) of plutonium stabilized.

Based on the above estimates and assuming a linear relationship of dose per mass of plutonium processed, the total PFP Facility worker dose during stabilization of the removed plutonium is estimated to be 7.9 person-rem.

### **D.5 ACCIDENT CONDITION EXPOSURES DURING STABILIZATION AND REMOVAL**

## OPERATIONS

This section evaluates the health effects that could occur from potential accidents involving the PFP Facility. These accidents could be initiated by operational events or natural phenomena. Operational events include human error and the physical failure of components and equipment. Natural phenomena involve an earthquake or other catastrophic event.

### D.5.1 OPERATIONAL EVENT ACCIDENT ANALYSIS

The methodology used to evaluate the health effects from an operational event is based on a fire or explosion occurring during routine stabilization alternative operations or drop of a duct segment during removal activities. For example, an explosion occurring during a glovebox operation could over-pressurize the glovebox and result in the release of plutonium and americium to the room and exhaust system. Another example would be a fire breaching a glovebox, resulting in a plutonium and americium release to the room and exhaust system. It is important to note that for all accident scenarios, it is assumed that the main release stack ventilation filters stay in place and that all contamination releases are confined to the room and exhaust system. None of the bounding accident events will be energetic enough to cause a failure of the main filtration system, resulting in an unfiltered release from the PFP Facility into the environment.

The analysis of the stabilization alternatives begins by estimating the amount of plutonium-bearing material that can escape the glovebox. The quantity released during the accident is calculated by determining the total mass (in grams) of each isotope that will be involved (at risk) at the time of the accident. Each isotope's mass is then multiplied by the percent released into the atmosphere (i.e., atmospheric entrainment) to give the mass that is actually airborne. The respirable mass, or amount available for intake, is then found by multiplying the mass airborne by the respirable fraction (particles less than 10 microns). An appropriate factor to account for the fraction of material escaping from the glovebox or other confinement is then applied.

The volume of air available for mixing with the release from the glovebox in the room outside the glovebox is then divided into the respirable mass to determine the respirable air concentration for PFP Facility workers. For individuals outside the facility, the respirable mass that passes the HEPA filters is multiplied by the applicable atmospheric dispersion factor. This gives the concentration of radionuclides that will be available for intake by the individual immediately following an operational accident.

The impacts from the accidents analyzed are quantified by applying conservatively derived factors as described in this section. Use of the conservative factors results in definition of the "maximally exposed individual." The results of the accidents presented in this EIS are based on the maximally exposed individuals in three categories: 1) the involved PFP Facility workers; 2) the Hanford Site workers not at the PFP Facility; and 3) the hypothetical individual member of the public residing at the Hanford Site boundary at the time of the accident. These results are useful for comparison among alternatives and will bound actual anticipated effects. They should not be taken as predictive of actual expected exposures. To provide perspective for the magnitudes of the bounding doses calculated for the various accident scenarios, the LCF predicted using the International Commission on Radiological Protection risk estimators (ICRP, 1991) are also presented. No population exposure estimates have been made for the accident cases because the maximum individual doses are low.

Consequences of accidents can be quantified by applying the following equation:

$$\text{Dose} = \text{MAR} \times \text{ARF} \times \text{RF} \times \text{LPF} \times \text{BR} \times \text{ACF} \times \text{DCF}$$

where:

Dose = exposure received by the receptor in rem effective dose equivalent.

MAR = Material at Risk in grams (material involved in the accident).

ARF = Airborne Release Fraction (fraction of the material at risk that becomes airborne as a result of the accident).

RF = fraction of the airborne material that is respirable (taken to be fraction of airborne material with aerodynamic equivalent diameter of 10 microns or less).

LPF = Leak Path Factor indicating the fraction of the airborne material that escapes from any containment or filtration devices.

BR = applicable standard man breathing rate (acute rate of  $3.3 \times 10^{-4}$  m<sup>3</sup>/sec applicable to accident cases).

ACF = airborne concentration factor relating the released material to the concentration in the air at the receptor location (C/Q for atmospheric dispersion in sec/m<sup>3</sup>, or exposure time divided by diluting air volume in the immediate vicinity of the accident for PFP Facility workers in sec/m<sup>3</sup>).

DCF = dose conversion factor relating the amount of material inhaled to the exposure received (rem/g).

Each of the foregoing factors must be selected specifically for the accident scenario being evaluated, based on the energies available to disperse the material at risk, the physical and chemical form of the material, the physical arrangement of the facility, and interactions with any other materials present. Judgment must be used in selecting the parameters to ensure that the consequences will be bounded using the values chosen. However, use of reasonable values to represent these factors is also appropriate for making comparisons among alternatives. Airborne release fractions and respirable fractions were obtained from the PFP FSAR (WHC, 1995a) or DOE Handbook 3010-94 (DOE, 1994c). Leak path factors are based on HEPA filtration of contaminated air prior to its release from the PFP Facility for calculating impacts to Hanford Site workers and the hypothetical maximally exposed individual at the Hanford Site boundary. For PFP Facility workers, leak path factors are based on reasonable assumptions concerning the amounts of material that may escape from the installed gloveboxes and dropped ducts.

C/Q values are from the 95 percent meteorology case used in the PFP FSAR for accident conditions. For the fire and explosion accidents evaluated, there is insufficient energy to cause the PFP Facility ventilation system to fail. Therefore, C/Q values for an elevated release from the PFP Facility stack were used, coupled with 95 percent meteorology, to select the worst occupied onsite location and Hanford Site boundary location to maximize the calculated impacts. The 95 percent meteorology is used to ensure worst case conditions are evaluated for accidents, which could occur at any time or meteorological conditions, such that the calculated consequences will be bounding 95 percent of the time. The accident case worst locations are the 242-S Facility 930 m (0.58 mi) south-southeast of the PFP Facility and the Hanford Site boundary 12.5 km (7.8 mi) west of the PFP Facility. The C/Q values at those locations are  $1.62 \times 10^{-5}$  sec/m<sup>3</sup> and  $5.73 \times 10^{-6}$  sec/m<sup>3</sup>, respectively. There are closer locations to the PFP Facility for both Hanford Site workers and the Hanford Site boundary individual, but when weighted by the historical meteorology, the selected locations provide maximum doses more than 95 percent of the time.

The breathing rate used is taken from International Commission on Radiological Protection Publication 23 (ICRP, 1975). A PFP Facility worker exposure time of 60 seconds was used. This exposure time is based on the judgment that PFP Facility workers would leave the area immediately in response to any serious accident in accordance with established procedures and common sense practices. The diluting air volume into which the gloveboxes or dropped ducts release their contents was taken to be 1000 m<sup>3</sup> (35,000 ft<sup>3</sup>).

Only the maximally exposed individual doses and associated health effects are presented in this EIS. Because of the large uncertainties in accident probabilities, actual release fractions, physical configurations, and numbers and proximities of workers, the maximally exposed individual doses for the three population groups represent the accident consequences and facilitate comparisons among the alternatives. Population exposure estimates could be made, but would provide no additional value in judging between alternatives. Because the doses to the maximally exposed individuals not working within the PFP Facility (the Hanford Site worker and the maximally exposed hypothetical member of the public) are generally small, the health consequences to them, as well as to any populations that would be exposed to smaller doses, would also be small.

Health effects from radiation exposure are computed by application of factors relating LCF to the amounts of exposure

received. International Commission on Radiological Protection values are used to estimate the effects on PFP Facility and Hanford Site workers and members of the public. The factors are  $4 \times 10^{-4}$  LCF/rem effective dose equivalent for workers and  $5 \times 10^{-4}$  LCF/rem effective dose equivalent for members of the general public, which could include babies and children as well as adults (ICRP, 1991).

The values for the various parameters involved in the accident evaluations are summarized in the following tables. Table D-11 lists the inventory at risk, release fractions, and leak path factors for each inventory group and alternative process step evaluated. The dose consequences and associated health effects from the radiation exposures are presented in Table D-12 for each evaluated process step for the various alternatives. To compare the potential severities of accidents among the alternatives, use the bounding or highest consequences for the individual process steps included in each alternative.

## D.5.2 NATURAL PHENOMENA

The postulated bounding natural phenomenon is an earthquake that causes damage to the existing plutonium containments. The probabilities and doses are presented in Subsection 9.2.4 of the PFP FSAR (WHC, 1995a). The doses received from such an event will result in a risk to both Hanford Site workers and the public.

**Table D-11 Accident Release Parameters for Various Alternative Process Steps**

Alternative Process Steps	Material at Risk (g Pu)	Airborne Release Fraction	Respirable Fraction (%)	Leak Path Factor for Release to Worker (%)	Leak Path Factor for PFP Facility Release
Solutions	.	.	.	.	.
Ion Exchange	1,330	$2.00 \times 10^{-6}$	1	0.1	$2.85 \times 10^{-4}$
Vertical Calcination	141	$2.00 \times 10^{-6}$	1	0.1	$2.85 \times 10^{-4}$
Thermal Stabilization	600	$5.00 \times 10^{-3}$	0.4	0.1	$2.85 \times 10^{-4}$
Hydroxide Precipitation	704	$1.20 \times 10^{-6}$	1	0.1	$2.85 \times 10^{-4}$
Oxides, Fluorides, and Process Residues	.	.	.	.	.
Thermal Stabilization Using a Continuous Furnace	600	$5.00 \times 10^{-3}$	0.4	0.1	$2.85 \times 10^{-4}$
Batch Thermal Stabilization Using a Muffle Furnace	600	$5.00 \times 10^{-3}$	0.4	0.1	$2.85 \times 10^{-4}$
Metals and Alloys	.	.	.	.	.
Repackage	1,400	$5.00 \times 10^{-4}$	0.5	0.1	$2.85 \times 10^{-4}$
Batch Thermal Stabilization Using a Muffle Furnace (Oxides only)	840	$5.00 \times 10^{-4}$	0.5	0.1	$2.85 \times 10^{-4}$



Batch Thermal Stabilization Using a Muffle Furnace (All Metals and Alloys)	840	$5.00 \times 10^{-4}$	0.5	0.1	$2.85 \times 10^{-4}$
Polycubes and Combustibles	.	.	.	.	.
Pyrolysis	90	$6.00 \times 10^{-3}$	0.01	0.1	$2.85 \times 10^{-4}$
Batch Thermal Stabilization Using a Muffle Furnace	90	$6.00 \times 10^{-3}$	0.01	0.1	$2.85 \times 10^{-4}$
Molten Salt Oxidation	63	$6.00 \times 10^{-3}$	0.01	0.1	$2.85 \times 10^{-4}$
Removal	.	.	.	.	.
Duct Drop	35	0.01	0.2	1	$2.85 \times 10^{-4}$

**Table D-12 Impacts from Accidents for the Alternative Process Steps Evaluated**

Alternative Process Steps	Doses (rem effective dose equivalent)	.	.	LCF	.	.
.	Max. Onsite Hanford Worker	Max. Site Boundary Individual	PFP Facility Worker	Max. Onsite Hanford Worker	Max. Site Boundary Individual	PFP Facility Worker
Stabilization	.	.	.	.	.	.
Solutions	.	.	.	.	.	.
Ion Exchange	$1.7 \times 10^{-7}$	$6.1 \times 10^{-8}$	$2.3 \times 10^{-1}$	$6.9 \times 10^{-11}$	$3.1 \times 10^{-11}$	$9.0 \times 10^{-5}$
Vertical Calcination	$1.8 \times 10^{-8}$	$6.5 \times 10^{-9}$	$2.4 \times 10^{-2}$	$7.3 \times 10^{-12}$	$3.2 \times 10^{-12}$	$9.5 \times 10^{-6}$
Thermal Stabilization	$7.8 \times 10^{-5}$	$2.8 \times 10^{-5}$	$1.0 \times 10^2$	$3.1 \times 10^{-8}$	$1.4 \times 10^{-8}$	$4.1 \times 10^{-2}$
Hydroxide Precipitation	$5.5 \times 10^{-8}$	$1.9 \times 10^{-8}$	$7.2 \times 10^{-2}$	$2.2 \times 10^{-11}$	$9.7 \times 10^{-12}$	$2.9 \times 10^{-5}$
Oxides, Fluorides, and Process Residues	.	.	.	.	.	.
Thermal Stabilization Using a Continuous Furnace	$1.9 \times 10^{-4}$	$6.9 \times 10^{-5}$	$2.5 \times 10^2$	$7.8 \times 10^{-8}$	$3.4 \times 10^{-8}$	$1.0 \times 10^{-1}$
Batch Thermal Stabilization Using a Muffle Furnace	$1.9 \times 10^{-4}$	$6.9 \times 10^{-5}$	$2.5 \times 10^2$	$7.8 \times 10^{-8}$	$3.4 \times 10^{-8}$	$1.0 \times 10^{-1}$

Metals and Alloys	.	.	.	.	.	.
Repackage	$4.0 \times 10^{-5}$	$1.4 \times 10^{-5}$	$5.2 \times 10^{-1}$	$1.6 \times 10^{-8}$	$7.1 \times 10^{-9}$	$2.1 \times 10^{-2}$
Batch Thermal Stabilization Using a Muffle Furnace (Oxides only)	$2.4 \times 10^{-5}$	$8.5 \times 10^{-6}$	$3.1 \times 10^{-1}$	$9.6 \times 10^{-9}$	$4.3 \times 10^{-9}$	$1.3 \times 10^{-2}$
Batch Thermal Stabilization Using a Muffle Furnace (All Metals and Alloys)	$2.4 \times 10^{-5}$	$8.5 \times 10^{-6}$	$3.1 \times 10^{-1}$	$9.6 \times 10^{-9}$	$4.3 \times 10^{-9}$	$1.3 \times 10^{-2}$
Polycubes and Combustibles	.	.	.	.	.	.
Pyrolysis	$5.7 \times 10^{-7}$	$2.0 \times 10^{-7}$	$7.4 \times 10^{-1}$	$2.3 \times 10^{-10}$	$1.0 \times 10^{-10}$	$3.0 \times 10^{-4}$
Batch Thermal Stabilization Using a Muffle Furnace	$5.7 \times 10^{-7}$	$2.0 \times 10^{-7}$	$7.4 \times 10^{-1}$	$2.3 \times 10^{-10}$	$1.0 \times 10^{-10}$	$3.0 \times 10^{-4}$
Molten Salt Oxidation	$4.0 \times 10^{-7}$	$1.4 \times 10^{-7}$	$5.2 \times 10^{-1}$	$1.6 \times 10^{-10}$	$7.1 \times 10^{-11}$	$2.1 \times 10^{-4}$
Removal	.	.	.	.	.	.
Duct Drop	$1.1 \times 10^{-5}$	$4.0 \times 10^{-6}$	$1.5 \times 10^{-2}$	$4.5 \times 10^{-9}$	$2.0 \times 10^{-9}$	$5.9 \times 10^{-2}$

The PFP FSAR conservatively evaluates the impacts from the entire Facility subjected to a 0.20-gravity design basis earthquake that has an estimated annual frequency of occurrence of  $1 \times 10^{-4}$ . The major Facility walls and floors were subjected to a detailed analysis and shown to survive the effects of this design basis earthquake. However, the internal components that are not seismically qualified are assumed to fail in a manner that maximizes the release of plutonium. This category includes non-qualified gloveboxes, some interior walls and floors, ventilation equipment, and tanks not seismically secured to the building structure. The building ventilation system is assumed in the analysis reported here to fail, allowing airborne activity to be removed from the PFP Facility by wind blowing through open doors.

The source term is defined as the quantity of respirable plutonium released to the environment. The source term released from the Facility is 1.94 g ( $4.3 \times 10^{-3}$  lb). This release represents a dose of 15.2 rem to the Hanford Site worker and 0.31 rem to the public, as calculated in the PFP FSAR. The same LCF probabilities of  $4.0 \times 10^{-4}$  per rem to PFP Facility and Hanford Site workers and  $5.0 \times 10^{-4}$  per rem to members of the public were used. This results in corresponding potential health effects of  $6.1 \times 10^{-3}$  expected LCF to the maximally exposed Hanford Site worker and  $1.6 \times 10^{-4}$  expected LCF to the maximally exposed member of the public.

This bounding seismic event is presented in this EIS to represent the magnitude of naturally induced events that could occur at the PFP Facility, for both the preferred alternatives and the no action alternative. The operations involved with stabilization and removal will not directly impact the outcome of this event, at least until after they are completed. Upon completion of removal and stabilization operations, the consequences of this seismic event would be reduced because of the more stable plutonium form and storage configuration.

## **D.6 CALCULATIONS AND ASSUMPTIONS FOR NORMAL CONDITION STABILIZATION OPERATIONS EXTERNAL RADIATION EXPOSURE**

### **D.6.1 BATCH THERMAL STABILIZATION OF OXIDES, FLUORIDES, AND PROCESS RESIDUES (as**

**described in Subsection 3.3.2.1)**

This section provides details concerning the method used to estimate personnel radiation exposure for the batch thermal stabilization alternative for oxides, fluorides, and process residues. Using exposure data from thermal sludge stabilization, an average exposure per unit mass of plutonium processed was determined.

This calculation was based on the sludge stabilization exposure data from March, April, and May 1995, which are assumed to be representative of future process exposures (WHC, 1995b).

The exposure reported during the sludge stabilization includes both gamma (g) and neutron (n) components. The total exposure (n + g) for March, April, and May was 3,000 person-millirem (1,096 person-millirem [neutron] plus 1,904 person-millirem [gamma]).

The ambient background dose rate (0.5 millirem/hr) for Room 230 A is assumed to be representative of background radiation received by the PFP Facility workers during sludge stabilization (WHC, 1995c).

The following personnel distribution per shift at the process location (exposed to ambient) was assumed, based on current comparable practices.

5 operators at 6 hrs per shift = 30 person-hours/shift

1 health physics technician at 4 hrs per shift = 4 person-hours/shift

1 manager at 2 hrs per shift = 2 person-hours/shift

Total time = 36 person-hours/shift

For the two-shift operation, this would be 72 person-hours/day.

The ambient exposure for a processing day would then be 36 person-millirem/day. During the months of March through May 1995, it was assumed that sludge stabilization activities occurred 20 days/month.

The total exposure due to ambient background radiation is, therefore, estimated to have been:

(3 months)(20 day/month)(36 person-millirem/day), or 2,160 person-millirem.

The contribution from the plutonium source being processed is the total exposure minus ambient. Therefore, the direct radiation dose attributable to the plutonium source equals 840 person-millirem (3,000 person-millirem minus 2,160 person-millirem).

From March through May, 159 containers of plutonium were processed, for a total mass of about 15,900 g of plutonium. This gives an estimated exposure per unit mass of plutonium processed (during sludge stabilization) of 0.053 person-millirem/g plutonium.

To estimate the exposures that would occur during processing of the different types of product specified in the four inventory groups, dose rates for each type of plutonium source material were estimated by the following formulas from "*A Guide to Good Practices at Plutonium Facilities*" (PNL, 1988).

Gamma dose:

$$D_g \text{ (rad/hr)} = 171f_{238} + 0.5f_{239} + 2.4f_{240} + 8.7f_{241} + 0.15f_{242} + (0.074f_{241})t,$$

where:

$D_g$  = surface dose rate,

$f_i$  = weight fraction of  $i$ th plutonium isotope at chemical separation, and

$t$  = time since chemical separation.

The time since chemical separation was calculated from the isotopic composition by the equation:

$$t = \ln [1 + (f_{Am241})/(f_{Pu241})(0.9667)]/0.0465,$$

except for the polycubes where  $t$  was assumed to be 25 years (Crowe and Szempruch, 1994).

The weight fractions of the plutonium isotopes are assumed to be unchanged since separation, except for Pu-241, for which the weight fraction  $f_{241}$ (at separation) is equal to the current fraction  $f_{241}$ (present) plus the current fraction  $f_{Am241}$  to account for ingrowth.

Applying the dose rate equations for the neutron components for the sludge that was stabilized gives:

Spontaneous fission:

$$D_n \text{ (millirem/hr)} = (2620f_{238} + 0.03f_{239} + 1020f_{240} + 1700f_{242} + 1.6f_{Am241})(.0097)$$

Alpha-n interactions:

$$D_{n\text{-oxide}} \text{ (millirem/hr)} = (16300f_{238} + 45f_{239} + 1070f_{240} + 1.8f_{241} + 1500f_{242} + 2700f_{Am241})(.0097)$$

Total neutron dose:

$$D_{n\text{-total}} = D_n + D_{n\text{-oxide}}$$

(Note this assumption conservatively overestimates the neutron dose contribution.)

The scale factors for the neutron and gamma dose rates from these formula are presented in Tables D-13 through D-18 for each inventory group. Dose rates for sludge stabilization were extrapolated to dose rates for the various inventory groups. The ratios of g and n dose rates for each group to the g and n dose rates for sludge are the g and n multipliers. These multipliers represent the relative dose source strength for each inventory group compared to those received during sludge stabilization.

The multipliers for the neutron and gamma components were weighted by the amounts of different material present to arrive at an average multiplier to represent each inventory type. For instance, for the oxides and residues type, the multiplier for the oxides (94 weight percent of the mass to be processed) are 4.0 and 1.8 for g and n, respectively, and for the residues (6 weight percent of the total) 0.6 and 0.9, respectively. These give a weighted average of a factor of 3.8 for g and 1.7 for n for 2,263 kg of plutonium in oxides and 154 kg of plutonium in residues for this inventory group.

From the sludge stabilization exposure data (March through May 1995), it is assumed that the source contribution ratios for n and g are in the same proportion as for the total exposure:

$$n/(n + g) = 1,096/(1,096 + 1,904) = 0.37$$

$$g/(g + n) = 1,904/(1,904 + 1,096) = 0.63.$$

**Table D-13 Neutron and Gamma Dose Rates for Sludge**

Isotope	Wt. Fraction	Gamma	Neutron	N-oxide	.	.
Pu-238	0.0003	51.3	0.008	0.047	Separation Time (yr)	12.45

Pu-239	0.9297	474.147	0.000	0.406	.	.
Pu-240	0.0629	150.96	0.622	0.653	.	.
Pu-241	0.0037	32.19	0.000	0.000	.	.
Pu-242	0.0004	0.06	0.007	0.006	.	.
Am-241	0.003	2,252.37	0.000	0.079	.	.
Total	1	2,961.02	0.637	1.191	total n dose rate	1.83
Gamma multiplier = 1	.	.	.	Neutron multiplier = 1	.	.

**Table D-14 Neutron and Gamma Dose Rates for Metals and Alloys**

Isotope	Wt. Fraction	Gamma	Neutron	N-Oxide	.	.
Pu-238	0.0006	102.6	0.015	0	Separation Time (yr)	20.48
Pu-239	0.8023	409.2	0.000	0	.	.
Pu-240	0.1642	394.1	1.625	0	.	.
Pu-241	0.0102	88.7	0.000	0	.	.
Pu-242	0.0059	0.9	0.097	0	.	.
Am-241	0.0168	14,938.5	0.000	0	.	.
Total	1	15,933.9	1.738	0	total n dose rate	1.74
Gamma multiplier = 5.4	.	.	.	Neutron multiplier = 0.95	.	.

**Table D-15 Neutron and Gamma Dose Rates for Oxides**

Isotope	Wt. Fraction	Gamma	Neutron	N-Oxide	.	.
Pu-238	0.0011	188.1	0.028	0.174	Separation Time (yr)	18.73
Pu-239	0.8603	438.8	0.000	0.376	.	.
Pu-240	0.1145	274.8	1.133	1.188	.	.
Pu-241	0.0087	75.7	0.000	0.000	.	.
Pu-242	0.0026	0.4	0.043	0.038	.	.

Am-241	0.0125	10,723.8	0.000	0.327	.	.
Total	0.9997	11,701.6	1.204	2.103	total n dose rate	3.31
Gamma multiplier = 4.0	.	.	.	Neutron multiplier = 0.95	.	.

**Table D-16 Neutron and Gamma Dose Rates for Process Residues**

Isotope	Wt. Fraction	Gamma	Neutron	N-Oxide	.	.
Pu-238	0.0001	17.1	0.003	0.016	Separation Time (yr)	11.11
Pu-239	0.9363	477.513	0.000	0.409	.	.
Pu-240	0.0599	143.76	0.593	0.622	.	.
Pu-241	0.002	17.4	0.000	0.000	.	.
Pu-242	0.0003	0.045	0.005	0.004	.	.
Am-241	0.0014	1,020.68	0.000	0.037	.	.
Total	1	1,676.5	0.600	1.087	total n dose rate	1.69
Gamma multiplier = 0.6	.	.	.	Neutron multiplier = 0.9	.	.

**Table D-17 Neutron and Gamma Dose Rates for Polycubes and Combustibles**

Isotope	Wt. Fraction	Gamma	Neutron	N-Oxide	.	.
Pu-238	0.0016	273.6	0.041	0.253	Separation Time (yr)	25.00
Pu-239	0.8054	410.8	0.000	0.352	.	.
Pu-240	0.1688	405.1	1.670	1.752	.	.
Pu-241	0.011	95.7	0.000	0.000	.	.
Pu-242	0.0057	0.9	0.094	0.083	.	.
Am-241	0.0075	12,492.1	0.000	0.196	.	.
Total	1	13,678.2	1.805	2.636	total n dose rate	4.44
Gamma multiplier =	.	.	.	Neutron multiplier =	.	.

4.6				2.4		
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**Table D-18 Neutron and Gamma Dose Rates for Plutonium-bearing Solutions**

Isotope	Wt. Fraction	Gamma	Neutron	N-Oxide	.	.
Pu-238	0.0002	34.2	0.005	0.032	Separation Time (yr)	19.80
Pu-239	0.9228	470.6	0.000	0.403	.	.
Pu-240	0.0683	163.9	0.676	0.709	.	.
Pu-241	0.0032	27.8	0.000	0.000	.	.
Pu-242	0.0005	0.1	0.008	0.007	.	.
Am-241	0.0050	4,384.2	0.000	0.131	.	.
Total	1	5,080.9	0.689	1.282	Total n Dose Rate	1.97
Gamma multiplier = 1.7	.	.	.	Neutron multiplier = 1.1	.	.

For the unit exposure of 0.053 person-millirem/g plutonium, there would be 0.020 person-millirem/g plutonium n dose and 0.033 person-millirem/g plutonium g dose. Applying the weighted average n and g multipliers for the oxides and residues inventory group gives:

$$n (0.020)(1.7) = 0.034 \text{ person-millirem/g}$$

$$g (0.033)(3.8) = 0.125 \text{ person-millirem/g}$$

total = 0.16 person-millirem/g of plutonium processed.

The following steps during sludge stabilization are common with the other stabilization alternatives:

- Retrieve plutonium from vaults
- Transfer plutonium to process location
- Seal plutonium into glovebox and proceed with feed preparation
- Thermally stabilize material in glovebox
- Package product and seal out
- Transfer to nondestructive assay
- Perform loss-on-ignition testing

Applying the above-derived factors to the total inventory of oxides, fluorides, and process residues for those steps gives:

$$(2,417 \text{ kg})(1,000 \text{ g/kg})(0.16 \text{ person-millirem/g plutonium}) (1 \text{ rem}/1,000 \text{ millirem}) = 387 \text{ person-rem.}$$

To estimate the ambient background exposure, assume the 0.5 millirem/hr and 3 shifts per day operation for the 16.2 operating years required to process all the oxides and residues. This gives:

$$(16.2 \text{ yrs}) (50 \text{ wk/yr}) (5 \text{ day/wk}) (3 \text{ shift/day}) (36 \text{ person-hr/shift}) (0.5 \text{ millirem/hr}) (1 \text{ rem}/1,000 \text{ millirem}) = 219$$

person-rem.

The total exposure for these steps in processing this inventory group is the source exposure plus the ambient exposure, or on a per batch basis:

$$2,417 \text{ kg}/(0.6 \text{ kg/batch})=4,028 \text{ batches}$$

$$387 \text{ person-rem}/4,028= 96 \text{ person-millirem/batch source exposure}$$

$$219 \text{ person-rem}/4,028=54 \text{ person-millirem/batch ambient exposure}$$

Total per batch =150 person-millirem.

Some additional steps are required to complete the processing estimates. These include:

#### 1. Nondestructive assay testing

Contact dose rates during nondestructive assay range from 20-30 to 200-300 millirem/hr (WHC, 1995d). A dose rate during non-destructive assay of 20 millirem/hr, and that it takes two persons five minutes (min) to complete the assay of each batch, is assumed for these estimates. This gives:

$$(2 \text{ persons})(20 \text{ millirem/hr})(5 \text{ min}) (1 \text{ hr}/60 \text{ min})/(\text{batch}) =$$

3 person-millirem per batch.

#### 2. Transfer to vault storage

Assume the average dose rate during transfer (including ambient) of a loaded wagon is 10 millirem/hr. Assume that the transfer takes 2 people 10 minutes for each five batches (five cans per transfer). This gives:

$$(2 \text{ persons})(10 \text{ millirem/hr})(10 \text{ min})(1 \text{ hr}/60 \text{ min})/(5 \text{ batches}) = 1 \text{ person-rem per batch.}$$

#### 3. Unload wagon into vault

Use the 60 millirem/hr average ambient dose in the storage vaults (from 2736-Z vault data provided in (WHC, 1995c). Assuming it takes 2 persons 10 minutes to unload the wagon (five batches or cans per transfer), gives:

$$(12 \text{ persons})(60 \text{ millirem/hr})(10 \text{ min})(1 \text{ hr}/60 \text{ min})/ (5 \text{ batches}) = 4 \text{ person millirem per batch.}$$

The total additional dose per batch for these other steps is 3 person-millirem for nondestructive assay testing, 1 person-millirem for transfers to the vault, and 4 person-millirem to unload in the vault, for a total of 8 person-millirem per batch. This is equivalent to 0.0133 person-millirem/g of plutonium processed and is assumed to apply to all of the inventory groups.

The total estimated exposure for processing this inventory group is the sum of the ambient (54 person-millirem/batch) plus source processing (96 person-millirem/batch) plus the other steps (8 person-millirem/batch), for a total of 158 person-millirem/batch. Therefore, the total for this alternative (4,028 batches) is 640 person-rem.

### **D.6.2 ION EXCHANGE, VERTICAL CALCINATION AND THERMAL STABILIZATION OF PLUTONIUM-BEARING SOLUTIONS (as described in Subsection 3.2.1.1)**

Plutonium-bearing solutions include Plutonium Uranium Extraction Facility (PUREX) solutions, which do not require ion exchange processing, as well as other residual acidic and caustic solutions that would benefit from ion exchange. The 228.5 kg (504 lb) plutonium in PUREX solutions would be sent directly to the vertical calciner and would subsequently be thermally stabilized.



For this fraction of the total mass, a 50 percent increase in exposure per unit mass as derived from sludge stabilization is assumed to account for the additional handling associated with the two-step process (vertical calciner and thermal stabilization).

Applying these factors to the PUREX solutions inventory gives an estimated direct exposure from processing this source of 27 person-rem.

For the balance of the solutions, the process would include three steps, ion exchange plus vertical calciner plus thermal stabilization. Caustic and fluoride solutions will be included with other solutions and exposure estimates as though they will be processed the same as the other solutions. The total plutonium inventory for the other solutions, excluding PUREX solutions, is 108.9 kg (240 lb). Assuming 50 percent greater exposure for each additional step gives 100 percent greater unit exposure for the three step process.

Applying the relative source strength and complexity factors gives an estimated direct exposure from the processed source of 17 person-rem for the other solutions.

To estimate the ambient background exposure, an operating duration of 2.75 years is used. At 0.5 millirem/hr, this would be 37 person-rem from ambient radiation levels.

To account for the other activities not included in the process estimate, the same factor as developed for the thermal stabilization of oxides and residues of 0.0133 person-rem/g plutonium is applied. This results in an estimate of 4.5 person-rem for implementing the associated steps for this alternative.

The total direct exposure for this alternative is the sum of the estimates for the foregoing steps, or 86 person-rem.

#### **D.6.3 THERMAL STABILIZATION OF OXIDES, FLUORIDES AND PROCESS RESIDUES IN A CONTINUOUS FURNACE (as described in Subsection 3.2.1.2)**

Assuming that the entire inventory (2,417 kg [5,329 lb] plutonium) will require processing (including high fired oxides) and that the exposure rate per gram will be the same as calculated for the batch thermal stabilization option gives the estimated exposure for the continuous furnace alternative of 387 person-rem.

The feed rate of the continuous furnace is 600 g (1.3 lb) plutonium per hour. This could result in a greater mass of plutonium in the process area with a corresponding increase in ambient dose rates. Assuming that the average ambient dose rate is doubled from 0.5 to 1.0 millirem/hr, for the 1.16 year operational duration, gives 31 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 32 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 450 person-rem.

#### **D.6.4 REPACKAGING OF METALS AND ALLOYS (as described in Subsection 3.2.1.3)**

Assuming that the entire inventory (770 kg [1,700 lb] plutonium) will require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, gives the estimated exposure for the repackaging step of this alternative of 152 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 1.18 year operational duration, gives 16 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 10 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 180 person-rem.

#### **D.6.5 PYROLYSIS OF POLYCUBES AND COMBUSTIBLES (as described in Subsection 3.2.1.4)**

Assuming that the entire inventory (35 kg [77 lb] plutonium) will require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, and assuming that half of the polycubes will require coating removal to facilitate processing (a 50 percent increase in processing exposure), gives the estimated exposure for the processing step of this alternative of 8.7 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 0.41 year operational duration, gives 5.5 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 0.5 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 15 person-rem.

#### **D.6.6 HYDROXIDE PRECIPITATION AND THERMAL STABILIZATION OF SOLUTIONS (as described in Subsection 3.3.1.1)**

Assuming that the entire inventory (338 kg [745 lb] plutonium) will require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, with a 50 percent increase in exposure to account for the two-step process, gives the estimated exposure for the processing portion of this alternative of 39.5 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 3 year operational duration, gives 40.5 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 4.5 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 85 person-rem.

#### **D.6.7 BATCH THERMAL STABILIZATION OF METALS AND ALLOYS (as described in Subsection 3.3.3.1)**

Assuming that the entire inventory (770 kg [1,700 lb] plutonium) would require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, with a 50 percent increase to account for the two step process, gives the estimated exposure for the processing portion of this alternative of 228 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 6.3 year operational duration, gives 85 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 10 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 320 person-rem.

#### **D.6.8 BATCH THERMAL STABILIZATION OF POLYCUBES AND COMBUSTIBLES (as described in Subsection 3.3.4.1)**

Assuming that the entire inventory (35 kg [77 lb] plutonium) will require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, and assuming the 50 percent increase in exposure rate for coating removal for half of the inventory, gives the estimated exposure for the processing step of this alternative of 8.7 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 1.43 year operational duration, gives 19.3 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 0.5 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 29 person-rem.

#### **D.6.9 MOLTEN SALT OXIDATION OF POLYCUBES AND COMBUSTIBLES (as described in Subsection 3.3.4.2)**

Assuming that the entire inventory (35 kg [77 lb] plutonium) will require processing, and applying the relative source strength factors to the sludge stabilization exposure rates, and assuming that half of the polycubes will require coating removal to facilitate processing (a 50 percent increase in processing exposure), gives the estimated exposure for the processing step of this alternative of 8.7 person-rem.

Assuming that the average ambient dose rate is 0.5 millirem/hr, for the 0.56 year operational duration, gives 7.6 person-rem for the background contribution.

As described above, to account for the other activities, the exposure of 0.0133 person-millirem/g plutonium processed is used. This gives a total of 0.5 person-rem for implementing these steps for this alternative.

The total exposure for this alternative is the sum of the individual estimates above, or 19 person-rem.

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## APPENDIX E

# THE IMMOBILIZATION ALTERNATIVE ASSUMPTIONS AND ANALYSIS OF IMPACTS

## E.1 INTRODUCTION

This appendix provides detailed information on the immobilization alternative. Subsection E.2 discusses U.S. Department of Energy (DOE) policies and requirements governing the immobilization alternative. Plutonium-bearing materials potentially suitable for immobilization are presented in Subsection E.3. Subsection E.4 provides a description of the immobilization alternative. And finally, Subsection E.5 describes the anticipated impacts of the immobilization alternative.

## E.2 POLICIES AND REQUIREMENTS GOVERNING THE IMMOBILIZATION ALTERNATIVE

### E.2.1 DOE POLICY REGARDING EXCESS PLUTONIUM-BEARING MATERIALS

Any U.S. Department of Energy (DOE) decision to immobilize plutonium-bearing material at the Plutonium Finishing Plant (PFP) would be made using the *Plutonium Disposition Plans* (Halsted, 1994), as described in Subsection E.2.1.1. DOE has recently drafted a new policy for the disposition of plutonium-bearing material. This draft policy, *Department of Energy Policy for the Treatment and Disposition of Excess Plutonium-bearing Residues* (Lytle, 1996), is described in Section E.2.1.2 and has been considered as well.

#### E.2.1.1 Plutonium Disposition Plans

In April 1994, DOE issued the *Plutonium Disposition Plans*. This document replaced the Economic Discard Limit approach for disposition of plutonium-bearing materials. As described by Halsted:

Previously, when demand for plutonium was high, DOE promulgated an Economic Discard Limit methodology to ensure that the cost to the Government for recovering plutonium from residues was less than the cost of new plutonium production.

Disposition decisions for plutonium-bearing materials are currently made based on the following criteria identified in the *Plutonium Disposition Plans*:

**Worker Safety** - Discard decisions should give full consideration to radiological and chemical hazards and their impact on the worker who must either repackage, treat, stabilize, ship, store, or discard the plutonium-bearing materials.

**Minimizing Environmental Impact** - Protection of the environment is of paramount interest and should be weighed accordingly.

**Regulatory Concerns** - Discard decisions should take into account the applicable federal and state regulations and any associated compliance agreements. An evaluation must be made to determine whether the proposed action meets all regulatory commitments.

**Waste Minimization** - Discard decisions should give consideration to the amount of transuranic waste and low-level waste produced as a result of discard or retention.

Disposal Technical Criteria - Waste acceptance criteria for individual waste packages, as well as overall disposal facility constraints such as volume and curie limits, should be considered.

Technical Risk - Any technology proposed to be utilized in discard or retention must be evaluated to determine the confidence level of success. Proven technologies should be weighed more heavily than those in the research and development stage.

Stakeholder Interest - The acceptance of stakeholders must be considered in the discard decision. Stakeholders include workers, unions, local communities, and federal and state regulatory authorities.

Risk Assessment - The risk of an accident and the potential exposure to workers and the public must be addressed for both radiological and chemical hazards.

Implementation Time/Feasibility - The use of well established simple technologies that could be readily implemented in existing facilities is to be encouraged. Decisions that result in shorter facility operating times and those that can be implemented while capability is available would be weighed more heavily.

Proliferation Potential - The proliferation implications of the decisions should be addressed.

Cost - The cost of activities to repackage, stabilize, treat, process, ship, store, and discard must be addressed.

Interim Storage - Consideration is to be given to the feasibility of storing the plutonium-bearing materials as is; storing after stabilization; or storing after treatment prior to discard, as appropriate.

Analysis using the above-listed criteria would be made prior to any DOE decision to immobilize plutonium-bearing materials at the PFP Facility.

#### **E.2.1.2 Draft DOE Policy for Excess Plutonium-bearing Residues**

On January 23, 1996, DOE internally issued for review and comment a proposed policy for the disposition of excess plutonium-bearing residues. If the draft *Department of Energy Policy for the Treatment and Disposition of Excess Plutonium-bearing Residues* is finalized, it would provide a consistent framework for evaluating the plans for dealing with these residues across the entire DOE complex (Lytle, 1996).

Under this draft policy, excess plutonium-bearing residues would be processed to one of two end-states: 1) plutonium separated from its residue matrix (not necessarily refined) and packaged for storage in accordance with the DOE storage standard (DOE, 1994a); or 2) waste suitable for disposal at the Waste Isolation Pilot Plant.

This policy also requires that a determination of which end-state is more cost-effective must be made by the responsible field office and approved by the appropriate DOE Secretarial Officer. It also requires that the evaluation include worker exposure, waste generation, and cost.

Although this policy has not been finalized, it is prudent to consider this policy and analyze potential impacts to the environment from immobilizing all candidate plutonium-bearing materials. The PFP Stabilization EIS Record of Decision will not include a decision on the immobilization alternative unless this draft policy or a comparable policy has been finalized.

#### **E.2.2 WASTE ACCEPTANCE CRITERIA**

The payload characteristics and package design requirements applicable to the selection of reasonable waste packaging and immobilization methods are discussed below. A more comprehensive list of acceptance criteria is found in the waste acceptance criteria for the Hanford Site solid waste management facilities and for the Waste Isolation Pilot Plant (WHC, 1995a and DOE, 1996).

1. Fissile or fissionable radionuclide content (in Pu-239 fissile gram equivalents(1)):

The maximum allowable fissile material contents (nuclear criticality criteria) for 55-gallon drums and standard waste boxes are 200 fissile gram equivalents and 325 fissile gram equivalents, respectively. Only 100 fissile gram equivalents of fissile material are allowed in drums that are lead-lined, contain absorbed liquid organics, or where the fissile material is contained within less than 20 percent of the drum volume (WHC, 1995a). The maximum for a pipe-container-in-drum is 200 fissile gram equivalents (DOE, 1996).

For transportation to an offsite storage facility, the drums or standard waste boxes must be overpacked in a TRUPACT-II package. There is also a fissile material criterion for each TRUPACT-II; therefore, the fissile content of a drum or a standard waste box is also limited by this criterion. For drums and standard waste boxes, each TRUPACT-II can contain up to 325 fissile gram equivalents (DOE, 1996). Since each TRUPACT-II overpack can contain 14 drums or standard waste boxes, the actual limit for these containers is only 23 fissile gram equivalents. For pipe-container-in-drum, the TRUPACT-II limit is 2,800 fissile gram equivalents (DOE, 1996). Each pipe-container-in-drum may contain up to 200 fissile gram equivalents.

2. The maximum dose rate at any point on the surface of a waste package stored at the Hanford Site solid waste management facilities will be no greater than 100 millirem per hour (millirem/hr) (beta, gamma, and neutron) (WHC, 1995a).

3. Payload containers must be vented (DOE, 1996).

4. Powders, ashes, and similar particulate waste materials are to be immobilized if more than 1 weight percent of the waste matrix in each package is in the form of particles below 10 microns in diameter, or if more than 15 weight percent is in the form of particles less than 200 microns in diameter (WHC, 1995a).

5. Transuranic waste in a package must not be in free-liquid form. Minor residual liquids remaining in well-drained inner packages are not to exceed 1 volume percent. The total liquid in the waste package is not to exceed 1 volume percent. Liquids are to be solidified, absorbed, or otherwise bound in the waste matrix by an inert material (WHC, 1995a and DOE, 1996).

6. Pyrophoric materials (other than radionuclides) will be rendered safe by mixing with chemically stable materials or will be processed. No more than 1 weight percent of the waste in each waste package may be pyrophoric forms of radionuclides. These are to be generally dispersed in the waste (WHC, 1995a and DOE, 1996).

7. There are no limits on void spaces in transuranic waste packages. If void space filler is used to provide padding or shoring, it is not to be considered as part of the waste matrix for purposes of calculating radioactive material concentrations (WHC, 1995a).

8. The container/assembly weight criteria include a requirement that 6-inch diameter pipe containers not exceed 30 kilograms (kg) (66 pounds [lb]) payload limit (DOE, 1996).

### **E.3 MATERIALS POTENTIALLY SUITABLE FOR IMMOBILIZATION**

Based on preliminary analysis using the *Plutonium Disposition Plans* and the draft *Department of Energy Policy for Treatment and Disposition of Excess Plutonium-bearing Residues*, the materials identified in Table E-1 are candidates for immobilization.

There would be two potential sources of plutonium-bearing materials suitable for immobilization. The first consists of some materials currently stored in PFP Facility vaults. The second consists of readily retrievable hold-up materials that would be removed from PFP Facility ductwork, process piping, gloveboxes, and the Plutonium Reclamation Facility (PRF) canyon.

#### **Table E-1 Plutonium-bearing Materials Potentially Suitable for Immobilization**

Description of Inventory Category	Plutonium Content (kg)
Oxides	
· Oxides < 50 wt% Plutonium	91
Process Residues	
· Ash	81
· Slag and Crucibles	43
Miscellaneous/Other Combustibles	7
Readily Retrievable Hold-up Materials	
· Removed from Ductwork	4.5
· Removed from Piping	4.3
· Removed from Gloveboxes	28
· Removed from PRF Canyon	12.5
Total	272

**Source:** WHC, 1996a

### **Vault Materials**

Approximately 1,500 items (266 7-gallon and 1,234 7-inch [7 inches high, approximately 1.6 l] containers) that are currently stored in PFP Facility vaults and contain about 222 kg (489 lbs) of plutonium are candidates for immobilization (WHC, 1996a). The nature of the contents of these containers varies because the sources of the materials differ. The major categories of materials are oxides, process residues, and miscellaneous/other combustibles. These materials are a subset of the materials being evaluated for stabilization.

Plutonium-bearing oxides in this inventory are very low in moisture and contain no organic materials. Process residues consist primarily of sand, slag, crucibles, and furnace ash. Sand and crucibles are composed primarily of magnesium oxide. Slag is composed of calcium iodide, calcium fluoride, residual plutonium, elemental calcium and iodine, and fluoride salts. Miscellaneous/other combustibles consist of items such as contaminated rags and paper. The size of these materials varies from fine particulates to large articles.

### **Readily Retrievable Hold-up Materials**

Up to 50 kg (110 lb) of plutonium may be recovered from PFP Facility hold-up. Up to 4.5 kg (9.9 lb) of plutonium would come from the E-4 ventilation system ductwork; up to 4.3 kg (9.5 lb) of plutonium would come from the process piping; up to 28 kg (62 lb) of plutonium would come from the gloveboxes and hoods; and up to 12.5 kg (28 lb) of plutonium would come from the PRF canyon. The plutonium concentration in these materials is not known. After assaying, it may be determined that some or all of these materials meet the criteria for immobilization.

## **E.4 DESCRIPTION OF THE IMMOBILIZATION ALTERNATIVE**

This subsection describes the activities that would occur under the immobilization alternative. Included is the cementation method that would be used for the candidate plutonium-bearing materials identified in Section E.3, above.



It also provides a description of how material would be packaged.

Appropriate immobilization and packaging methods have been selected based on their ability to satisfy waste acceptance criteria as well as worker safety and economic considerations. A description of how the material would be managed as waste is also included.

#### **E.4.1 CEMENTATION METHOD**

A cement system would be a reasonable immobilization method because: 1) it meets the Hanford Site solid waste acceptance criteria; 2) the ingredients are inexpensive, safe, and readily available; 3) the equipment required can be very simple; 4) the final waste form has proven stability; and 5) the method has been used extensively at the Hanford Site for immobilizing wastes. The cementation process for the plutonium-bearing materials would consider the following:

- Appropriate equipment for the cementation process would be obtained. Factors that would be considered include: 1) plutonium-bearing materials and cement feeding equipment that would control of feed rates; 2) cooling equipment to maintain a low temperature for the cement-plutonium material-water mixture to minimize water vapor in the glovebox; and 3) whenever possible, use of the same container for mixing, curing, and confining the cemented material, reducing worker exposure and waste generation.
- It is anticipated that three containers of material would be placed in a pipe-container-in-drum.
- The maximum allowable limit for plutonium in each pipe-container-in-drum is 200 grams (g) (0.44 lb). To ensure that the drums would be acceptable at the receiving facility, the plutonium content target for each drum would likely be set at 170 g (0.37 lb) (Burton, 1996). This means that each container would contain an average of 56 g (0.12 lb) of plutonium.
- Some of the candidate plutonium-bearing materials consist of less than 1 weight percent plutonium. Materials with low plutonium content may be blended with those at higher content in order to achieve the targeted quantity of 56 g (0.12 lb) per container.
- The amount of plutonium-bearing materials and cement for each batch would be determined prior to mixing. The compatibility of the plutonium-bearing materials and cementitious materials would be evaluated to ensure that they would be cemented and cured as planned.

Portland cement is a common material that has been used as an immobilization matrix. Portland cement consists mostly of hydrated calcium silicates, with some aluminates and magnesium compounds. Additives such as blast furnace slag or fly ash may also be used to modify reactivity, curing time, and cement strength.

The cementation process would take place inside a glovebox in the PFP Facility. Plutonium-bearing materials would be cemented in batches. Final cementation volume of each batch would be approximately 3.4 liters (l) (0.9 gallons [gal]). A proposed cementation process is shown in Figure E-1.

Some of the candidate plutonium-bearing materials consist of less than 1 weight percent plutonium. Materials with low plutonium content may be blended with those at higher content in order to achieve the targeted quantity of 56 g (0.12 lb) per container. A predetermined amount of plutonium-bearing material would be fed into a mixing container using an auger feeder for accurate control. An appropriate amount of water would also be added to ensure proper curing.

A measured amount of Portland cement (and additives if needed) would be slowly added to the slurry while the mixer is in operation. After all the cement had been added and well mixed, the mixer would be shut off and the container removed from the mixer.

The small inner containers originally containing the plutonium-bearing materials and any large waste articles may be placed individually into the final waste containers before the plutonium-bearing material-cement slurry is added.

The container would then be moved to an out-of-the-way location within the glovebox and allowed to set up. Once three containers are set up, they would be bagged out of the glovebox and packaged into a pipe-container-in-drum. Approximately 1,600 drums would be generated by this alternative.

## **E.4.2 PACKAGING METHOD**

The cement/plutonium-bearing mixture would be placed in 3.4-1 (0.9-gal) containers. The containers would then be packaged prior to shipment to a storage facility. Potential packages to be used include 55-gallon drums, standard waste boxes, 55-gallon drums overpacked in standard waste boxes, and pipe-container-in-drums. Any of these packages could meet the waste acceptance criteria for packaging.

It is desirable to minimize the number of packages for a number of reasons: 1) less handling is required with fewer drums, thereby reducing worker exposure; 2) both onsite and offsite transuranic waste storage capacities are limited; and 3) the costs associated with handling, shipping, and storing the packages are reduced. The use of the pipe-container-in-drum would result in the fewest number of drums.

A diagram of a pipe-container-in-drum is shown in Figure E-2. The package consists of a stainless steel pipe-container placed vertically in the middle of a 55-gallon drum. The stainless steel lid is attached with steel bolts.

[Figure E-1. A Proposed Cementation Process A Proposed Cementation Process](#)

[Figure E-2. Pipe-container-in-drum](#)

The pipe-container is passively vented through a filter. An O-ring is used to ensure a good seal.

The U.S. Department of Transportation-approved drum is lined with a straight wall liner. A plywood-fiberboard bonded assembly, on which the container rests, is placed on the bottom of the liner. The space between the container and the vertical wall of the liner is filled with fiberboard packing. The drum is closed as follows:

- 1) A fiberboard-plywood-fiberboard bonded assembly and a spacer are placed on top of the container
- 2) Liner and drum lids are closed
- 3) A locking ring is put in place.

The drum is also passively vented through a filter. Packaging the containers in the pipe-container-in-drum would generate approximately 1,600 drums over the life of the alternative.

## **E.4.3 WASTE MANAGEMENT**

The immobilized plutonium-bearing materials would be managed as transuranic and transuranic mixed waste following immobilization. Transuranic wastes are currently being packaged to meet the waste acceptance criteria for the Waste Isolation Pilot Plant in Carlsbad, New Mexico. At the Hanford Site, transuranic wastes are being stored at the Central Waste Complex and the Transuranic Waste Storage and Assay Facility. In addition, small amounts of transuranic waste are managed at the Low-Level Burial Grounds. Once a final repository site is selected, transuranic wastes would likely be sent to the Hanford Waste Receiving and Processing Facility for assay, certification, and loading into TRUPACT-II overpacks for transport to the selected site. Transuranic waste packages stored onsite must meet the Hanford Site solid waste acceptance criteria which incorporate the Waste Isolation Pilot Plant waste acceptance criteria (WHC, 1995a). For this analysis, it is assumed that the PFP Facility transuranic material would be transported to the Transuranic Waste Storage and Assay Facility for onsite storage (Burton, 1996).

## **E.5 ANTICIPATED IMPACTS OF THE IMMOBILIZATION ALTERNATIVE**

Anticipated impacts from the immobilization alternative are evaluated in terms of the following elements:

- Health effects
- Physical environment
- Transportation

- Unavoidable adverse environmental impacts
- Potential mitigation measures.

### E.5.1 HEALTH EFFECTS

This subsection discusses the anticipated health effects that could occur from exposure to ionizing radiation as a result of implementing the immobilization alternative. Both normal operations and accident conditions would contribute to radiation exposures to PFP Facility workers, other Hanford Site workers, and members of the public. Efforts have been taken to conservatively estimate the possible consequences to ensure that the predicted health effects bound those that would actually occur if this option were implemented. The methods, factors, and parameters used in estimating doses and consequent health effects are the same as described in Appendix D of this EIS unless otherwise noted.

#### E.5.1.1 Normal Condition Exposures from the Immobilization Alternative

Exposures to radiation would result from normal operational activities associated with the immobilization alternative. The PFP Facility workers would be subject to direct external radiation exposures due to their proximity to the plutonium source material. They would be protected from inhalation hazards by engineered barriers, monitoring, and personal protective devices employed during routine operations. Routine releases of small quantities of plutonium from the PFP Facility stack during operations can contribute to doses to Hanford Site workers and the offsite public. Potential exposures to each of these population groups is addressed in the following subsections.

#### Direct Radiation Exposures to PFP Facility Workers from Routine Immobilization Operations

The actual external radiation doses that could be received by PFP Facility workers during implementation of the immobilization alternative would be affected by the length of time each individual is exposed to the plutonium source, source strength, distance from the source, shielding between the individual and the source, and the background radiation levels in the area. Direct radiation doses that could be received by PFP Facility workers implementing the immobilization alternative have been extrapolated from current PFP Facility exposure data and estimates of the amounts of time involved in the various process steps. The extrapolation was based on the physical characteristics of the materials being processed and the technologies involved, as described below.

A scenario for immobilization of the plutonium-bearing material is shown in Figure E-3. The scenario consists of a series of steps, each of which would result in a certain amount of radiation dose to the PFP Facility workers. A summary of the estimated worker exposures associated with these steps is provided in Table E-2. These steps, as described below, would be repeated until all immobilized materials have been shipped to a storage facility.

[Figure E-3. A Proposed Scenario for Immobilization](#)

**Table E-2 Summary of Estimated Routine Worker Exposures**

Step	Activity	Dose (person-rem)
Readily Retrievable Inventory Only		
A	Remove containers of readily retrievable plutonium-bearing hold-up materials from gloveboxes	5.9
B	Load containers onto wagon	0.35

C	Move loaded wagon to an assay station	0.18
D	Perform assay	1.6
E	Move containers to cementation glovebox	0.18
Vault Inventory Only		
1	Remove containers of plutonium-bearing materials currently stored in PFP Facility vaults	5.2
2	Load containers onto wagon	1.8
3	Move loaded wagon to the cementation glovebox	0.90
All Inventory		
4	Load containers into the glovebox	2.1
5	Immobilize plutonium-bearing materials in cement matrix	7.6
6	Unload containers of cemented material from the glovebox	37
7	Package and seal drums	8.4
8	Move drums to staging area	1.2
9	Ship drums to storage	1.4
	Total	74

Following are the assumptions used in calculating the routine PFP Facility worker dose.

#### Readily Retrievable Inventory Only

##### A. Remove containers of readily retrievable plutonium-bearing hold-up materials from gloveboxes:

- Plutonium-bearing hold-up materials would be sent to the immobilization station directly from the gloveboxes where they would be recovered.
- On average, 100 to 150 g (0.22 to 0.33 lb) of plutonium would be placed in each container. This is based on past inventory data. To be conservative in the impact calculations, an average weight of 100 g (0.22 lb) per container would be used.
- Loading out a container from a glovebox would involve two operators and a radiation control technician. One operator would handle the container for 20 minutes, while the other operator would handle it for 15 minutes (WHC, 1996b). Both would receive dose at a contact rate of 20 millirem/hr (WHC, 1995b). The radiation control technician would receive dose at the background rate of 0.5 millirem/hr for 20 minutes (WHC, 1995c).

The total worker dose for this step is estimated at 5.9 person-rem.

##### B. Load containers onto wagon:

- Five containers may be loaded onto the wagon per trip.
- Two operators would be involved for 10 minutes per load (WHC, 1996c). The first operator would receive dose at the contact rate of 20 millirem/hr; the second operator would receive dose at the background rate of 0.5 millirem/hr.

The total worker dose for this step is estimated at 0.35 person-rem.

C. Move loaded wagon to an assay station:

- Two operators would be involved for 10 minutes per trip (WHC, 1996c). A lead-acrylic blanket would be used to provide shielding. The first operator would receive dose at a reduced rate of 10 millirem/hr; the second operator would receive dose at the background rate of 0.5 millirem/hr.

The total worker dose for this step is estimated at 0.18 person-rem.

D. Perform assay:

- For each container, two workers would be involved for five minutes. Both would receive dose at the contact rate of 20 millirem/hr.

The total worker dose for this step is estimated at 1.6 person-rem.

E. Move containers to cementation glovebox:

- The assumptions and calculations for this step would be the same as those in Step C. Therefore, the total worker dose for this step is estimated at 0.18 person-rem.

Vault Inventory Only

1. Remove containers of plutonium-bearing materials currently stored in PFP Facility vaults:

- The dose rate in the vault is 60 millirem/hr (WHC, 1995c); background dose rate outside the vault is 0.5 millirem/hr.
- The configuration of the wagon limits the load to one 7-gallon container or five 7-inch containers.
- Two operators would be involved in this step. The first operator would enter the vault to remove the containers while the other remains outside. On the average, it would take 10 minutes to enter the vault, locate the 7-gallon or 7-inch containers, and move them to the portal for removal.

The total worker dose for this step is estimated at 5.2 person-rem.

2. Load containers onto wagon:

- It would take two operators an average of 10 minutes to load the containers and place a shielding blanket onto the wagon (WHC, 1996c). The first operator would receive dose at the contact rate of 20 millirem/hr. The other operator would receive dose at the background rate of 0.5 millirem/hr.

The total worker dose for this step is estimated to be 1.8 person-rem.

3. Move loaded wagon to the cementation glovebox:

- Two operators would be involved for 10 minutes per trip (WHC, 1996c). A lead-acrylic blanket would be used to provide shielding. The first operator would receive dose at a reduced rate of 10 millirem/hr; the second operator would receive dose at the background rate of 0.5 millirem/hr.

The total worker dose for this step is estimated to be 0.90 person-rem.

Both Inventories

4. Load containers into the glovebox:

- It would take two operators and a radiation control technician an average of 10 minutes to load a batch into the glovebox (WHC, 1996c). Dose rate experienced by the first operator is 20 millirem/hr. The second operator and radiation control technician would receive dose at the background rate of 0.5 millirem/hr.

The total worker dose for this step is estimated to be 2.1 person-rem.

#### 5. Immobilize plutonium-bearing materials in cement matrix:

- The processing rate would be two 3.4-1 (0.9-gal) containers of cemented material per hour.
- The maximum payload limit for a pipe-container-in-drum is 200 g (0.44 lb) of plutonium. To ensure that the drums would meet this requirement, an administrative target of 170 g (0.37 lb) of plutonium would likely be established.
- Because of the configuration of the pipe-container-in-drum, only three containers fit into this pipe. Thus, each container would contain approximately 56 g (0.12 lb) of plutonium.
- Materials at this level of transuranic content have not previously been cemented at the PFP Facility. Dose rate incurred during muffle furnace operation is assumed to bound the dose rate for the cementation process. This assumption is reasonable because the cemented material would provide some degree of self-shielding. The average dose rate for muffle furnace operation is estimated at 0.7 millirem/hr. This estimate is based on the following data: 3,000 person-millirem for three months, 36 person-hour per shift, two shifts per day, and 20 operating days per month. It is assumed that cementation would require a crew similar to that for muffle furnace operation (36 person-hours per shift) (WHC, 1995d).

The total worker dose for this step is estimated to be 7.6 person-rem.

#### 6. Unload the containers of cemented material from the glovebox:

- Unloading a container from a glovebox would involve two operators and a radiation control technician. One operator would handle the container for 20 minutes, while the other operator would handle it for 15 minutes (WHC, 1996b). Both would receive dose at the contact rate of 13 millirem/hr. (The bounding contact dose rate of 20 millirem/hr would be reduced by a factor of 1.5 to account for self-shielding from the cement matrix.) The radiation control technician would receive dose at the background rate of 0.5 millirem/hr for 20 minutes.

The total worker dose for this step is estimated to be 38 person-rem.

#### 7. Package and seal drums:

- It would take an operator 20 minutes to bolt the lid onto the pipe-container and 10 minutes to pack and seal the drum. Dose rate during the first 20 minutes would be 13 millirem/hr; dose rate during the last 10 minutes would be 4 millirem/hr, taking into account shielding and distance. A second operator would receive dose at the background rate of 0.5 millirem/hr for 30 minutes (WHC, 1996b).

The total worker dose for this step is estimated to be 8.4 person-rem.

#### 8. Move drums to staging area:

- It would take two operators approximately 10 minutes to move a drum by dolly to the staging area. The first operator would receive dose at a rate of 4 millirem/hr; the second operator would receive dose at the background rate of 0.5 millirem/hr (WHC, 1996b).

The total worker dose for this step is estimated at 1.2 person-rem.

#### 9. Ship drums to storage:

This step includes loading the drums onto a truck via a forklift, driving the truck to a Hanford Site solid waste management facility, and unloading the truck.

- Loading a truck with 18 drums would be completed by a forklift operator in approximately two hours. Another operator would unload the truck in the same amount of time. Both operators would receive dose at the rate of 4 millirem/hr (WHC, 1996b).
- For each trip, the truck would be driven for approximately 3.2 kilometers (km) (2 miles [mi]) at 24 km/hr (15 mi/hr). The driver would receive dose at a rate not higher than the administrative limit of 2.5 millirem/hr (WHC, 1996b).

The total worker dose for this step is estimated to be 1.5 person-rem.

The total exposure to PFP Facility workers involved in the immobilization of the plutonium-bearing materials is conservatively estimated to be 74 person-rem. Health effects from radiation exposure are computed by application of factors relating latent cancer fatalities (LCF) with the amounts of exposure received. International Commission on Radiological Protection values are used to estimate the effects on PFP Facility workers. The factor is  $4 \times 10^{-4}$  LCF/rem effective dose equivalent for PFP Facility and Hanford Site workers (IRCP, 1991). Thus, the LCF probability for PFP Facility workers for the immobilization alternative is conservatively estimated to be 0.03.

The empty 7-gallon and 7-inch containers would be crushed and placed into 55-gallon drums and disposed of as low-level waste. The worker exposure associated with the disposal of the empty containers would be minor compared to the exposure due to cementation activities.

### Doses from Routine Immobilization Alternative Operations to Hanford Site Workers and the Public

As described in Sections 3 and 5 of this EIS, conservative estimates of the airborne releases from each of the stabilization process steps have been estimated for purposes of comparing alternatives and bounding the anticipated consequences of stabilization activities at the PFP Facility. Similarly, implementation of the immobilization alternative would also result in small routine operational releases from the material being handled. The releases from implementing the immobilization alternative would be filtered through the main PFP ventilation system before being released to the atmosphere through the main exhaust stack. After discharge from the stack, atmospheric dispersion would affect the concentrations of released activity. The applicable dispersion factors for quantifying the concentrations of radioactivity at the receptor locations were calculated using the 1983 to 1987 historical data collected at the Hanford Meteorological Station, as described in Subsection 8.6.3 of the PFP FSAR (WHC, 1995e). The elevated release dispersion factors used in this EIS for routine release are tabulated in Table D-4 of Appendix D of this EIS.

In order to estimate the amount of plutonium-bearing material that could become airborne during the cementation process (pouring the material into a mixing container, adding cement, etc.), the bounding airborne release fraction of  $2 \times 10^{-3}$  and the respirable fraction of 0.3 from DOE Handbook HDBK-3010-94 for free falling powders (DOE, 1994b) were used. The calculations done using these figures give an estimate of the total quantity of material that may be released into the PFP Facility ventilation system. As done for the routine emissions from the other alternatives evaluated in this EIS, credit is taken for the high efficiency particulate air (HEPA) filtration steps prior to release out the PFP Facility stack. Using the same meteorology and release parameters presented in Appendix D of this EIS for the routine releases gives the results shown in Table E-3. The health effects resulting from the calculated doses shown in the table are based on the International Commission on Radiological Protection LCF probability factors (ICRP, 1991) used throughout this EIS.

**Table E-3 Estimated Doses and Health Effects from Routine Operations**

Exposed Individual or Population	Dose Received	LCF Probability
PFP Facility Workers	74 person-rem	0.03
Hypothetical Maximally Exposed Individual (Hanford Site Worker)	$1.2 \times 10^{-4}$ rem	$4.8 \times 10^{-8}$
Hanford Site Workers	$6.2 \times 10^{-4}$ person-rem	$2.5 \times 10^{-7}$

Hypothetical Maximally Exposed Individual (Member of Offsite Public)	2.3 x 10 <sup>-5</sup> rem	1.2 x 10 <sup>-8</sup>
General Public (80-km radius population)	2.2 person-rem	1.1 x 10 <sup>-3</sup>

### E.5.1.2 Accident Condition Exposures from the Immobilization Alternative

This subsection evaluates the health effects that could occur from potential accidents involved with implementing the immobilization alternative at the PFP Facility. These accidents could be initiated by operational events or natural phenomena. Operational events include human error and the physical failure of components and equipment. Natural phenomena involve an earthquake or other catastrophic event and are the same as described in Appendix D of this EIS.

#### Immobilization Accident Scenarios

All of the accident scenarios and frequency of occurrence information described for muffle furnace operations are also generally applicable to immobilization activities. Explosion scenarios are considered to be less plausible in association with immobilization activities than for stabilization processes because process parameters would be controlled to ensure temperatures are low and hydrogen concentration is maintained below lower flammability limits. However, some hydrogen gas could accumulate from cementation chemical reactions and hydrolysis. A fire inside the glovebox where cementation operations would occur is unlikely, and a large fire inside a glovebox interacting with radiological materials is extremely unlikely. A motor associated with equipment (e.g., a mixer) located in the glovebox could catch fire. However, since a motor contains very little combustible material, and since there would not routinely be meaningful quantities of combustible material located in the glovebox, it is extremely unlikely that the radioactive materials located in the glovebox would interact with the fire.

Other accidents postulated in association with immobilization activities are as follows:

- Mishap with equipment located in the cementation glovebox
- Mishap while transporting a drum on a dolly
- Forklift mishap while handling loaded drum(s)
- Vehicle accident while transporting loaded drums from the PFP Facility.

Human error or a malfunction with electro-mechanical equipment used in the cementation glovebox could result in an accident. The effects of such an event would be very localized. It is likely that confinement of radiological materials within the glovebox would be maintained for the majority of human errors or malfunctions that could be postulated. A contaminated wound is an anticipated event for reasons cited in Appendix C of this EIS.

Loaded drums would be transported on a dolly from a satellite area to a staging area. Prior to this movement, the drum's lid would be installed. Because of the strength and integrity requirements of the drums that would be used (WHC, 1983), no credible accident scenario for dolly movement of drums exists that could lead to the release of radiological materials.

A forklift would be used to transfer loaded drums from the staging area in the PFP Facility to a transport vehicle and to transfer the drums from the vehicle to a storage location. A Safety Analysis Report for Building 664 at DOE's Rocky Flats Site provides a frequency of 0.075 per year for the breaching of a drum because of punctures, falls, or collisions (DOE, 1991). The breaching is envisioned to occur for reasons such as: 1) the failure of a forklift's steering or brakes; 2) forklift operator error; 3) maintenance or other heavy equipment malfunction or operator error; or 4) a waste container falling because of unanticipated phenomena. Another approach using Idaho National Engineering Laboratory Radioactive Waste Management Complex data yields a similar frequency. Unusual Occurrence Reports for the Radioactive Waste Management Complex document one forklift puncture producing a contamination event over a 15-year interval for an annual frequency of 0.067.

However, the accident frequencies from both Rocky Flats Building 664 and the Idaho National Engineering Laboratory Radioactive Waste Management Complex are associated with the handling of many thousands of drums. In contrast, the proposed immobilization operations would involve the handling of only 1,600 drums. A forklift mishap is



unlikely, and given the pipe-container-in-drum configuration, it is extremely unlikely that a forklift-induced accident would result in a release of radioactive materials. Even if such an event were to occur, the consequences would be limited to localized contamination.

Groups of drums (e.g., 18 drums) would need to be periodically transported from the PFP Facility to a storage facility (e.g., Transuranic Waste Storage and Assay Facility) on the Hanford Site. The mean accident rate for all classes of vehicles capable of transporting radioactive materials on the Hanford Site is  $1.1 \times 10^{-7}$  accidents per mile (1.6 km) (WHC, 1996d). The Transuranic Waste Storage and Assay Facility is 3.2 km (2 mi) from the PFP Facility. Assuming 18 drums per shipment, 90 trips between the PFP Facility and the storage facility would be required to move 1,600 drums. Based on a total distance of 320 km (200 mi) traveled to ship all of the drums, the chance of an accident would be  $2.2 \times 10^{-5}$ . Assuming only one in every 100 vehicle accidents results in any release of radioactive material, the chance of an accident during the shipment of the drums that would result in the release of radioactive material would be  $2.2 \times 10^{-7}$ , less than one in a million.

### Accident Analysis Methodology

The methodology used to evaluate the health effects from an operational event is based on a fire or explosion occurring during immobilization. For example, an explosion occurring during a glovebox operation could over-pressurize the glovebox and result in the release of plutonium and americium to the room. Another example would be a fire breaching a glovebox, resulting in a plutonium and americium release to the room. It is important to note that for all of the credible accident scenarios postulated, it is assumed that the HEPA filters stay in place, and all contamination releases are contained in the room and ventilation system. None of the bounding accident events would be energetic enough to cause the main filtration system to fail and result in an unfiltered release from the PFP Facility into the environment.

The analysis begins by estimating the amount of plutonium-bearing material that could escape from the glovebox. The quantity released during the accident is calculated by determining the quantity of each isotope that would be involved (at risk) at the time of the accident. Each isotope's mass is then multiplied by the percent released into the atmosphere (i.e., atmospheric entrainment) to give the mass that would actually be airborne. The respirable mass, or amount available for intake, is then found by multiplying the mass airborne by the respirable fraction. An appropriate factor to account for the fraction of material escaping from the glovebox or other confinement is then applied.

The volume of air available for breathing, or breathing zone volume (assumed to be 1,000 cubic meters [m<sup>3</sup>] or 35,000 cubic feet [ft<sup>3</sup>]), is then divided into the respirable mass to determine the respirable air concentration for PFP Facility workers, or the atmospheric dispersion factor applied for Hanford Site workers or the offsite public. This gives the concentration of radionuclides that would be available for intake by the individual immediately following an operational accident.

The impacts from the accidents analyzed are quantified by applying conservatively derived factors as described in this section. Use of the conservative factors result in the identification of the maximally exposed individual. The results of the accidents presented in this EIS are based on the maximally exposed individuals in three categories: 1) PFP Facility workers; 2) Hanford Site workers; and, 3) the hypothetical individual of the public residing at the Site boundary at the time of the accident. These results are useful for comparison among alternatives and will bound actual anticipated effects, but should not be taken as predictive of actual expected exposures. To provide perspective for the magnitudes of the bounding doses calculated for the various accident scenarios, the LCF predicted using the International Commission on Radiological Protection risk estimators (ICRP, 1991) are also presented, although no population exposure estimates have been made.

Consequences of accidents can be quantified by applying the following equation:

$$\text{Dose} = \text{MAR} \times \text{ARF} \times \text{RF} \times \text{LPF} \times \text{BR} \times \text{ACF} \times \text{DCF}$$

where:

Dose = exposure received by the receptor in rem effective dose equivalent

MAR = material at risk in grams (material involved in the accident) taken to be 500 g of plutonium based on glovebox criticality specification limits (WHC, 1995e)

ARF = airborne release fraction (fraction of the material at risk that becomes airborne as a result of the accident). This value is taken to be  $5 \times 10^{-3}$  (DOE, 1994b)

RF = fraction of the airborne material that is respirable (the fraction of airborne material with an aerodynamic equivalent diameter of 10 microns or less). This value is taken to be 0.40 (DOE, 1994b)

LPF = leak path factor indicating the fraction of the airborne material that escapes from any containment or through filtration devices ( $2.85 \times 10^{-4}$  for releases from the PFP Facility stack based on a conservative estimate of dual HEPA or 0.1 for releases from the glovebox for PFP Facility worker exposure)

BR = applicable standard man breathing rate (acute rate of  $3.3 \times 10^{-4}$  cubic meters per second [m<sup>3</sup>/sec] applicable to accident cases)

ACF = airborne concentration factor relating the released material to the concentration in the air at the receptor location in sec/m<sup>3</sup> (C/Q for atmospheric dispersion, or exposure time divided by diluting air volume in the immediate vicinity of the accident for facility workers)

DCF = dose conversion factor relating the exposure received to the amount of material inhaled in rem/g.

Each of the foregoing factors must be selected specifically for the accident scenario being evaluated, based on the energies available to disperse the material at risk, the physical and chemical form of the material, the physical arrangement of the facility, and interactions with any other materials present. Judgement must be used in selecting the parameters to ensure that the consequences will be bounded using the values chosen. Airborne release fractions and respirable fractions were obtained from DOE, 1994b, or the PFP Final Safety Analysis Report (FSAR) (WHC, 1995e). Leak path factors are based on HEPA filtration of contaminated air prior to its release from the PFP Facility for calculating impacts to onsite workers and the hypothetical maximally exposed individual at the Hanford Site boundary. For PFP Facility workers, leak path factors are based on reasonable assumptions concerning the amount of airborne material that could escape from installed equipment configurations.

C/Q values are from the 95 percent meteorological accident case used in the PFP FSAR. For the fire and explosion accidents evaluated, there is insufficient energy to cause the PFP Facility ventilation system to fail. Therefore, 95 percent meteorology C/Q values for an elevated release from the PFP Facility stack were used, to select the worst occupied onsite location and Hanford Site boundary location to maximize the calculated impacts. These worst locations are the 242-S Facility 930 m (0.58 mi) south-southeast of the PFP Facility, and the Hanford Site boundary 12,500 m (7.8 mi) west of the PFP Facility. The C/Q values at those locations are  $1.62 \times 10^{-5}$  sec/m<sup>3</sup> and  $5.73 \times 10^{-6}$  sec/m<sup>3</sup>, respectively. There are closer locations to the PFP Facility for both Hanford Site workers and the Site boundary, but when weighted by the historical meteorology, the selected locations provide maximum doses greater than 95 percent of the time.

The breathing rate used is taken from the International Commission on Radiological Protection Publication 23 (ICRP, 1975). The dose conversion factors are based on the isotope specific values from Eckerman, et al. 1988. A PFP Facility worker exposure time of 60 seconds was used. This exposure time is based on the judgement that involved workers would leave the area immediately in response to any serious accident in accordance with established procedures and common sense practices. The diluting air volume into which the gloveboxes release their contents was taken to be 1000 m<sup>3</sup> (35,000 ft<sup>3</sup>).

Doses and associated health effects for the maximally exposed hypothetical individual for accident cases are presented in this EIS. Because of the large uncertainties in accident probabilities, actual release fractions, physical configurations and numbers and proximities of workers, the maximally exposed individual doses for the three population groups are used to represent the accident consequences and facilitate comparisons among the alternatives. Population exposure estimates could be made, but would be directly proportional to the doses presented, and would, therefore, have no

additional value in judging between alternatives. Because the doses to the maximally exposed individual not working within the PFP Facility are generally small, the health consequences would also be small.

Health effects from radiation exposure are computed by application of factors relating LCF with the amounts of exposure received. International Commission on Radiological Protection values are used to estimate the effects on workers and members of the public. The factors are  $4 \times 10^{-4}$  LCF/rem effective dose equivalent for workers and  $5 \times 10^{-4}$  LCF/rem effective dose equivalent for members of the general public, which could include babies and children as well as adults (ICRP, 1991).

Based on the factors described above, the maximally exposed individuals representing the three population groups would receive the following doses and associated LCF risks shown in Table E-4.

**Table E-4 Anticipated Health Effects from Accident Releases**

Hypothetical Maximally Exposed Individual	Dose Received	LCF Probability
PFP Facility Worker	210 rem	$8.4 \times 10^{-2}$
Hanford Site Worker	$1.6 \times 10^{-4}$ rem	$6.4 \times 10^{-8}$
Offsite Individual	$5.7 \times 10^{-5}$ rem	$2.8 \times 10^{-8}$

## E.5.2 PHYSICAL ENVIRONMENT

Impacts of the immobilization alternative on the physical environment are examined in terms of the following elements:

- Air quality
- Waste treatment, storage, and disposal capacity.

### E.5.2.1 Air Quality

Implementing the immobilization alternative would result in minimal impacts to air quality. HEPA filters in use at the PFP Facility would minimize the amount of contaminants that would be discharged to the atmosphere. Although most expected air contaminants would be trapped by these filters, some fine particulate matter, referred to as PM10 (particulates less than 10 microns in size) would be emitted.

The total estimated release of respirable particles from the immobilization alternative is  $2.6 \times 10^{-9}$  g/sec ( $5.7 \times 10^{-12}$  lb/sec). This value is calculated based on the following:

- A total mass of materials (bulk weight) being handled of 37,000 kg (82,000 lb) or 4,800 3.4-l (0.9-gal) containers of cemented material at 2.2 kg/l (19 lb/gal)
- An airborne release fraction of  $2 \times 10^{-3}$
- A respirable fraction of 0.3 for free fall of powders used to represent the magnitude of release from cementation and packaging (DOE, 1994b)
- The release being routed through double HEPA filters and out the main PFP Facility exhaust stack.

The maximum downwind contaminant concentrations projected by the Environmental Protection Agency Model ISCST3, Version 95-250 (40 CFR 51, Appendix W) and the ambient air standards are provided in Table E-5. The contaminant levels anticipated from the immobilization alternative are much lower than the regulatory ambient air standard.

**Table E-5 Projected Maximum Ground Level Concentrations of Particulate Air Contaminants**

Air Contaminant	Maximum Average Concentration <sup>a</sup> ( $\mu\text{g}/\text{m}^3$ )	Background Concentration <sup>b</sup> ( $\mu\text{g}/\text{m}^3$ )	Ambient Air Standard ( $\mu\text{g}/\text{m}^3$ )
PM10 (24-hr)	$6.7 \times 10^{-9}$	81	150
PM10 (Annual)	$1.4 \times 10^{-9}$	27	50

**Notes:**a. Modeled maximum ground-level concentrations occurred at 630 m from the stack.

b. Background concentrations for PM10 taken from 1987 data (PNL, 1991)

#### E.5.2.2 Waste Treatment, Storage, and Disposal Capacity

Hanford Site solid waste management facilities that would potentially manage waste generated at the PFP Facility include the Transuranic Waste Storage and Assay Facility, the Central Waste Complex, the Low-Level Burial Grounds, and the Waste Receiving and Processing Facility.

The amount of low-level radioactive, mixed, and dangerous waste that would be generated as compared to the amount of transuranic waste that would be generated is small. It is anticipated that the immobilization alternative would generate approximately 1,600 drums of transuranic waste. It is assumed that drums would be transferred from the PFP Facility to the Transuranic Waste Storage and Assay Facility for storage. There is currently space for 500 additional drums of waste at this facility (Irwin, 1996). Additional space would become available when existing drums at the facility are transferred to other Hanford Site solid waste management facilities.

#### E.5.3 TRANSPORTATION

Implementing the immobilization alternative would result in transportation impacts. Over a 6- to 12-month period, up to 90 truck trips would result from the shipment of the immobilized materials from the PFP Facility to Hanford Site solid waste management facilities. This corresponds to an average of 7 to 15 trips per month. These trips would be short in distance (3.2 km [2 mi]) and would be made during off-peak hours. Compared with the volume of vehicular traffic on nearby Hanford Site transport roadways, the additional truck trips would not be expected to adversely impact the existing or future Hanford Site transportation system.

#### E.5.4 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

The most common areas of unavoidable environmental impact are to land use and water resources. Immobilizing plutonium-bearing materials would take place in existing facilities and transportation would be on existing roads, and therefore, would not impact land usage or water resources.

The immobilization alternative involves those actions necessary to process, package, and deliver the plutonium to storage facilities at Hanford Site solid waste management facilities. Actions and associated environmental impacts for subsequent handling and delivery of the plutonium to the final offsite disposal facility are not considered in this EIS.

Implementation of the immobilization alternative would have the potential for unavoidable adverse impacts in the areas of health effects, and accident phenomena.

Under routine operations, health impacts to the PFP Facility workers would be anticipated. The maximum total potential worker dose for all immobilization activities could be 74 person-rem with a corresponding LCF of 0.03.

Hydrogen and other flammable gasses may be generated in the cementing process or through radiolysis. This means that glovebox explosion or fire scenarios are plausible. Human error or a malfunction with electro-mechanical equipment used in the cementation glovebox is also possible. Potential accidents resulting from forklift operation or transportation from the PFP Facility to the selected solid waste management facilities are not considered likely and the consequences resulting from such accidents are expected to be localized.

### **E.5.5 POTENTIAL MITIGATION MEASURES**

Since land use and water resources would not be impacted by the immobilization alternative, no mitigation measures would need to be taken to protect these resources. Mitigation measures as discussed in this EIS (e.g., HEPA filtration of exhaust pathways) would be provided.

As noted in Subsection E.4, the immobilization alternative involves only those actions necessary to process, encapsulate, and deliver the plutonium to the Hanford Site solid waste management facilities. The environmental impacts for subsequent handling and delivery of the immobilized plutonium-bearing materials to the disposal facility are considered not within the scope of this EIS.

To ensure that activities and consequences (e.g., radiological dose to PFP Facility workers) for normal activities would remain within established requirements, and to ensure that the risk of accidents would be minimized, numerous mitigation measures would be taken in association with the immobilization alternative. These measures include adequate engineered design features for gloveboxes, systems, and components; the development of safety analyses consistent with the process established by DOE; and the implementation of numerous programs that already exist at the Hanford Site. Examples of these programs are as follows:

- Maintenance program - Ensures hardware performs as expected when demanded
- Fire protection program - Mitigates property loss and minimizes human health impacts due to fire
- Radiological controls program - Mitigates routine and accident-related doses
- Industrial hygiene program - Mitigates routine and accident-related chemical exposure
- Occupational safety program - Ensures safe and healthful conditions for workers.
- Training program - Minimizes and mitigates adverse impacts to personnel by training them in proper ways to perform their job and to respond during emergency events.

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WHC, 1996c, *Response to 2/28/96 DSI*, Personal communication with Britta Nelson-Maki, Westinghouse Hanford Company, and Dames & Moore, March 4, 1996.

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(1) Pu-239 fissile gram equivalent is a value indicating the quantities of transuranic elements in a material. Pu-239 fissile gram equivalent can be calculated using the method described in Appendix C of the Hanford Site Solid Waste Acceptance Criteria (WHC, 1995a).





## APPENDIX F

# PUBLIC COMMENTS ON THE *PLUTONIUM FINISHING PLANT* STABILIZATION ENVIRONMENTAL IMPACT STATEMENT AND U.S. DEPARTMENT OF ENERGY RESPONSES

### F.1 INTRODUCTION

The U.S. Department of Energy (DOE) completed the *Plutonium Finishing Plant (PFP) Stabilization Draft Environmental Impact Statement (EIS)* in November 1995, and on December 8, 1995, the U.S. Environmental Protection Agency (EPA) published a Notice of Availability for the document in the *Federal Register* (60 FR 63044). EPA's notice started the public comment period on the Draft EIS. A subsequent EPA notice (60 FR 64423) extended the ending date of the public comment period on the Draft EIS to January 23, 1996. During the public comment period for the Draft EIS, 12 individuals provided comments through public hearing testimony and written submittals. Individuals commenting on the Draft EIS represented either themselves, government agencies, or public interest groups. This appendix presents the comments received from the public and government agencies during the comment period and DOE's responses to those comments.

Comments by letter, telephone, voice mail, facsimile, and in formal statements made at the public hearing were accepted. A public hearing was held in Pasco, Washington on January 11, 1996. Comments from three individuals were received at the hearing. Nine letters were received. Two comments were submitted over a toll-free telephone line that was set up to receive comments and requests for documents or information on the Draft EIS and to provide information on the public hearing. Comments received over the telephone were transcribed onto a public hearing comments form and forwarded to the commentor for review and signature. Both commentors who originally submitted their comments over the telephone, signed and returned the form. No comments were submitted by voice mail or facsimile. Each commentor was assigned a unique commentor code as follows:

Hearing: H01 through H03

Letters: L01 through L11

Specific comments by each commentor were numbered sequentially (i.e., 01, 02, etc.) to provide unique identifiers. The names of the individuals, government agencies, and other organizations that submitted comments are provided in Table F-1.

The comment submittal, review, and response process complied with the National Environmental Policy Act of 1969 (NEPA) as amended (42 U.S.C. §§ 4321 et seq.) and the provisions of the Council on Environmental Quality regulations (40 CFR 1500). Comments on the Draft EIS were assessed and considered individually and collectively by DOE.

This appendix responds to all types of comments, even those that did not warrant further action. Comments not requiring an EIS change usually resulted in a response to clear a commentor's concern, an explanation of DOE policy or position, or references to the EIS Scope and Purpose and Need Statement.

### Table F-1 Public Comments on the Draft EIS

Commentor Number	Commentor	Affiliation	Page Number



H01	Gerald Pollet	Heart of America Northwest	F-4
H02	Bob Cook	Self	F-17
H03	Joseph Roemer	Self	F-21
L01	LaPriel C. Barnes	Self	F-30
L02	Marvin Lewis	Self	F-32
L03	Gerald Pollet	Heart of America Northwest	F-34
L04	Pamela Jansen	Self	F-36
L05	Joseph Roemer	Self	F-38
L06	Marvin L. Vialle	Washington Department of Ecology	F-57
L07	Kerry Grant	Washington State Department of Transportation	F-62
L08	Richard B. Parkin	U.S. EPA, Region 10	F-64
L09	Mary Lou Blazek	Oregon Department of Energy	F-67
L10	Al Conklin	State of Washington, Department of Health	F-71
L11	Charles Polityka	U.S. Department of the Interior	F-75

### **F.1.1 HOW DOE CONSIDERED PUBLIC COMMENTS IN THE NEPA PROCESS**

This Final EIS identifies DOE's preferred alternative. The preferred alternative is based on consideration of safety and health impacts to people and the environment, statutory and regulatory compliance, programmatic missions, Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) provisions, public issues and concerns, and DOE policy. Public input considered in DOE's identification of the preferred alternative included concerns, desires, and opinions regarding proposed activities in the EIS. Also considered were the expectations of the public regarding decisions to be made and actions to be taken by DOE within the scope of this EIS.

The Final EIS, including its preferred alternative, will be considered by the DOE Hanford Site Manager, along with other factors, to arrive at a decision to be documented in a Record of Decision. The Record of Decision completion is scheduled for June 1996.

### **F.1.2 CHANGES TO THE EIS RESULTING FROM PUBLIC COMMENTS**

A major purpose of an EIS is to promote efforts that will prevent or eliminate damage to the environment by ensuring informed decision making on major actions significantly affecting the quality of the human environment. Consideration of public comments on the Draft EIS helps ensure that the Final EIS is an adequate decision-making tool. Accordingly, this EIS has been enhanced, as appropriate, in response to specific public comments, issues, and concerns.

Several comments were received regarding a lack of detail pertaining to anticipated health effects. As a result, Appendix D, Anticipated Health Effects under Normal and Accident Conditions, was added to the Final EIS.

## **F.2 STATEMENTS MADE AT PUBLIC HEARINGS**

The following section presents transcripts of comments made during the public hearing held in Pasco, Washington on

January 11, 1996 and the DOE responses to those comments. Specific comments are enumerated and marked in the margin of the transcript. The DOE responses to each comment immediately follow each transcript.



H01-01 In June 1993, DOE announced its proposal to operate certain processes in the PFP Facility to stabilize the reactive materials and prepare an environmental assessment pursuant to NEPA. As part of the NEPA process for the environmental assessment, DOE conducted public meetings in the summer and fall of 1993 in Richland, Seattle, and Spokane, Washington, and in Portland and Hood River, Oregon, to discuss the proposal to stabilize the chemically reactive materials. Hundreds of persons attended these meetings. As a result of the public comments received, DOE decided that an EIS would be the appropriate level of NEPA review.

To support the *PFP Stabilization EIS*, the public scoping process was held over a 45-day period. During this period, 12 scoping meetings were conducted in six cities in Washington and Oregon. DOE revisited the cities where the meetings for the environmental assessment were held in the summer and fall of 1993. The cities included Richland, Seattle, Bellevue, and Spokane, Washington, and Portland and Hood River, Oregon. A total of 30 persons provided comments at the scoping meetings.

Because of the lessened public interest, as shown by the low attendance at the *PFP Stabilization EIS* scoping meetings, and the need to save money, DOE decided that holding only one public hearing was prudent. This is in compliance with DOE's implementing procedures and guidelines for NEPA (10 CFR 1021.313(b)), which states that DOE shall hold at least one public hearing on draft EISs.

Various media were used to solicit comments on the Draft EIS and to notify the public that a public hearing would be held on January 11, 1996 in Pasco, Washington and to provide the opportunity for public input. On December 5, 1995, a Notice of Availability was published in the *Federal Register*; on December 15, 1995 an information flyer was sent to the 4,300 individuals and organizations listed on the Hanford Site "Clean-up List;" on January 7, 1996, advertisements were placed in newspapers originating in Tri-Cities, Seattle, and Spokane, Washington, and Portland, Oregon; and a 24-hour, toll-free telephone line was set up.

During the public comment period, 11 letters were received and there were only three commentors present at the public hearing. DOE has received only one comment requesting that additional meetings be held. Had additional public requests been made, DOE was prepared to hold additional meetings. As a contingency, DOE made reservations for meeting space in Seattle, Washington, and Portland, Oregon. Those arrangements were canceled because few people attended the Pasco, Washington meeting and only one comment was received which requested that an additional meeting be held. Based on the public involvement for the Draft EIS, DOE believes that holding only one public hearing was appropriate.

H01-02 The final disposition of plutonium-bearing materials at the PFP Facility is outside the scope of this EIS. The scope of this EIS covers activities required to stabilize reactive plutonium-bearing materials, without establishing policy or precedent for the disposition of the nation's plutonium stockpile. DOE's *Storage and Disposition of Weapons-Usable Fissile Material Draft Programmatic EIS* (DOE, 1996) scopes alternatives for ultimate disposition of the plutonium-bearing materials, including alternatives involving vitrification and disposal in a geologic repository. This approach is discussed in the Introduction of this EIS.

Vitrification was considered as a candidate process for stabilization of plutonium-bearing materials under the *PFP Stabilization EIS*. Vitrification was rejected as a stabilization technology based on the rationale discussed in Subsection 3.6. Volume increases associated with vitrification are incompatible with the vault storage capability at the PFP Facility. Additional pretreatment steps are needed to accommodate material incompatibility. Operation of a vitrification facility is not compatible with the configuration of the PFP Facility.

H01-03 Regarding disposal of plutonium-bearing materials as waste, this EIS considers only the disposal of materials that have nominal reactivity or minimal plutonium content and thus may be candidates for stabilization measures and vault storage. Disposal actions are limited to those required to meet the waste acceptance parameters of Hanford Site

waste management facilities. These materials may be immobilized through a cementation process. For completeness, this process and its potential impacts are discussed in the EIS. Also refer to response to Comment H01-02.

H01-04 This EIS does not rely upon the *Sludge Stabilization at the Plutonium Finishing Plant Environmental Assessment* (DOE, 1994a). Stabilization of the material "cleaned out" in this EIS is covered in this EIS. Based on this comment, the cumulative impacts from the Environmental Assessment activities have been included for consideration in this Final EIS.

H01-05 The two existing gloveboxes containing muffle furnaces have at least two stages of high efficiency particulate air (HEPA) filters in their exhaust systems. The new muffle furnace gloveboxes would contain a minimum of two stages of HEPA filters in their exhaust systems.

H01-06 Appendix D of this EIS provides the details of the worker exposure calculations and the basis for the estimated background dose rates assumed for the processing activities. As indicated in the comment, not all areas in the PFP Facility have the same background dose rate. The value used for the calculations of potential worker impact, 0.5 millirem per hour (millirem/hr), is representative of the background dose rates for past stabilization activities. Use of this value allows comparison of impacts to workers among the alternatives on a consistent and reasonably conservative basis. Similarly, the assumptions for airborne doses are explained in Appendix D, Anticipated Health Effects under Normal and Accident Conditions.

H01-07 Appendix D of this EIS provides the basis for the accident calculations. The assumptions depend on estimates of releases and properties of the materials being processed, and historical meteorological condition records. The worst-case meteorological conditions are used to estimate accident consequences to provide assurance that the results presented are conservative. These calculations do not depend in any way on the historical calculations by Pacific Northwest National Laboratory (PNNL) of maximally exposed individuals. They are, however, performed to categorize the maximally exposed hypothetical receptors into groups corresponding to their possible location during an accident and the degree of control DOE can be expected to exert on them if an accident were to occur. The consequences are presented for three different groups of potentially exposed individuals: 1) the workers at the PFP Facility; 2) other Site workers at the nearest occupied facility; and 3) a hypothetical individual located at the Site boundary in the closest downwind direction at the time of the accident who is assumed to remain at the centerline of the accident plume for the entire duration of its passage. It is expected that no member of the public would be at that location for that length of time, so this hypothetical individual would represent the maximally exposed member of the public. Any members of the public invited to be onsite (including subcontractors, etc.) would be accompanied by trained workers who would help to shelter or evacuate them if an accident were to occur that threatened their safety. These individuals would not be expected to receive as high a total integrated exposure as the maximally exposed hypothetical individual despite the fact that they may be physically closer to the Facility than the Site boundary for a relatively short period of time. Use of these three classes of individuals to represent the classes of possible consequences of accidents is consistent with past practice, and provides the desired bases for comparisons among alternatives. The consequences are purposely calculated to be conservatively high, so that no real individuals would be expected to receive greater doses under the accident conditions being evaluated.

H01-08 Using the latest published recommendations of the International Commission on Radiological Protection (ICRP, 1991) (which are numerically the same as BEIR-V) on the "stochastic" random or statistical probabilities of a given exposure to ionizing radiation causing a health effect to a whole population of  $5.0 \times 10^{-4}$  latent cancer fatalities (LCF) per rem, indicates that a total dose to the population of 2,000 rem will likely cause one fatality. Any cumulative exposure to doses less than this would not be expected to result in a fatality. Therefore, this EIS correctly states that there would be no fatalities expected from the radiological consequences of the accidents evaluated, with consequences ranging up to 252 rem effective dose equivalent (0.1 LCF). As far as National Emission Standards for Hazardous Air Pollutants and Clean Air Act compliance are concerned, the accident scenarios assumed very conservative release quantities from the different alternative processes which far exceed those actually experienced in operations at the PFP Facility in the past.

H01-09 Waste volume projections for the preferred alternative indicated that up to 1,200 cubic meters (m<sup>3</sup>) (1,570 cubic yards [yd<sup>3</sup>]) of mixed waste would be generated by 2002 due to all activities at the PFP Facility, including

routine activities and decontamination and decommissioning activities (PFP, 1996). Mixed waste quantities due to activities associated with the preferred alternative are incidental to these overall volume projections. The Hanford Site Solid Waste Management Program has accounted for this projection in its future planning. The Hanford Site units that would manage this waste are described in Subsection 4.9 of this EIS. Impacts that may result from the management of this waste stream are described in Section 5 of this EIS. The *Draft Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE, 1995a) is currently evaluating alternatives to manage this waste stream.

It is anticipated that up to 340 m<sup>3</sup> (440 yd<sup>3</sup>) of transuranic mixed waste would be generated by 2002 due to activities associated with implementing the immobilization alternative. This waste stream would be stored at Hanford Site solid waste management facilities identified in Subsection 4.9, and is being taken into account by the Hanford Site Solid Waste Management Program.

H01-10 Refer to response to Comment H01-04.

H01-11 The population basis for the estimates of population effects from normal operations under the preferred and other alternatives at the PFP Facility is explained in Appendix D of this EIS, and is based on the 1997 population extrapolation given in the *PFP Final Safety Analysis Report* (FSAR) (WHC, 1995a), which does take into account the projected growth in the area. Consequences for the accident scenarios presented are given in terms of maximally exposed individuals, a very limited population, with health effects estimated for those individuals using the same LCF probabilities applicable to larger populations. The population distribution indicates that the maximally exposed hypothetical public individual would receive an exposure at least an order of magnitude higher than the average individual in the population. This EIS is using excess LCF probabilities consistent with the latest International Commission on Radiological Protection guidance.

The public accident consequences in the *Environmental Assessment, Sludge and Solid Residue Stabilization at the Plutonium Finishing Plant* (DOE, 1995b) of 0.011 LCF are based on the total exposed population dose of 21.5 person-rem and the  $5.0 \times 10^{-4}$  LCF per person-rem probability. The routine worker exposure estimate referred to by the commentor is 80 person-rem which corresponds to 0.032 LCF. These two numbers are already population exposures and take into account the number of PFP Facility workers exposed and the doses they would receive. There is no factor of ten difference per 100 people as stated in the comment. (Note that the correct risk per 25 millirem is one in 100,000, not one in 10,000 as stated by the commentor.)

Note also that in this comment the conversion of 22 person-rem to average individual dose among the 115,000 population is inverted. "5.2" is the number of people per millirem, not the number of millirem per person as stated, overestimating the alleged effect by a factor of about 28. The 22 person-rem (21.5 person-rem in Table 6 of the *Environmental Assessment, Sludge and Solid Residue Stabilization at the Plutonium Finishing Plant*, [DOE, 1995b]) is a population dose for which the LCF probability of  $5.0 \times 10^{-4}$  is appropriate, resulting in the 0.011 LCF consequence stated. There is no validity in trying to redistribute these numbers and come up with a different answer. Appendix D contains the details of the methodology for calculating the doses and health effects presented in this EIS. For all cases, the doses and effects to the maximally exposed individuals for normal and accident conditions are presented. In addition, to provide further information, the total population doses are also presented for the normal operational exposure scenarios.

H01-12 Refer to response to Comment H01-02.

H01-13 The doses to workers during the alternative processing steps are presented in Appendix D of this EIS, and are composed of both the "ambient room background" levels and contributions from actually handling collected amounts of product in the gloveboxes, based on an actual processing campaign. The 930 person-rem is based on the crew sizes presented in Appendix D spread over the 5.5 operating years as defined. As stated in Appendix D, these dose estimates are higher than doses actually expected to be received by the workers, but are presented on a consistent basis to allow comparisons among alternatives. When the actual processing facilities are designed and installed, as low as reasonably achievable (ALARA) principles and good radiological control practices will limit doses to workers to established limits. Taking the total and assuming a workforce size to get 1.5 rem per worker is not necessarily reasonable, but

further extrapolating that dose amount to the entire Hanford Site population is not appropriate. The total population dose to PFP Facility workers is estimated to be 930 person-rem as stated. This corresponds to 0.37 LCF over the length of time required to complete the processing (about 6 operating years). That is all the LCF there are in the exposure number. Note that it is less than unity, so there are no expected fatalities. As far as maximally exposed hypothetical individual doses versus average population doses are concerned, both values are presented for the normal operations cases so that decisions can be based on a clear understanding of the expected impacts. The size of the exposed population is based on established bases explained in Appendix D, including the actual wind and projected population distributions out to 80 km (50 mi). In the case of the *Environmental Assessment, Sludge Stabilization at the Plutonium Finishing Plant*, (DOE, 1994a), the exposed population of 115,000 is the population living southeast of the PFP Facility out to 80 km (50 mi). The dispersion and dilution of the source makes any doses received beyond 80 km (50 mi) so low that they are negligible. This is not a statistical game, but is based on scientific facts and principles that have been and are accepted by knowledgeable people and regulatory agencies around the world.

H01-14 Historical emissions at the PFP Facility were not used in predicting the plutonium emissions for either the preferred or other alternatives. Calculations were made for each alternative using assumptions that result in potential releases that are much higher than actually expected. All documents referenced in this EIS are publicly available. Key documents were provided to DOE public reading rooms and information repositories. The records alluded to regarding past releases were not relevant to the analyses performed in this EIS.



H02-01 The final disposition of plutonium-bearing materials at the PFP Facility is outside the scope of this EIS. The scope of this EIS covers activities required to stabilize reactive plutonium-bearing materials, without establishing policy or precedent for the disposition of the nation's plutonium stockpile. DOE's *Storage and Disposition of Weapons-Usable Fissile Material Draft Programmatic Environmental Impact Statement* (DOE, 1996) scopes alternatives for ultimate disposition of the plutonium-bearing materials, including alternatives involving vitrification and disposal in a geologic repository. This approach is discussed in the Summary and Introduction of this EIS.

Vitrification was considered as a candidate process for stabilization of plutonium-bearing materials under the *PFP Stabilization EIS*. Vitrification was rejected as a stabilization technology based on the rationale discussed in Subsection 3.6. Volume increases associated with vitrification are incompatible with the vault storage capability at PFP. Additional pretreatment steps are needed to accommodate material incompatibility. Operation of a vitrification facility is not compatible with the current configuration of the PFP Facility.

H02-02 The purpose of an environmental impact statement is to present the results of the analyses that were performed, not to make any conclusions. DOE's decision will be made in the Record of Decision, a document which follows the issuance of the Final EIS.

Although DOE holds the health and safety of workers and the public in the highest regards, the potential impacts to other areas of the environment will also be considered in DOE's decision. In making that decision, DOE considers, but is not limited by the rationale behind past Records of Decision.

DOE is not making a decision to decontaminate and decommission the PFP Facility in this EIS. Therefore, the inclusion of decontamination and decommissioning activities is beyond the scope of this EIS.

H02-03 Refer to response to Comment H02-01. Since final disposition is not being considered in this EIS, associated cost savings are not relevant.

H02-04 A number of studies have been conducted comparing the efficiencies of various types of air purification equipment. One 1989 study by the International Atomic Energy Agency entitled *Treatment of Off-Gas from Radioactive Waste Incinerators* (IAEA, 1989) states that electrostatic precipitators typically have a cleaning efficiency of 98 percent for particles 0.3 microns in size, 91 to 99 percent for particles ranging from 0.5 to 1 micrometers in size, and 95 to 99 percent for particles ranging in size from 1 to 10 microns. For these larger particles, cleaning efficiencies for electrostatic precipitators may approach 99.9 percent.

HEPA filters are defined as being 99.97 percent effective for 0.3-micron particles of dioctylphthalate aerosol. In their paper, "Prediction of HEPA Filter Pressure Drop and Removal Efficiency During Dust Loading," Letourneau, et al. (1989), demonstrate that filters in general have increased efficiency as they are loaded with particles. Letourneau, et al. and others clearly show that efficiencies for HEPA filters exceed 99.999 percent with particulate loading of 0.015 cm<sup>3</sup> of submicrometer particulate per 100 cm<sup>2</sup> of filter material. It is clear that HEPA filtration systems provide greater air cleaning capability than electrostatic precipitators.

H02-05 International Commission on Radiological Protection Publication 66 (ICRP, 1994), published in 1994, contains an excellent description of the evolution of respiratory tract modeling for dose assessment purposes. The models have evolved over the past few decades. The initial models were based on very limited understanding of retention times and mechanisms, as well as limited knowledge about aerosol characteristics to which exposures were postulated. With the issuance of each new generation of models, considerable effort has been expended in their verification and definition of limitations and exceptions to their use. The national and international councils responsible for radiation protection agreed that despite the limitations in representivity of the models for specific conditions, the conservatism built into the assumptions, coupled with the uncertainties about actual exposure conditions, would in general lead to acceptable levels of quantification. There is now an excellent understanding of the effects of particle size on respiratory functioning. Inhalation dose factors based on modern models are felt to be very representative of the actual doses that would be received. In any case, the models used in this EIS are approved by the National Council on Radiation Protection for this use. Other than for questions on proper use and interpretation of the factors used, arguments on their general validity and applicability are outside the scope of this EIS.



H03-01 An EIS should be prepared to present technical material in language that a lay person can understand. The Council on Environmental Quality regulations implementing the procedural provisions of NEPA require that an EIS be written in plain language and suggest appropriate graphics so that the decision makers and the public can readily understand them (40 CFR 1502.8). The intent of the document is to inform, not intimidate the interested public.

The *PFP Stabilization EIS* presented particular challenges because of the nature of the problems and potential solutions. It is evident from your comment that the level of detail needed to inform the public was not sufficient to satisfy the needs of a person who is already very familiar with the processes at the PFP Facility. The Draft EIS provided three additional levels of information to support the analysis and the needs of the critical reviewer.

1. The appendices at the end of the EIS provided additional information on the PFP Facility (Appendix A), engineering assumptions, process flow diagrams, and material balances (Appendix B), and accidents (Appendix C). In the Final EIS, additional appendices have been provided to discuss the radiation health effects analysis (Appendix D) and the immobilization alternative (Appendix E).
2. Key documents used to support the preparation of the EIS (such as the *Plutonium Finishing Plant Final Safety Analysis Report* [WHC, 1995a]) were provided to libraries throughout the Northwest and in Washington D.C. A list of these libraries was included in the cover letter that accompanied all copies of the Draft EIS.
3. Only publicly available documents were used in the preparation of the EIS. None of the documents used were restricted in distribution so that they would be available through college, university, or DOE libraries or by calling our telephone hotline number.

H03-02 The definition for PM<sub>10</sub> has been included in the Glossary. In this document, fine particulate matter from the alternative process exhausts is made up of plutonium and other miscellaneous metal oxides. The isotopic mix used in this EIS is included in Appendix D.

H03-03 The Council on Environmental Quality regulations for implementing the procedural provisions of NEPA require environmental impact statements to "succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives."

In keeping with the regulations (40 CFR 1502.15), Section 4, Affected Environment, of the *PFP Stabilization EIS*

provides a cursory description of the Hanford Site and the surrounding communities that may be affected by the proposed actions. Section 4 of this EIS concentrates most of the description on the 200 West Area where the PFP Facility is located. This is appropriate considering that most of the potential impacts would be concentrated within the 200 West Area.

H03-04 The analysts chose to use an overall efficiency of 99.999 percent for the two final-stage HEPA filters prior to stack discharge. The efficiency of ceramic filters in the various alternatives was not included because we could not certify the removal efficiency associated with ceramic filters.

DOE agrees that HEPA filters test at 0.9997 percent; however, problems associated with handling and installing filters have prompted the establishment of in-place performance standards of 0.9995 percent for in-place testable stages (Gonzales, et al., 1976).

The following is taken from "Performance of Multiple HEPA Filters Against Plutonium Aerosols" (Gonzales, et al., 1976). Although this work addressed three stages of HEPA filters the concept is applicable to situations involving two sets of filters. According to the authors:

Individual HEPA filters provide a DF (decontamination factor) of approximately  $2 \times 10^3$ , and three in series theoretically could provide a DF of approximately  $8 \times 10^9$ , if all filters performed equally well. However, each stage of filtration modifies the challenge aerosol so that particle diameters at each successive filter stage approach a size of maximum penetration (SMP). Performance of the second and third filters against this most difficult-to-collect aerosol limits the overall system DF.

Based on this, the efficiency of two banks of HEPA filters used in the EIS (99.999 percent) is reasonably conservative.

Since the efficiency of filters upstream of the HEPA filters cannot be tested, only assumed, it was reasonably conservative not to take credit for these filters.

H03-05 The conservatism applied in calculating the radiation exposures to workers and the public was not excessive. The purpose of the conservatism was to bound the potential impacts of radiation exposure. The resulting bounding conditions are well within acceptable air quality limits and therefore should not be a concern to the public.

H03-06 The term HEPA filter has been redefined in the Glossary. As defined, HEPA filters are those with a minimum installed capture efficiency of 99.95 percent for particulates down to 0.3 microns in diameter. HEPA filters can remove particles down to less than 0.3 microns in diameter.

It is not necessary for the EIS to discuss how a HEPA filter works, only to provide a definition.

H03-07 Offgas mass emissions for each process were determined as part of the process flow diagrams and material balances (see Appendix B). Emissions were averaged for process batch completion times. Particulate matter was reduced to reflect a final HEPA removal efficiency of 99.999 percent and any internal collection by scrubber. Estimated particulate matter releases from the *PFP Stabilization EIS* investigated processes are partially plutonium and other metal oxides. Under federal and state air quality standards the final stack emission must be considered both as particulates and as radionuclides.

H03-08 Refer to response to Comment H03-05.

H03-09 The Council on Environmental Quality regulations are specific on the types of analyses that must be conducted and alternatives compared in the preparation of an EIS. A simple inspection of the environmental status of the PFP Facility and its surroundings will not suffice as scientific evidence of the consequences of stabilizing the plutonium-bearing material at the PFP Facility. Also refer to response to Comment H01-01 regarding the public's request for an EIS.

H03-10 The assumptions used in calculating the material balances in Appendix B are identified for each alternative evaluated. For muffle furnaces, one percent of the plutonium oxides in the feed was assumed to be exhausted in the

offgas. We interpret the comment to mean that the stated assumption is overly conservative and that actual plutonium oxides in the offgas will be much less than estimated using the assumption.

The intended purpose of the material balances was to bound the emissions for environmental impact analysis and allow comparison among the alternatives where significant differences were expected. We believe the assumption and related material balance were adequate for this purpose.

H03-11 The *PFP Stabilization EIS* satisfies the requirements of NEPA (42 U.S.C. §§ 4321, et seq.), DOE NEPA Implementing Procedures (10 CFR 1021), and the Council on Environmental Quality (40 CFR 1500) regulations.

The Council on Environmental Quality regulations for implementing the procedural provisions of NEPA state that;

NEPA's purpose is not to generate paperwork - even excellent paperwork - but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore and enhance the environment.

The proposed actions should be described in sufficient detail so that their potential impacts can be identified. In addition, EISs should not address insignificant impacts in detail, but indicate that all relevant environmental attributes were considered and provide enough information to show why greater consideration is not needed.

### **F.3 CORRESPONDENCE RECEIVED FROM GOVERNMENT AGENCIES AND THE PUBLIC**

The following section presents copies of letters received during the public comment period for the Draft EIS and the DOE responses to those comments. Specific comments are enumerated and marked in the margin of the letters. The DOE responses to each comment immediately follow each letter.



L01-01 Plutonium and other transuranic elements were produced artificially in our nation's nuclear reactors. These radioactive materials constantly give off energies associated with their decay into less radioactive species. Eventually, all radioactive materials will decay into non-radioactive materials, however this process happens very slowly, over the course of thousands or even millions of years. It is not possible to destroy radioactive materials or to artificially render them non-hazardous. It is thus necessary to manage these radioactive materials in a manner that is protective of human health and the environment. There are no ground-based facilities available for disposal of the plutonium-bearing materials at the PFP Facility. It is necessary to store these materials in a manner that protects the workers, public, and environment. The *PFP Stabilization EIS* scopes the alternatives available to do so.

L01-02 The plutonium-bearing materials at the PFP Facility are not and will not be sold to other countries. Stringent safeguards are in place to protect the materials until decisions are made on how to safely dispose of them.



L02-01 The proposed actions would not result in contaminated discharges to the environment that would require groundwater monitoring. Hazardous liquid effluents produced from the stabilization activities would be sent to the 200 Area Tank Farms. The subject tanks are double-walled tanks with leak detection and are effective at keeping liquid waste out of the environment. Some effluents that have not come into contact with hazardous or radiological contaminants would be sent to the 200 Area Treated Effluent Disposal Facility, a facility permitted by Washington's Department of Ecology that discharges wastewater to the ground.



L03-01 Appendix D of this EIS presents the details of the health effects calculations. The LCF probabilities used are from BEIR V (NRC, 1990),  $5.0 \times 10^{-4}$  LCF per rem for the general population, and  $4.0 \times 10^{-4}$  LCF per rem for



workers. Both maximally exposed individual and population dose exposures in effective dose equivalents, consistent with 40 CFR 61, are given for normal operational conditions for three classes of individuals: 1) PFP Facility workers; 2) Hanford Site workers; and 3) the public. No individual member of the general public is estimated to receive greater than 10 mrem/yr from routine operational releases from implementing the alternatives described in this EIS, nor will the cumulative impacts from the entire Hanford Site exceed this exposure level under normal conditions. These dose projections are consistent with the requirements of 40 CFR 61, although they are hypothetical projections, not actual measured values. During operations, actual measurements will be taken consistent with applicable regulatory requirements.



L04-01 Thank you for your comment.



L05-01 The assumptions and supporting calculations for the EIS are contained in Appendices B and D.

The *PFP Stabilization EIS* satisfies the requirements of NEPA (42 U.S.C. 4321 et seq.), DOE NEPA Implementing Procedures (10 CFR 1021), and the Council on Environmental Quality (40 CFR 1500) regulations.

The Council on Environmental Quality regulations for implementing the procedural provisions of NEPA state that:

NEPA's purpose is not to generate paperwork - even excellent paperwork - but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore and enhance the environment.

The proposed actions should be described in sufficient detail so that their potential impacts can be identified. In addition, EISs should not address insignificant impacts in detail, but indicate that all relevant environmental attributes were considered and provide enough information to show why greater consideration is not needed.

L05-02 DOE is particularly sensitive to radiation doses incurred by PFP Facility and Hanford Site workers and the public. One of the prime reasons for this action is to reduce future worker dose. Additional wording to explain the different dose models for PFP Facility workers, Hanford Site workers, and general public are now included in Appendix D of this EIS.

L05-03 The definition for PM10 has been included in the Glossary. In this document, fine particulate matter from the alternative process exhausts is made up of plutonium and other miscellaneous metal oxides.

L05-04 The term HEPA Filter has been redefined in the Glossary. As defined, HEPA filters are those with a minimum installed capture efficiency of 99.95 percent for particulates down to 0.3 microns in diameter. HEPA filters can remove particles less than 0.3 microns in diameter.

It is not necessary for the EIS to discuss how a HEPA filter works, only to provide a definition.

L05-05 Differences in ground acceleration projections are discussed in the EIS. The Geomatrix (WHC, 1993) peak ground acceleration values are somewhat higher than the Woodward-Clyde Consultants (WHC, 1989) values because Geomatrix 1) used multiple attenuation models, some with higher levels of dispersion; 2) updated estimates of earthquake occurrence; and 3) included additional sources of potential future earthquakes.

The Safety Analysis Report for the PFP Facility will address the different Hanford Site seismic analyses and their applicability to the PFP Facility. It is not the intent of, nor is it appropriate for, this EIS to independently evaluate the applicability of different seismic models and their impact on the PFP Facility.

L05-06 One objective of this EIS is to determine the environmental effects resulting from the stabilization of the plutonium-bearing materials in the PFP Facility. To accomplish this, a review of the surrounding environment and existing facilities was accomplished. This information is presented in Section 4, Affected Environment. The information is useful for EIS readers and decisionmakers to understand the present status of the surrounding environment.

Once environmental conditions in the surrounding environment were identified, the potential effects of plutonium stabilization activities on this environment were evaluated.

In this EIS, the impacts associated with plutonium stabilization were not limited to the PFP Facility. The information presented in Section 4, Affected Environment, will allow readers to draw their own conclusions regarding the impacts of the proposed action relative to historical impacts.

L05-07 Conservative assumptions were made throughout the EIS. These assumptions simplified the analysis and were used to bound the potential impacts from the stabilization alternatives. Whereas some of the assumptions are known to be extremely conservative, the assumptions were applied consistently throughout the document. The consistent application of these assumptions allows a fair comparison of the alternatives and bounds the impacts.

The comment suggests that some technologies might be rejected as the result of conservative assumptions made during analysis. Subsection 3.6 of the EIS describes the alternative selection methodology. Technologies were not disqualified based on conservative assumptions. Rather, conservative assumptions were made during the evaluation of qualified technologies.

L05-08 DOE agrees that HEPA filters test at 99.97 percent; however, problems associated with handling and installing filters have prompted the establishment of in-place performance standards of 99.95 percent for in-place testable stages (Gonzales, et al., 1976).

The following is taken from "Performance of Multiple HEPA Filters Against Plutonium Aerosols" (Gonzales, et al., 1976). Although this work addressed three stages of HEPA filters the concept is applicable to situations involving two sets of filters. According to the authors:

Individual HEPA filters provide a DF (decontamination factor) of approximately  $2 \times 10^3$ , and three in series theoretically could provide a DF of approximately  $8 \times 10^9$ , if all filters performed equally well. However, each stage of filtration modifies the challenge aerosol so that particle diameters at each successive filter stage approach a size of maximum penetration (SMP). Performance of the second and third filters against this most difficult-to-collect aerosol limits the overall system DF.

Based on this, the efficiency of two banks of HEPA filters used in the EIS (99.999 percent) is reasonably conservative.

Since the efficiency of filters upstream of the HEPA filters cannot be tested, only assumed, it was reasonably conservative not to take credit for these filters.

L05-09 The National Ambient Air Quality Standards (40 CFR 61) for the listed gases and particulates were used in the EIS for impact analysis. The EIS discussion of standards for air quality are based on federal and state standards. What the commentor discusses are industrial hygiene standards, which are not applicable to the EIS section on Air Quality.

L05-10 The safety margins applicable to working with radioactive materials can be categorized into three main groups: 1) physical and engineering controls that are conservatively devised and implemented to provide greater protection than is actually required by the type and amount of material in use; 2) conservatism in the derivation and implementation of applicable dose limits and standards; and 3) conservatism in the derivation of dose response factors relating consequences to exposures received. Both design practices and work controls implemented at the Hanford Site are devised to provide more than adequate protection from materials anticipated to be involved in the work, to account for possible deviations and variations in material properties and work activities. National and international regulatory bodies have adopted conservative standards and requirements to ensure that people exposed within the limits proposed would not receive harmful effects, and have adopted conservative dose response factors and relationships that are

generally felt to overestimate the effects from radiation exposure. It is not possible to accurately quantify all of the conservatisms and margins of safety that would be involved in implementing the various alternatives. This EIS, therefore, simply states that the results presented are conservative overestimations of the actual impacts that would be anticipated from implementing the various alternatives, presented for comparisons among the choices, and to ensure that actual effects would be less than those stated. There are many excellent discussions of the margins of safety involved in radiation protection in the public literature, and rehashing these issues in this EIS is not felt to be productive or essential in making decisions among alternatives.

L05-11 The impacts presented in this EIS are not intended to either diminish management's ability to manage nor scare the public. The impacts have been calculated on a consistent and reasonable, although admittedly conservative, basis to ensure that no one would receive effects greater than those presented and to allow comparisons among the alternatives. No expected latent cancer fatalities would result from routine operations for the stabilization alternatives. The potential impacts from the bounding accidents must be considered in concert with the associated possibilities of the accidents happening. Accidents during implementation of the alternatives discussed in this EIS could have some serious consequences to workers. However, design practices and administrative controls on the work performed would ensure that accident risks are reduced to within acceptable levels.

L05-12 The selected release materials are air quality contaminants by regulation. The criteria pollutants (PM<sub>10</sub>, CO, and NO<sub>x</sub>) involved have ambient air quality standards with which to compare projected downwind concentrations. Styrene is an Ecology-listed Toxic Air Pollutant, for which an Acceptable Source Impact Level has been promulgated. When tasked with an impact requirement, it is required that the regulated emissions be evaluated. The EIS evaluated plutonium as both a non-radionuclide and radionuclide contaminant.

L05-13 It is unclear from the comment what regulatory standard DOE may be violating.

Although conservatively derived, there is no intention for the calculated emission rates to be misleading. They are simply based, as stated in the text, on a certain fraction of the material being processed becoming entrained in the exhaust airflow, processed and released through the two-stage HEPA filtration, and released with the normal stack flow from the PFP exhaust stack. They have been consistently calculated to allow comparison among the alternatives.

L05-14 Refer to response to Comment L05-01. Since no work would occur in the PFP yard outside the building, such a disturbance was not analyzed.

L05-15 DOE believes the level of analysis was adequate to address public concern. Spectrographic analysis was not performed during preparation of this EIS. This analysis was not required to complete the selection and evaluation of the proposed action.

L05-16 The assumptions used in calculating the material balances for each alternative evaluated are identified in Appendix B. For muffle furnaces, one percent of the plutonium oxides in the feed was assumed to be exhausted in the offgas. We interpret the comment to mean that the stated assumption is overly conservative and that actual plutonium oxides in the offgas will be much less than estimated using the assumption.

The intended purpose of the material balances was to bound the emissions for environmental impact analysis and allow comparison among the alternatives where significant differences were expected. We believe the assumption and related material balance were adequate for this purpose.

L05-17 Refer to response to Comment L05-16.

L05-18 Refer to response to Comment L05-16. Stack alarm limits are not pertinent to the development of the bounding air quality analyses.

L05-19 Inconsistencies have been corrected.

L05-20 Appendix D of this EIS provides the details on the normal and accident release calculations. The normal release figures used are the same as those presented in EIS Sections 3 and 5.

L05-21 Isotopic composition was considered during analysis of routine and accident conditions. These compositions for each inventory group defined are included in Appendix D of this EIS.

L05-22 Refer to response to Comment L05-03.

L05-23 Whereas the alpha particle is the primary method of radioactive decay for plutonium, we do not believe that it is appropriate to include this in the definition of the alpha particle. Radioactive decay is further explained in Appendix D of this EIS.

L05-24 Accepted. Changes to the text have been incorporated.

L05-25 Accepted. Changes to the text have been incorporated.

L05-26 Refer to response to Comment L05-04.

L05-27 Alpha particle recoil was examined and determined to be a theoretical contributor to release. Its actual contribution could not be determined based on current knowledge.

L05-28 The definition of "hood" is correct.

L05-29 As defined by DOE Order 5820.2A, low-level waste is radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material.

L05-30 The comment is basically correct; however, as used in this EIS, the word "particulates" is only associated with air quality issues. The definition is, therefore, adequate.

L05-31 The comment is basically correct; however, as used in this EIS, the definition of "precipitate" is adequate.

L05-32 The purpose of Figure 4-4 is to provide general information on hydrological surface features in the vicinity of the 200 West Area. At the beginning of Section 4, the reader is referred to the documents titled *Hanford Site National Environmental Policy Act (NEPA) Characterization*, Revision 7, (PNL, 1995a) and the *Hanford Site Environmental Report for Calendar Year 1994* (PNL, 1995b). These two documents provide detailed information about the Hanford Site.

L05-33 Risk is classically defined as the frequency of occurrence of an undesired event multiplied by the consequences (e.g., human health effects) of such an event. This definition is routinely employed in the scientific community and in various textbooks. For most of the undesired events discussed in the EIS, data do not exist to support a scientifically meaningful time-dependent distribution function as to when the undesired event is most likely to occur over the given frequency interval. Even if data did exist to support the development of time-dependent distribution functions, such functions are considered to be beyond the scope of this EIS, and, for the vast majority of the accident phenomena discussed in this EIS, are not considered to inform an agency and the public in making reasonable choices among alternatives.

L05-34 Refer to response to Comment L05-01. The qualifications of the individuals who prepared this EIS are included in Section 8.

L05-35 This EIS was reviewed by personnel knowledgeable of PFP Facility operations, personnel from three national laboratories, and DOE Richland Operations Office and Headquarters personnel.

L05-36 In June 1993, DOE announced its proposal to operate certain processes in the PFP Facility to stabilize the reactive materials and prepare an environmental assessment pursuant to NEPA. As part of the NEPA process for the environmental assessment, DOE conducted public meetings in the summer and fall of 1993 in Richland, Seattle, and Spokane, Washington, and in Portland and Hood River, Oregon, to discuss the proposal to stabilize the chemically-reactive materials. Hundreds of persons attended these meetings. As a result of the public comments received, DOE decided that an EIS would be the appropriate level of NEPA review.

L05-37 The historical impacts resulting from Hanford Site and/or PFP Facility activities do not provide justification to not evaluate the impacts of the proposed stabilization activities. See responses to Comments L05-36 and H01-01 for an explanation of the need for an EIS.

The comment correctly identified that all stabilization activities will be operated in accordance with applicable regulations. These regulations provide protection to people and the environment from the risks associated with the proposed activities. However, Council on Environmental Quality guidelines do not permit an assessment of the impacts which simply states that emissions will be below applicable standards. An evaluation of the possible impacts is required. This evaluation helps decision makers and the public understand the alternatives and their impacts.

L05-38 The preparation of this EIS, to satisfy NEPA requirements, will cost approximately \$2.4 million. This includes costs for scoping, issuing the Implementation Plan, issuing the Draft and Final EIS, and activities supporting the Record of Decision.

L05-39 Refer to response to Comment L05-36.



L06-01 The Council on Environmental Quality regulations do not require that a justification for choosing a preferred alternative be presented in an EIS. However, several different stabilization alternatives were identified that represented acceptable technologies. These were identified with the assistance of personnel from Pacific Northwest National Laboratories (PNNL), DOE's Maintenance and Operations Contractor, and DOE during 1994 and 1995 (see Sevigney et al., 1995). The preferred alternative was selected from the acceptable alternatives based on the professional judgement of engineers and scientists from PNNL, the General Support Services Contractor (GSSC), DOE's Maintenance and Operations Contractor, DOE, and an independent consultant.

The Record of Decision will present DOE's decision on which alternative to implement as well as the rationale behind that decision.

L06-02 The Council on Environmental Quality regulations for implementing the procedural provisions of NEPA (40 CFR 1500.14) state that the alternatives section should present the environmental impacts of the proposed action and the alternatives in comparison form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public.

Subsection 3.5 of the EIS contains a comparison of all alternatives analyzed. We believe that the key issues have been defined. These include health effects, effluent generation, and to a lesser degree, population and socioeconomic effects. Because of the number of alternatives considered, the comparison was spread over several tables. The Council on Environmental Quality regulations do not prevent us from taking this approach.

L06-03 An environmental impact statement is required to evaluate the anticipated effects from all alternatives analyzed, to human resources and the natural environment. Although operational as well as capital costs will be factored into DOE's decision, they are not the predominant factor. The costs for the alternatives analyzed are comparable.

L06-04 The *PFP Stabilization EIS* uses the phrase "interim storage" in lieu of "short-term storage." Interim storage as defined in the glossary, is safe and secure storage pending final disposition. This coincides with the terminology used by the *Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement* (DOE, 1996).

The phrase "long-term storage" taken in the context of the Programmatic EIS and the *PFP Stabilization EIS* has been added to the glossary. Long-term storage refers to the storage of national security and programmatic inventories of highly enriched uranium, plutonium, minor actinides, and surplus weapons-usable fissile materials. The duration for long-term storage will be determined by the Record of Decision for the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement*. Facilities for the secure long-term storage of both

strategic and surplus weapons-usable fissile materials covered by this Programmatic EIS, would be designed to operate for at least 50 years.

L06-05 The purpose and need for this EIS is as follows:

Unstable forms of plutonium in the PFP Facility pose risks to workers, the public, and the environment. DOE needs to expeditiously and safely reduce radiation exposure to workers and the risk to the public; reduce future resources needed to safely manage the Facility; and remove, stabilize, store, and manage plutonium pending DOE's future use and disposition decisions.

To date, DOE has not made a programmatic decision on the disposition of the materials covered by the *PFP Stabilization EIS*. When such a decision is made, the need for any additional treatment of the plutonium-bearing material will be determined. At that time, the need for NEPA documentation will be evaluated.

L06-06 The schedule for completion of stabilization activities would not affect the overall analyses presented, and therefore has not been included in the EIS to allow flexibility in conducting the proposed actions. The operational duration of stabilization activities would extend from 1996 to 2002, and is consistent with the *DNFSB Recommendation 94-1 Hanford Site Integrated Stabilization Management Plan* (WHC, 1995b). The level of risk posed by the plutonium-bearing materials has been considered by DOE, and associated priorities are reflected in the milestones contained in the above reference.

L06-07 The purpose of this section is to identify areas where plutonium-bearing materials are in hold-up. The pipes and storage tanks located in Building 241-Z were identified as a hold-up location. The lines within Building 241-Z are single wall stainless steel. The transfer lines between Building 241-Z and the 200 Area Tank Farms are double walled steel with leak detection and cathodic protection.

Any actions taken as a result of this EIS will be in compliance with applicable federal and state regulations.

L06-08 The term "DOE storage standard" refers to DOE-STD-3013-94, *Criteria for Safe Storage of Plutonium Metals and Oxides* (DOE, 1994b). This is referenced in Subsection 3.2.1.1.

L06-09 The degree to which the readily retrievable plutonium material would be removed will be determined following characterization of the material. This decision would be based on ALARA principles.

L06-10 The costs of the alternatives analyzed are comparable and therefore cost was not considered a relevant selection criterion.

L06-11 The alternatives are discussed in sufficient detail to inform the reader and to permit DOE to make an informed decision. The *PFP Stabilization EIS* has been prepared to comply with the Council on Environmental Quality regulations for implementing the procedural provisions of NEPA. Specific measures have been taken to prepare an analytic rather than encyclopedic EIS, and to discuss only briefly the insignificant issues.

L06-12 A comparison of the anticipated environmental impacts of the alternatives is contained in Subsection 3.5. This approach is consistent with Council on Environmental Quality regulations.

L06-13 The purpose of Section 5, Environmental Impacts, is to present the results of the analyses that were performed, not to make any conclusions. NEPA requires that agencies follow a specific course of action before making a decision. DOE's decision will be made in the Record of Decision, a document which follows the Final EIS.



L07-01 Thank you for your comment.



L08-01 The purpose of this section is to summarize information presented in more detail in Section 5. This section of the text has been revised to include a reference to Section 5.

L08-02 The mitigative features described in Subsection 5.1.12 will be fully implemented in accordance with existing programs and practices at the Hanford Site for any alternative selected.

L08-03 The Summary and Section 7, Statutory and Regulatory Requirements, have been expanded to include a discussion of the Tri-Party Agreement and the role this agreement plays on the Hanford Site (Ecology, EPA, and DOE, 1994). The Tri-Party Agreement establishes the regulatory framework under which the Hanford Site waste management and cleanup must occur. It establishes an action plan for cleanup that contains priority actions/problems and milestones. The Tri-Party Agreement sets milestones to achieve coordinated cleanup of the Hanford Site and provides and uses enforceable milestones to keep the program on schedule. The Tri-Party Agreement establishes the applicability of the Resource Conservation and Recovery Act of 1976 (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and their amendments to the Hanford Site.

No CERCLA activities would be occurring under this EIS, therefore it is unnecessary to provide a description of the act.

L08-04 Clarifying language has been added to the Summary and the Introduction of this EIS.

L08-05 As indicated in Subsection 5.1.10, occupational radiation exposures would be controlled to meet EPA and DOE standards, as well as ALARA principles. PFP Facility worker doses would be controlled to meet all applicable standards and operating restrictions. Appendix D of this EIS has been added to provide a brief description of the consequences of exposure to radioactivity.



L09-01 DOE recognizes the vulnerability associated with container pressurization due to radiolysis. As described within Subsection 3.1.1.3, radiolysis is caused by the contact of the plutonium-bearing material with the organic material used in container packaging. Radiolysis contributes to the failure of the storage containers. DOE does not feel that providing the information requested would influence its decision.

L09-02 Solvent dissolution was not considered a viable pretreatment process in the absence of laboratory developmental testing identifying an appropriate organic solvent.

The commentor's reference to the 400 grams of plutonium that could be associated with the offgas stream is tied to an assumption that 1 percent of the plutonium is entrained in the offgas stream. This assumption is very conservative in order to bound the associated impacts and waste streams. The actual quantity of plutonium that would be associated with the subject organic waste stream would be much less. Similar conservative assumptions would be applied to estimating the quantity of plutonium that could be theoretically filtered from a solvent dissolution liquid waste stream as suggested.

L09-03 A more detailed examination of the criticality potential associated with the addition of foam would be performed prior to activities affected the ductwork. Analyzing this specific job evolution (i.e., the addition of foam) as regards criticality is considered too detailed for inclusion in the EIS. The appendices already contain substantial discussions regarding criticality concerns. Criticality-related safety analyses per appropriate DOE Orders would be developed prior to the proposed activity. Additionally, criticality safety evaluations and criticality prevention specifications are developed on a "case-by-case" basis. Subsection 3.2.2 of the Draft and Final EIS lists characterization of ductwork contamination as the first step in removal of readily retrievable plutonium-bearing material from ductwork. The information from this characterization effort would be analyzed with other factors (e.g., reflection, moderation, geometry, etc.) to ensure that the addition of foam does not present a criticality hazard. It is assumed that the distribution of plutonium-bearing materials in combination with these "other factors", will render the addition of foam an unimportant contributor in regard to criticality concerns.

L09-04 The primary purpose of Appendix C to this EIS is to present a range of accident phenomena, their estimated

frequency of occurrence and the basis for that estimation, and accident-related preventive and mitigative measures. Only radiation exposure from historical events are presented. One exception, the consequences from the PFP FSAR for a wind-induced accident with nitric acid, is mentioned qualitatively. Based on engineering judgement and a review of historical events associated with DOE facilities, most of the accident phenomena discussed in this EIS are expected to have small consequences. For other events such as an aircraft crash or man-made external event at a nearby transportation route, there is a high degree of confidence in the scientific basis for determining that these events are incredible or extremely unlikely. Accidents were screened for a consequence assessment on these two criteria - expected small consequences and/or high confidence in a very small frequency of occurrence. The addition of the anticipated consequences of each of the accident types listed in Appendix C would not provide a better basis for decisionmaking.

L09-05 As the commentor notes, Unified Building Code 1991 identifies a 0.20 g earthquake criteria, as does the current Hanford Site criteria (DOE, 1989). The PFP Facility is in compliance with these standards although they were prepared after the Facility was constructed. Three issues are considered pertinent in this regard: 1) the PFP Facility original design criteria; 2) results of subsequent seismic studies for PFP structure; and 3) current DOE seismic requirements for the Hanford Site/PFP Facility, and DOE's disposition of facilities that are noncompliant with current requirements.



L10-01 The September 1995 version of the PFP FSAR (WHC, 1995a) states, "The evaluation indicated that the 236-Z Building will meet the code requirement to resist the DBE motions postulated for the site." The FSAR goes on to state:

It is to be emphasized that this is not a load carrying wall and its performance will not affect the structural behavior of the building. The entire area of the concrete block wall has been covered with welded steel plates that overlap into the poured concrete wall. The plates were installed on the exterior side with anchor bolts and sealed all around to preclude a leak path.

Therefore, references to the seismic instability of the south wall of Building 236-Z have been deleted from this EIS.

L10-02 The discussion describes in general terms the activities that would be undertaken under the preferred alternative. The phrase in question does not refer, nor was it intended to refer, to the regulatory definition of "modification" found at Chapter 246-247 WAC.

L10-03 The section to which the commentor is referring states: "These doses are well below the DOE limit of 100 millirem per year for members of the general public, the state of Washington dose limit of 100 millirem per year for the general public in WAC 246-221-060, and the EPA criterion of 10 millirem per year for air emissions in 40 CFR 61.92." This statement compares the calculated dose received by the hypothetical maximally exposed individual as a result from all Hanford activities with the federal and state regulatory limits. It demonstrates that in the most recent year for which data was available, the Hanford Site complied with these federal and state requirements. Section 7 of this EIS presents the various laws, DOE Orders, and regulations that would be complied with at the PFP Facility.

40 CFR 61.92 establishes a 10 millirem per year effective dose equivalent limit for the public due to air emissions. WAC 246-221-060 establishes annual state dose limits for members of the public at 100 millirem total effective dose equivalent. Chapter 246-247 WAC does not establish dose limits, but refers the reader to other federal and state regulations. Chapter 246-247 WAC is, therefore, not included in this discussion of the affected environment. Subsection 7.2 of this EIS states that the preconstruction review and approval requirements of Chapter 246-247 WAC would, indeed, be complied with.

L10-04 There was no mention of Washington State Department of Health regulations that relate to the maximally exposed individual or total effective dose equivalent in Section 6, Cumulative Impacts, of this EIS. WAC 246-247-040(1) requires the regulated community to comply with the most stringent standards in effect. These standards are currently located at 40 CFR 61, Subpart H. Therefore, by referencing the most stringent radiation exposure requirement and demonstrating compliance with this requirement, the DOE is demonstrating compliance with the Washington State



Department of Health regulations that relate to radiation exposure to the general public.

Total effective dose equivalent incorporates the dose due to external exposures and the committed effective dose equivalent due to internal exposures (WAC 246-247-030(26)). When used in this EIS, the calculated dose received by the hypothetical maximally exposed individual incorporates dose due to external exposure and the committed effective dose equivalent due to internal exposure. For the exposure scenarios evaluated, these are the same elements that are included in the Washington State Department of Health term "total effective dose equivalent." The definition of the term "effective dose equivalent" has been expanded in the glossary to more accurately reflect its usage in this EIS.

L10-05 All water used in hoods and gloveboxes is protected by backflow preventers which are tested annually.

L10-06 DOE is committed to complying with all applicable federal, state, and local requirements. These requirements are listed in Section 7, Statutory and Regulatory Requirements, of the EIS and include, among others, the State of Washington Department of Health regulations at Chapter 246-247 WAC.

L10-07 There are several factors that lead to concluding that a current ion-exchanger accident would not be as severe as the one cited as an historical example. That column was allowed to sit unattended for several days fully loaded with plutonium and generating hydrogen gas from radiolysis that was not vented. Based on the lessons learned from that historical example, current operations would not allow a loaded exchanger to sit for an extended period, would not allow un-vented accumulations of hydrogen, and would not allow shutting off the flow to a loaded bed. Therefore, the quantities of hydrogen that can accumulate under current conditions would be much less than the amount causing the historical explosion. It is not anticipated that any workers would be so violently and directly impacted by the ejected material from the accidents postulated in this EIS.

As explained in other comment responses, Appendix D of this EIS contains the details of the health effects consequence calculations, including: a) isotopic masses involved; b) the various release fractions and references; c) the dispersion models used; and d) the locations of the various receptors. The differences in the scenarios between the muffle furnace and ion-exchange column are in the estimated airborne release fractions ( $5 \times 10^{-3}$  versus  $2 \times 10^{-6}$ ), appropriate for the difference in physical conditions, and the initial amount of material of risk. These factors equate to an overall difference in the release of about a factor of 450, which is also the difference in the room concentrations and resultant doses. These results are not contradictory, but consistent with the assumptions and physical conditions involved. Note that an ion-exchange process involves relatively low temperature and low pressure liquid streams; whereas, the muffle furnace operates at high temperatures and involves molten materials.



L11-01 Thank you for your comment.

### References:

10 CFR 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

40 CFR 1500, "Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

42 U.S.C. §§ 4321 et seq., "National Environmental Policy Act of 1969," *United States Code*, as amended.

60 FR 63044, "Environmental Impact Statements; Notice of Availability," *Federal Register*, December 8, 1995.

60 FR 64423, "Extension of comment period, Draft Environmental Impact Statement for the Plutonium Finishing Plant Stabilization Hanford Site, Richland, Benton County, Washington", *Federal Register*, December 15, 1995.

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## **APPENDIX G**

### **DISTRIBUTION LIST**

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Office of Environment, Health, and Natural Resources  
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Confederated Tribes of the Umatilla Indian Reservation  
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Cascade Geographic Society  
Mr. Michael P. Jones  
Rhododendron, OR 97049

Central Washington Building Trades Council  
Mr. Richard Berglund  
Pasco, WA 99301

Columbia Basin Minority Economic Development Assoc.  
Ms. Kathy Hackley  
Richland, WA 99352

Columbia River United  
Mr. Greg Debruler  
Bingen, WA 98605

Columbia River United  
Ms. Cindy Debruler  
Hood River, OR 97031

Hanford Action of Oregon  
Ms. Robin Klein  
Portland, OR 97215

Hanford Advisory Board  
Merilyn Reeves, Chairperson  
Amity, OR 97101

Hanford Education Action League  
Lynne Stenbridge, Executive Director  
Spokane, WA 99201

Hanford Education Action League  
Mr. Todd Martin  
Spokane, WA 99201

Hanford Watch  
Ms. Paige Knight  
Portland, OR 97214

Heart of America Northwest  
Mr. Gerald Pollet, Executive Director  
Seattle, WA 98101

Heart of America Northwest  
Cynthia Sarthou  
Seattle, WA 98102

Lower Columbia Basin Audubon Society  
& Columbia River Conservation League  
Mr. Rick Leaumont  
Pasco, WA 99301

Northwest Environmental Advocates  
Mr. Eugene Rosalie  
Portland, OR 97204

Northwest Environmental Advocates  
Ms. Paige Knight  
Portland, OR 97216

Nuclear Environmental Services  
Mr. Richard Kingsley  
Richland, WA 99352

Military Production Network  
Mr. Bill Mitchell  
Seattle, WA 98103

Military Production Network  
Ms. Sharon Carlsen  
Seattle, WA 98103

Oregon Hanford Waste Board  
Ms. Shelley Cimon  
LaGrande, OR 97850

Oregon League of Women Voters  
Ms. Marilyn Reeves  
Amity, OR 97101

Physicians for Social Responsibility  
Mr. Richard Belsey  
Portland, OR 97219-6566

Physicians for Social Responsibility  
Mr. Martin Fleck  
Seattle, WA 98105

Washington Environmental Council  
Ms. Betty Tabbutt  
Olympia, WA 98502

Washington Nuclear Waste  
Advisory Board

Mr. Robert Stilger  
Spokane, WA 99205

## G.7 INDIVIDUALS

Mr. Peter Allan	Professor Jan Crouter
M. Jamie Altman	Mr. Daryl R. Delong
Ms. Sonja Anderson	Mr. Dan Devine
Mr. Paul Anthony	Mr. John F. Doherty
Mr. Everett Anttila	Mr. Charles H. Eccleston
Ms. Tejpal Basra	Mr. Richard H. Engelmann
Ms. Elizabeth Berlin	Mr. Leo Faust
Mr. John Bigas	Mr. Steve Folga
Mr. Jerry Boese	Ms. Lynn Ford
Mr. D.C. Brink	Mr. Ben Gannon
Mr. Mark Chernisky	Mr. Frank Gearhart
Mr. Mark Clemence	Mr. Jeremy Gray
Mr. Randy Coleman	Ms. Miriam Halsen
Ms. Kathryn Crandall	Mr. Don Hansen
Ms. Betsie Crouse	Ms. Pat Herbert

Mr. Norton Hildreth	Ms. Debbie Phillips
Mr. Dave Hoover	Mr. Ron Phillips
Mr. John Hunter	Mr. Rich Ranellone
Mr. Harold Johnson	Ms. Rosemary Reed
Ms. Laura Johnson	Mr. Lou Rodgers
Mr. Ron Koll	Mr. Gordon Rogers
Mr. George Kmiazewycz	Mr. Donald Roeder
Mr. Terry Kuykendall	Mr. Joe Roemer
Mr. Fred Lascoe	Mr. Carl Rupert
Mr. James Langford	Mr. Paul Sharp

M. Kelly Lewis	Ms. Carrie Sikorski
Mr. Marvin Lewis	Ms. Lynn Sims
Ms. Gail Lewis-Kido	Mr. Dale Sirek
Mr. John Lindsay	Ms. Bobbi Smith
Mr. George Lobsenz	Ms. Ellen Smith
Mr. Stewart Mackay	Mr. Sidney Stock
Mr. Kazu Martinez	Ms. Tina Storgaard
Mr. Don McBride	Ms. Lois Thiede
Mr. Dick Millward	Mr. Richard Van Konynenburg
Mr. Tom Morris	Mr. Theodore J. Venetz
Mr. John Nash	Mr. Eric Vogt
Mr. Robert Nelson	Ms. Evelyn Weiss
Ms. Britta Nelson-Maki	Ms. Barbara D. Williamson
Mr. Bill Nettleton	Ms. Roseanne Willmole
Ms. Sally Pangborn	Mr. Chuck Wuller
Ms. Gerri Peck	Mr. Brad Yazzolino
Mr. Tim Peschman	Mr. Frank Yuse

## **G.8 LIBRARIES**

Hanford Technical Library  
Richland, WA 99352

University of Oregon Library  
Mr. Tom Stave  
Eugene, OR 97403

Mid-Columbia Library  
L. Phelps Shepard  
Kennewick, WA 99336

Mid-Columbia Library  
Benton City Branch  
Benton City, WA 99320

Oregon State Library  
Mr. Jay Wan  
Salem, OR 97310



Pasco Public Library  
Mr. Tom Moak  
Pasco, WA 99301

Prosser Library  
Prosser, WA 99350

Richland Public Library  
Mr. Wayne Suggs, Head Librarian  
Richland, WA 99352

## **G.9 PUBLIC INFORMATION REPOSITORIES**

U.S. Department of Energy  
Headquarters  
Washington, D.C. 20585

U.S. Department of Energy  
Richland Operations Office  
Public Reading Room  
Washington State University, Tri-Cities  
Richland, WA 99352

Gonzaga University  
Foley Center  
Government Documents  
Spokane, WA 99258

Portland State University  
Branford Price Millar Library  
Portland, OR 97207

University of Washington Library  
Government Publications  
Seattle, WA 98195-2900





## GLOSSARY

**absorbed dose:** The energy deposited per unit mass by ionizing radiation. The unit of absorbed dose is the rad.

**acceptable source impact level:** A concentration of a toxic air pollutant in the atmosphere in any area which does not have restricted or controlled public access. This air pollutant concentration is used to evaluate the air quality impacts of a single source.

**actinides:** Any of the heavy radioactive metallic elements with similar behavioral characteristics in the series of increasing atomic numbers beginning with actinium (89), ending with lawrencium (103), and including plutonium (94).

**activity (radiological):** The rate of disintegration (transformation) or decay of radioactive material. The unit of activity is the curie (Ci).

**adsorption:** Surface retention of atoms, molecules, or ions by a solid or a liquid.

**airborne release fraction:** The coefficient used to estimate the amount of a radioactive material that can be suspended in air and made available for transport under a specific set of accident conditions.

**air quality standards:** The prescribed level of pollutants in the outside air that cannot be exceeded legally during a specified time in a specified area.

**alpha (α) particle:** A positively charged elementary particle consisting of two protons and two neutrons that is emitted from the nucleus of certain nuclides during radioactive decay. It is the least penetrating of the three common types of radiation.

**ambient air:** The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.

**americium:** Decay product of plutonium. Americium is an alpha and gamma emitter.

**aquifer:** A subsurface geologic formation that contains sufficient saturated permeable material to conduct groundwater and to yield significant quantities of groundwater.

**as low as reasonably achievable (ALARA):** Making every reasonable effort to maintain exposures to radiation as far below the allowable dose limits as practical.

**background radiation:** Routinely used to refer to the amount of radiation to which a member of the population is exposed from natural sources, such as terrestrial radiation due to naturally occurring radionuclides in the soil and cosmic radiation originating in outer space. These naturally occurring radionuclides are found in food, water, and air. Also used in this EIS to refer to ambient radiation exposure to in-facility workers due to radioactive material located in the Facility, but not directly attributable to any specific source.

**beta (β) particle:** A negatively charged elementary particle emitted from a nucleus during radioactive decay. It is identical to an electron, and is easily stopped by a thin sheet of metal or plastic.

**bounded:** Used in analyses to identify the upper range of impacts.

**canyon:** A heavily shielded building used in the chemical processing of radioactive materials to recover special isotopes for national defense or other programmatic purposes. At the PFP Facility, equipment in the canyon is accessed by gloveboxes.

**capable (fault):** A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or

transverse slippage of the earth's crust has occurred in the past.

**committed dose equivalent:** The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

**contact liquid:** Liquids that have been part of the stabilization process or may have come into contact with the process and contain or have a high probability of containing radioactive material.

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

**crucible:** A container for heating materials.

**cumulative effects:** Additive environmental, health, and socioeconomic effects that result from a number of similar activities in an area.

**curie (Ci):** The official unit of radioactivity, defined as exactly  $3.70 \times 10^{10}$  disintegrations per second.

**decay product:** A nuclide formed by the radioactive decay of another nuclide.

**decay, radioactive:** The transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).

**decontamination:** Removal of radioactive contamination from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

**design basis accident:** An accident that is considered credible enough to be used to establish design and performance requirements for systems, structures, and components important to safety.

**design basis earthquake:** The maximum intensity earthquake that might occur along the nearest capable fault to a structure.

**disposal:** As defined by DOE Order 5820.2A, emplacement of waste in a manner that ensures isolation from the biosphere for the foreseeable future with no intent of retrieval and that requires deliberate action to regain access to the waste.

**disposition:** The decision and associated actions concerning the ultimate fate or alternative use of a material or a facility under the jurisdiction of DOE.

**DOE storage standard:** *Criteria for Safe Storage of Plutonium Metals and Oxides*, DOE-STD-3013-94, U.S. Department of Energy, Washington, D.C.

**dose, radiation:** In terms of public health and safety, radiation dose is a measure of the amount of ionizing radiation absorbed by the body or body tissue. Various forms of radiation have different impacts on tissues and different tissues have different responses in terms of overall impact on the body. The source of radiation may originate outside the body, or inside the body as a result of inhalation, ingestion, absorption, or as a result of medical treatment.

**dose rate:** The radiation dose delivered per unit time (e.g., rem per year).

**effective dose equivalent:** A value used for estimating the total risk of potential health effects from radiation exposure. This estimate is the sum of the dose equivalent to organs or tissues from internal deposition of radionuclides in the body and the dose equivalent from external radiation received during a year.

**elute:** To remove adsorbed material from an adsorbent by means of a solvent.

**fine particulate matter (PM<sub>10</sub>):** Particulate matter in which the particles have an aerodynamic diameter of less than 10 microns (micrometers).

**fiscal year:** U.S. government fiscal year, from October 1 to September 30.

**fissile:** Capable of being split or divided (fissioned) by the absorption of thermal neutrons.

**fission:** The splitting or breaking apart of a heavy atom such as plutonium. When a plutonium atom is split, large amounts of energy and one or more neutrons are released.

**fission products:** A general term for the complex mixture of nuclides produced as a result of nuclear fission. Most, but not all, nuclides in the mixture are radioactive, and they decay, forming additional (daughter) products, with the result that the complex mixture of fission products formed contains about 200 different isotopes of over 35 elements.

**full-time equivalent (FTE):** A measure of employment calculated by taking the sum of the regular hours worked in a month and dividing this by the hours actually worked each month by the average employee. Overtime hours are not included in the calculation.

**gamma (g) rays:** High-energy, short-wavelength electromagnetic radiation accompanying fission, radioactive decay, or nuclear reactions. Gamma rays are more penetrating than alpha and beta radiation.

**glovebox:** A filtered and ventilated enclosure with gloves installed in its walls that allows handling of hazardous materials without direct worker contact with the material.

**greenhouse:** In radiation protection, a temporary structure used as a confinement barrier between a radioactive work area and a non-radioactive area to prevent the spread of contamination.

**half-life (radiological):** The time in which half the atoms of a radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

**Hanford Site worker:** Those workers employed at the Hanford Site who are not PFP Facility workers.

**high efficiency particulate air (HEPA) filter:** A type of filter with a minimum installed capture efficiency of 99.95 percent for particulates 0.3 microns in diameter. HEPA filters can remove particles less than 0.3 microns in diameter.

**high- and low-fired oxides:** High-fired oxides are produced at a temperature in excess of 950·C (1,742·F); low-fired oxides are produced at temperatures below 950·C, typically 400·C to 600·C (752·F to 1,112·F).

**high-level waste:** The highly radioactive wastes that result from the processing of defense materials.

**hold-up:** Material that has accumulated or been retained in PFP Facility gloveboxes, hoods, process equipment, piping, exhaust and ventilation systems, and canyons as a result of years of operations at the Facility.

**hood:** A canopy and exhaust duct used to confine hazardous materials in order to reduce the exposure to industrial workers. Often loosely used in the PFP Facility to also denote a glovebox.

**hydrolysis:** Decomposition of a chemical compound by reaction with water.

**immobilization:** The combination of steps or activities to make a material nondispersable.

**interim storage:** Safe and secure storage pending final disposition.

**ion:** An atom or molecule that has gained or lost one or more electrons and has become electrically charged.

**ion exchange:** Process in which a solution containing soluble ions to be removed is passed over a solid medium, which removes the soluble ions. The process is reversible so that the trapped ions can be collected (eluted) and the column can be regenerated.

**isotope:** Isotopes of the same element have the same number of protons, but different numbers of neutrons. They are chemically the same, but physically different. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus.

**latent cancer fatalities (LCF):** The excess cancer fatalities anticipated in a population due to exposure to a carcinogen.

**long-term storage:** The storage of national security and programmatic inventories of highly enriched uranium, plutonium, minor actinides, and surplus weapons-usable fissile materials. The duration for long-term storage will be determined by the Record of Decision for the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement*. Facilities for the secure long-term storage of both strategic and surplus weapons-usable fissile materials covered by this Programmatic EIS would be designed to operate for at least 50 years.

**loss-on-ignition:** The percentage of mass lost when a representative sample of processed plutonium oxide is heated at a specified temperature for a specified time period. The mass loss is residual moisture and other volatiles.

**low-level waste:** As defined by DOE Order 5820.2A, low-level waste is radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material.

**maximally exposed individual:** A hypothetical member of the public assumed to permanently reside at the location of highest calculated dose.

**millirem:** One thousandth of a rem.

**mixed waste:** Waste that contains both radioactive and hazardous chemical components.

**natural radiation or natural radioactivity:** See background radiation.

**neutron:** An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen.

**nitrogen oxides (NO<sub>x</sub>):** Oxides of nitrogen, primarily nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). These occur naturally and are also produced in the combustion of fossil fuels.

**nuclide:** An atomic nucleus specified by atomic weight, atomic number, and energy. A radionuclide is a radioactive nuclide.

**oxide(s):** Compound(s) in which an element binds chemically with oxygen.

**particulate matter/total suspended particulates (PM):** Small particles, either solid or liquid, which become suspended in air.

**person-rem:** The radiation dose commitment to a given population; the sum of the individual doses received by a population segment.

**perched water:** Unconfined groundwater separated from an underlying main body of groundwater by an unsaturated zone.

**PFP Facility worker:** Those workers who are subject to the PFP Facility Building Emergency Plan. Specifically, the PFP Facility worker is one of three classes of individuals (the other two being Hanford Site worker and the public) for whom health effects have been calculated. A representative bounding dose is provided for those in this class involved in handling or processing plutonium-bearing material associated with the alternatives evaluated in this EIS.

**pH:** A measure of the hydrogen ion concentration in aqueous solution. Pure water is neutral and has a pH of 7, acidic solutions have a pH less than 7, and alkaline solutions have a pH greater than 7.

**plume:** The distribution of contaminants at a distance away from a point source in a medium like groundwater or air.

**plutonium (Pu):** A transuranic, heavy (average atomic mass about 240 atomic mass units), silvery metal with 15 isotopes that is produced by the neutron irradiation of natural uranium.

**precipitate:** A solid (when used as a noun). To form a solid substance in a solution by a chemical reaction (used as a verb).

**radioactive isotopes:** Isotopes of an element that are unstable because their nuclei emit high-energy particles (alpha or beta), rays (X rays or gamma) or both, in the process of decaying into another radioactive isotope of lower atomic mass. Some radioisotopes are naturally occurring (e.g., potassium-40) while others are produced by nuclear reactions.

**radiolysis:** A radiation-induced, chemical change which may create several by-products, among which is often hydrogen.

**readily retrievable:** Plutonium-bearing material which is on the surface of the host structure (e.g., glovebox interior, canyon floor, process piping), does not require extraordinary means to extract, and is potentially suitable for subsequent stabilization.

**receptor:** Individuals or populations that could be exposed to radiation, radioactive materials, or toxic chemicals.

**rem:** Dosage of ionizing radiation that will cause the same biological effect as one roentgen of x-ray or gamma ray exposure.

**resin:** An ion-exchange medium; organic polymer used for the preferential removal of certain ions from a solution.

**risk:** In accident analysis, the probability-weighted consequence of an accident, defined as the accident frequency per year multiplied by the consequence. The term "risk" is also commonly used in other applications to describe the probability of an event occurring.

**special nuclear materials:** Plutonium, U-233, U-235, or uranium enriched to a higher percentage than normal of the U-233 or U-235 isotopes.

**stabilization:** The combination of steps or activities to secure, convert, and/or confine radioactive and/or hazardous materials (e.g., thermal treatment). Activities needed to bring a facility to a minimal surveillance level.

**stack:** A vertical pipe or flue designed to exhaust gases and suspended particulates.

**swarms (earthquake):** Dense cluster of seismic events of comparable magnitude (usually 2 or less on the Richter scale). Generally, this seismic activity is associated with shallow depths (less than 6 km).

**transmissivity:** Capability of the aquifer to convey water.

**transuranic:** An element of higher atomic numbers than uranium (92), not found naturally. Plutonium is a transuranic.

**transuranic waste:** Radioactive waste containing alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste.

**Tri-Party Agreement:** The Hanford Federal Facility Agreement and Consent Order. It is an agreement signed in 1989 and amended periodically by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions.

**vadose zone:** The unsaturated region of soil between the ground surface and the water table.

**vault:** A reinforced concrete structure for storing special nuclear materials.

**vented containers:** Plutonium storage containers that are equipped with a vented stopper to prevent pressurization, thereby reducing the potential for container failure.

**wind rose:** A diagram designed to show the distribution of wind directions at a given location. One variation shows wind speed groupings by direction.

**x-rays:** A penetrating form of electromagnetic radiation emitted when the inner orbital electrons of an excited atom return to their normal state.

### METRIC CONVERSION CHART

To Convert Into Metric			To Convert Out of Metric		
If you know	Multiply By	To Get	If you know	Multiply By	To Get
inches	2.540	centimeters	centimeters	0.3937	inches
inches	0.02540	meters	meters	39.37	inches
feet	30.48	centimeters	centimeters	0.03281	feet
feet	0.3048	meters	meters	3.2808	feet
miles	1.609	kilometers	kilometers	0.6214	miles
sq. feet	0.09290	sq. meters	sq. meters	10.76	sq. feet
sq. miles	2.590	sq. kilometers	sq. kilometers	0.3861	sq. miles
quarts	0.9463	liters	liters	1.057	quarts
gallons	3.785	liters	liters	0.264	gallons
cubic feet	0.02831	cubic meters	cubic meters	35.31	cubic feet
ounces	28.35	grams	grams	0.03527	ounces
pounds	453.6	grams	grams	0.002204	pounds
pounds	0.4538	kilograms	kilograms	2.203	pounds
miles per hour	0.4470	meters per second	meters per second	2.237	miles per hour
pounds per sq. inch	70.30	grams per sq. centimeter	grams per sq. centimeter	0.01422	pounds per sq. inch
pounds per sq. foot	4.884	kilograms per sq. meter	kilograms per sq. meter	0.2048	pounds per sq. foot
Fahrenheit	Subtract 32 then multiply by 5/9	Celsius	Celsius	Multiply by 9/5, then add 32	Fahrenheit

**EXPONENTIALS**

Prefix	Symbol	Multiplication Factor
mega-	M	1,000,000 ( $10^6$ ; one million)
kilo-	k	1,000 ( $10^3$ ; one thousand)
hecto-	h	100 ( $10^2$ ; one hundred)
centi-	c	0.01 ( $10^{-2}$ ; one one-hundredth)
milli-	m	0.001 ( $10^{-3}$ ; one one-thousandth)
micro-	$\mu$	0.000001 ( $10^{-6}$ ; one one-millionth)
nano-	n	0.000000001 ( $10^{-9}$ ; one one-billionth)
pico-	p	0.000000000001 ( $10^{-12}$ ; one one-trillionth)

